

SOURCE WATER PROTECTION
2005 - ABSTRACTS

Source Water Protection

Alphabetical list of
Abstracts 2005

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A COMPARISON OF REMOVAL EFFICIENCIES OF PHARMACEUTICALS AND PERSONAL CARE PRODUCTS DURING NITRIFICATION AND DENITRIFICATION

Andrews, David M, Huck, Dr. Peter M, Natvik, Olav, Regional Municipality of Waterloo

Abstract:

A trial was conducted at a Canadian wastewater treatment plant (WWTP) aimed at comparing the treatment performance of two bioreactors, operating in parallel; one in nitrification mode and the other in denitrification mode. The original objectives of the trial were to compare performance of the two processes with respect to ammonia removal, nitrate removal, alkalinity and oxygen utilization. Pharmaceuticals and personal care products (PPCP's) are a group of emerging contaminants of concern and survey work has identified wastewater effluent as a significant point source for their entry in to the environment. Other studies have suggested that PPCP removal could be enhanced by the optimization of operating conditions at the WWTP, so a survey of PPCP's was included in this trial to compare their removal efficiencies in the two treatment processes. PPCP's were selected based on previously reported presence in wastewater and available analytical capabilities. The PPCP's included acidic pharmaceuticals, neutral pharmaceuticals and triclosan. The performance of both bioreactors was unexpectedly similar for the removal of conventional contaminants, likely due to the presence of pre-anoxic zones in each treatment train. Concentrations and removals of PPCP's were consistent with other studies. Overall removals were not impacted by the treatment process but a more detailed statistical review identified the removal of naproxen and trimethoprim as being significantly impacted by the type of treatment process employed. Sample extracts were subsequently reanalyzed for a group of sulfonamide pharmaceuticals, Sulfacetamide, Sulfamethoxazole and Sulfapyridine, which again exhibited a significant difference in removals based on the type of treatment process employed.

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MODELLING OF KEMPTVILLE CREEK WATERSHED USING MIKE11

Asif, Shahbaz, Ahmed, Ferdous. Rideau Valley Conservation Authority

Abstract:

A numerical model for the Kemptville Creek Watershed has been developed using Mike11 model of the Danish Hydraulic Institute. The whole watershed has been sub-divided into 7 sub-basins, which were modelled using the rainfall-runoff (RR) module of Mike11. The main stem of the Kemptville Creek and a tributary have been modelled using the hydrodynamic (HD) module. Oxford Mills Dam is located upstream of Kemptville Town on the Kemptville Creek and is operated by Ontario Ministry of Natural Resources (MNR) to achieve certain seasonal water level targets, the structure has been modelled with the structure operation (SO) module.

The input data included cross sections from river surveys, information on structures and roughness for the HD model and precipitation, temperature, evaporation, land cover, vegetation, and soil texture for the RR model. The integrated model was calibrated for ten years (1981-90) using measured streamflow data upstream of Kemptville Town. The model successfully captured the regime over most of the ten years period.

In this paper, we describe our experience in modelling complex Kemptville Watershed with moderate human interference (dam operation). It is one of the first applications of a state-of-the-art numerical model, Mike11 model, in the Province of Ontario. Potential applications of this model in watershed management including source water protection are also briefly discussed.

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COMPARISON OF TWO SURFACE-GROUND WATER MODELLING APPROACHES FOR THE TAY WATERSHED

Bahar S.M. Habibullah, Hall, Kevin, Queen's University

Abstract:

The Centre for Water and Environment at Queen's University is currently undertaking a five year research project focused on developing rational tools and models for providing rapid, accurate assessment of water movement and water quality through complete watersheds. Over the span of three to four years, develop watershed management tools that will allow for the appropriate response to requests for water taking, management of existing water taking, determination of the impacts of development, management of the potential impact of large-scale agricultural activities, and the protection and management of rural water supplies. The management tools will consist of a suite of numerical models and decision/risk-based software that can be utilized separately or in combination to address specific water management issues. The development of the models and software will be entirely terrain-based (i.e. bottom up) with the intention that the tools will be transferable between watersheds within Ontario and can be utilized at a sub-watershed scale.

The tools will be developed with sufficient pre and post-processing to make the tools useable by engineers employed by the conservation authority who have a basic understanding of the issues involved but may not have advanced training in a detailed technical area. The tools will communicate with GIS based applications. This paper will focus on the comparison of two modelling approaches for the Tay Watershed.

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TOXIC EFFECTS OF SELECTED PHARMACEUTICALS EMITTED TO THE ST-LAWRENCE RIVER FROM A MAHOR MUNICIPAL WASTEWATER SOURCE

Blaise, Christian, Pavleta Pavlova, François Gagné, Robert Tardif, Manon Harwood

Abstract:

Municipal wastewaters are now well-recognized as sources of "emerging chemicals" comprising diverse household products, hormonally-active substances and pharmaceuticals. In particular, effects of the latter class on aquatic biota are poorly understood at present. Twelve such chemicals were recently detected in the final effluent of the City of Montreal's wastewater treatment plant which treats close to three million cubic meters of combined sewage and industrial liquid waste per day. To gain a first insight on the effects they might have on aquatic organisms, their individual and combined (sub)lethal toxicity was reported via standard measurement endpoints using laboratory bioassays representative of different levels of biological organization. Toxicity testing was conducted with bacteria (*Vibrio fischeri* light inhibition assay), micro-algae (*Selenastrum capricornutum* growth inhibition assay), micro-crustaceans (*Thamnocephalus platyurus* lethality assay), cnidarians (*Hydra attenuata* sublethality and lethality assay) and fish cells (rainbow trout hepatocyte cytotoxicity assay). Additionally, with the cnidarian animal model, *Hydra attenuata*, a more subtle sub-lethal endpoint – prey ingestion inhibition – was also investigated. The relative toxicity of these 12 pharmaceuticals to bioassay organisms and their potential impact on freshwater receiving environments will be highlighted during this presentation.

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THE STATE OF DRINKING WATER SOURCE PROTECTION IN CANADA

Bonnell, Jennifer, Haseen Khan, Govt. of Newfoundland and Labrador

Abstract:

Source water protection (SWP) is vital for ensuring safe drinking water by protecting the integrity of water in lakes, rivers and aquifers. It is the first barrier in a multi-barrier approach for drinking water safety, and can be broken down into an assessment phase and a protection phase. Management of SWP plans needs to be done at a watershed level, and as such, political boundaries are often secondary. Cooperation between all levels of

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government, as well as stakeholders and the general public, is needed. For SWP to be successful, water must be viewed as the main factor to environmental health, and as a commodity with real value that requires management. SWP is still evolving in Canada, where Provinces and Territories are allowed to exercise direct control over most of their water management. The purpose of this presentation is to detail the current state of SWP, its legislative and regulatory status in Canada, and evaluate and critique Canadian programs with reference to other countries, including the United States, Australia and New Zealand. An introduction to source water, the need for its protection, and the steps involved in planning and implementation are presented. Federal, provincial, territorial and municipal water strategies, policies and legislation are summarized. Case studies are used to illustrate their effectiveness and their deficiencies, if any. Recommendations are made on how SWP should evolve based on what we can learn from other countries' successes, and the steps necessary to achieve this evolution are outlined.

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ADAPTING AND APPLYING A NUTRIENT MANAGEMENT DECISION SUPPORT TOOL FOR CANADIAN CONDITIONS

Boston, Trevor , Evans, Barry, Walters, Mike, Greenland International Consulting Ltd.

Abstract:

As human development continues to intensify, so too have demands and impacts on water resources. Increased extraction of surface and groundwater, degraded agricultural runoff from intensive fertilizer and pesticide applications and overall reductions in vegetation cover on lands that have experienced urban development are just a few examples of issues impacting watersheds and water quality. The growing popularity of geographic information systems (GIS) coupled with hydrologic and water quality modelling tools provide a widely accepted, cost effective means of watershed management. This paper describes the adaptation of a nutrient and sediment management tool to

provide decision support for watersheds in Southern Ontario. Three (3) watersheds were selected for a pilot study involving the Canadian ArcView Nutrient and Water Evaluation Tool (CANWET) with the objective of source protection of drinking water and development of total maximum daily loads (TMDL) for protection of aquatic systems. The resulting software package draws on a spatial database derived from a wealth of information sources to estimate spatially referenced constituent loading rates and attribute them to specific land uses using a continuous modelling approach.

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THE WATERSHED EVALUATION OF BMPS IN SOUTH CENTRAL BRITISH COLUMBIA.

Broersma¹, Klaas, Bruce Roddan¹ and Asit Mazumder²

Abstract:

The **Watershed Evaluation of Beneficial Management Practices (WEBs)** is a multi-million dollar project led by Agriculture and Agri-Food Canada through its Greencover Canada Program that runs from 2004 to 2008. Ducks Unlimited is a key partner and has contributed over 20 % to the total funding. WEBs is being conducted at seven sites across Canada. The objective of the study is to evaluate the impacts of applying agricultural BMPs on the watershed by working with local landowners and watershed agencies by monitoring the net effect on water quality. The study in BC is located in the south central interior of the province and within the Salmon River watershed. The Salmon River Watershed Roundtable, one of the main partners in the BC project, is active in watershed monitoring and doing stream rehabilitation. The Salmon River is about 120 km in length and drains an area of about 1500 km². Land use in the watershed consists mainly of forestry, agriculture, urban development and recreation. Agriculture is diverse but is dominated by forage based agriculture that includes some dairy but mostly beef production. The present Salmon River water quality concerns are bacteria, sediments, nitrogen, phosphorus, and low summer flows that have high temperatures. The BMP study in the Salmon River watershed focuses on three cow/calf beef farms using fencing to create functional riparian buffers. Fencing, off-stream watering and

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controlled or engineered cattle crossings will be installed to improve water quality, reduce sediments loading, and develop better soil and vegetation conditions. Modeling and economics are also evaluated.

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TEN YEARS OF MONITORING SURFACE WATER FROM URBAN DEVELOPMENT AREAS ON THE WATERLOO MORAINÉ

Brown, S.R., Gorrie¹, J.E., Stantec Consulting Ltd.,

Abstract:

Stantec has been monitoring surface water quality within the 180 ha Laurelwood subdivision on the Waterloo Moraine since 1994. The monitoring data have provided insight into local stormwater runoff quality, and the performance of the five stormwater management facilities including the innovative stormwater infrastructure within the road rights-of-way.

Before the City of Waterloo permitted development in this area, detailed studies were completed to determine planning/growth objectives and to identify environmental constraints such as groundwater recharge areas for municipal water supply wells, sensitive watercourses, Provincially Significant Wetlands and Environmentally Sensitive Policy Areas. The area is also upstream of the Grand River intake works for the Mannheim water supply system. One of the conditions of development approval was the implementation of a monitoring program that evaluated water quality conditions prior to, during and following development.

Surface water monitoring included samples at stormwater management inlets and outlets, as well as within the receiving systems upstream and downstream of the site. Parameters monitored included flow, water temperature, dissolved oxygen, total suspended solids, total phosphorus and bacteria. The results indicated that the facilities performed well for temperature and dissolved oxygen, while total suspended solids and total phosphorus showed general improvement with facility and catchment area maturity.

As a result of this monitoring program, a number of modifications to typical stormwater management design have been implemented on subsequent stages within the Laurelwood neighbourhood and in other development projects. These modifications have successfully controlled threats related to urban storm runoff to Laurel Creek and other downstream receivers.

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FATE OF IN-FEED MEDICATIONS AFTER LAND APPLICATION IN ONTARIO.

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Abstract:

Soil dissipation rate studies were performed in a farm field soil for antibiotics applied with and without manure. A robust high-throughput method was developed to extract the three growth-promoting antibiotics, tylosin (TYL), chlortetracycline (CTC), and monensin (MON) from soil. Analysis was performed by Electrospray Liquid Chromatography tandem Mass Spectrometry (ESI-LC-MS-MS). TYL, CTC, and MON followed first order dissipation kinetics with half-lives of 4.5, 24, and 3.3 days with the addition of manure. Manure application significantly increased the TYL dissipation rate, perhaps due to the introduced microbial flora, but had no significant effect on CTC or MON. MON dissipation half-life was found to be much shorter in the field study than in a controlled laboratory study, which may be due to differences in microbial community. The antimicrobials were not highly mobile. CTC was the only antibiotic detected at 25 to 35 cm depth and only up to 2% of the initial concentration in a sandy loam soil. These antibiotics are therefore expected to primarily degrade in agricultural soils before moving to greater depths or to groundwater in significant concentrations in most agricultural systems.

DETERMINATION OF INCLUSION EFFICIENCY OF MERCURY WITH CYCLODEXTRINS USING HPLC AND PURGE AND TRAP GC-FID

Cathum, S.J., Obenauf, A.K., Brown, C.E., SAIC Canada

Abstract:

There is increasing interest in using cyclodextrins for remediation of mercury in water. This study was designed to investigate the inclusion efficiency of mercury with cyclodextrins using high performance liquid chromatography

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(HPLC) and purge and trap gas chromatography – flame ionization detector (GC-FID). Different mercury compounds were treated with cyclodextrins and the unbound mercury compound was determined. This study was capable to discriminate between the free mercury and the mercury-cyclodextrin compound. None of the cyclodextrin or its mercury-complexes was found to interfere with these measurements. It was found that the inclusion efficiencies of fifteen mercury compounds ranged from 50% to 100% under experimental conditions.

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FIRST NATION PERSPECTIVE AS IT RELATES TO SOURCE WATER PROTECTION AND GOVERNANCE.

Chiblow, Sue, A First Nation's Perspective, Chiefs of Ontario

This presentation provides a First Nation perspective as it relates to source water protection and governance.

Turtle Island is the homeland of many indigenous nations who shared a civilization and diplomatic relations in much the same way as the Europeans did in their own continent. The Chiefs of Ontario is the governing structure for the First Nations in Ontario. It consists of four political confederacies and several independent First Nations.

Water is spiritually significant to First Nation members and important to many cultural practices. Aboriginal Knowledge continues to positively inform the attitudes and practices of Ontario First Peoples, including in their stewardship of the water resources they share with the rest of Ontario's residents

The inherent right of self-government of First Nations is recognized in section 35 of the Canada Act, 1982. Thus, with the division of powers between the federal and provincial Crown governments, First Nations retain inherent jurisdiction that requires harmonization with Canada and the Provinces consistent with the existing nation-to-nation and the government-to-government relationship.

First Nations maintain unique perspectives on and in relationship to water. These should be drawn upon by government and various committees in order to provide insight to water quality issues in Ontario through full and meaningful consultation with First Nations.

Source water protection presents challenges and opportunities to First Nations. Challenges include resources and capacity issues and opportunities include the beginning of a new paradigm to work with government in ensuring safe and clean drinking water for those yet to be born.

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ADVANCED WASTEWATER TREATMENT TO PROVIDE DRINKING WATER SOURCE PROTECTION

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Abstract:

Advanced treatment of wastewater to produce water suitable for reuse provides a potential alternative water resource that offers the added benefit of reducing the quantity of wastewater effluent discharged to the environment while also improving its quality. As such, this contributes to drinking water source protection. Indirect potable reuse has been practiced in the U.S. for decades via the introduction of highly treated reuse water to a surface water or a groundwater system that is ultimately used as a potable water supply. Unintentional and unplanned indirect potable water reuse occurs every time a wastewater effluent is discharged to the source water of a drinking water treatment plant. This study examined the impact of discharging reuse water to a major drinking water source in terms of its impact on subsequent water quality and treatment performance.

Reuse water produced from municipal wastewater by a membrane bioreactor and reverse osmosis (MBR-RO) system was blended with untreated Lake Ontario water, then subjected to conventional water treatment processes, and evaluated in terms of disinfection by-products (DBPs), nitrate and coliforms. The addition of reuse water to the lake water was found to improve water quality in terms of total organic carbon (TOC) and bromide, which resulted in reduced trihalomethane (THM) formation. This appeared to be entirely due to dilution with no specific impact from the conventional treatment process. Nitrate levels in the reuse water (1.4 mg/L) were higher than the lake water (0.4 mg/L) and, therefore, an increase in the reuse:lake water blend ratio resulted in a linear increase in nitrate levels. The conventionally treated blend water was shown to meet U.S. drinking water regulations for THMs, haloacetic

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PRIVATE WELL PROGRAMS TO ADDRESS GROUNDWATER PROBLEMS

Conboy, Dr. Mary Jane, Hydrogeologist, Ontario Federation of Agriculture

Abstract:

The Ontario Farm Groundwater Quality survey sampled 1200 private wells across Ontario in 1991- 1992. Follow-up research sampled wells up to 13 times over 5 years and found some wells always had bacteria while others rarely had problems. The type and condition of the water well were found to be the most predominant factors in determining the vulnerability of a well to bacterial contamination.

The Ontario government has sponsored two excellent programs aimed at addressing deficiencies in private wells. The Well Aware program funded by the Ministry of Environment and run by the Green Communities Association in partnership with Ontario Groundwater Association and the Association of Professional Geoscientists, has 5 components to educate the public about their well. The most intensive component is the Guided Self Assessment. A homeowner is guided around their property, looking at their well, septic system and stewardship practices. This 2 hour visit educates and empowers clients to recognize and correct problems with their well. This program also provided a look at the actual condition of rural wells. 88% of the wells observed were in need of some repair. Another excellent program aimed at addressing water well deficiencies was the Healthy Futures Upgrading and decommissioning subsidy program. The program ran 2001 - 2002. The uptake of the program was excellent and many projects fixing serious structural problems were funded. An audit of close to 500 wells showed that well improvement methodologies are not consistent and can lead to different degrees of enhanced water quality.

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SPREAD OF THE WATERBORNE PATHOGENS, CRYPTOSPORIDIUM AND GIARDIA, BY FILTH FEEDING FLIES IN AGRICULTURAL AND MUNICIPAL WATERSHED AREAS

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Abstract:

Transmission of waterborne zoonotic pathogens is a health concern where drinking water supplies receive runoff from agricultural lands. This situation characterizes much of the St. Lawrence River in Ontario, Quebec, and New York, where intensive dairy farming is conducted on lands that drain directly into the river upstream from many municipalities. Among the most important pathogens are *Cryptosporidium parvum* and *Giardia lamblia*, which cause intestinal diseases in humans and animals. Our previous studies throughout eastern North America have employed bivalve molluscs as monitors to demonstrate that viable *Cryptosporidium* and *Giardia* occur widely, including the St. Lawrence River. Other studies have demonstrated that these pathogens are carried by filth-feeding flies that are invariably associated with livestock. In summer 2004, we studied flies of the families Calliphoridae, Muscidae, and Sarcophagidae at dairy, beef, equine, sheep, and wildlife areas in northwest Georgia. We trapped wild flies and tested for pathogens carried on the exoskeleton and in the gut, as well as on visited surfaces. Flies and surfaces were washed into testing vessels, homogenized, and subjected to a highly reliable combination of fluorescent in situ hybridization (FISH) and immunofluorescent antibody (IFA) technologies. Flies from all families were carrying viable *Cryptosporidium* and *Giardia*, and deposited them on surfaces. Thus, these flies serve as vectors of spread in all these settings, and undoubtedly contribute to the movement of pathogens into water supplies. In future years, we plan to apply this model to dairy farms in the St. Lawrence River valley, where dramatically different climate conditions prevail.

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DISTRIBUTION OF INVASIVE DREISSENID MUSSELS AND NATIVE BENTHIC MACROINVERTEBRATES IN THE ST. LAWRENCE RIVER AND LAURENTIAN GREAT LAKES: REPORT OF THE 2004 NAVIGATIONAL BUOY MONITORING PROGRAM

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In January 2005 we examined navigational buoys that had been in the St. Lawrence River and lower Great Lakes throughout the 2004 shipping season, thus completing the 15th year of such studies. The buoys are removed from the water every December, then replaced in the same location every March. Since the invaders peaked in the mid 1990s, we have expanded our survey from the upper St. Lawrence and Eastern Basin of Lake Ontario, to Lake Erie and Lake St. Clair to the west, and eastward toward Montreal. Also, we have examined the populations of native caddisflies (locally known as shadflies) and amphipod crustaceans to determine whether they are experiencing changes in distribution and abundance correlated with those of the mussels. In 2005 we examined nearly 250 buoys in Canadian and U.S. ports. Mussel populations are remaining relatively stable, with wide differences between sites. Dominance of *Dreissena polymorpha* (zebra) in major Lake Ontario ports, dominance of *Dreissena bugensis* (quagga) in the upper St. Lawrence River, and the very low numbers of both in the narrow stretch of the upper river remain similar to patterns in recent years. Abundance and distribution of hydropsychid caddisflies remain stable in the area near Cornwall, Ontario and Massena, New York, but the important population of *Brachycentrus incanus* caddisflies downstream from Prescott, Ontario and Ogdensburg, New York appear to have declined over the last few years. We plan to continue this annual survey into the foreseeable future to develop a long-term perspective of these important changes.

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PERFORMANCE OF AnnAGNPS MODEL IN SIMULATING IN ONTARIO CONDITIONS

Das, Samaresh, Rudra, R.P., Gebremeskel, S., Gharabaghi, B., Goel, P.K. University of Guelph

Abstract:

Watershed scale Non-Point Source (NPS) pollution models are useful tools in watershed management by assessing water quantities and qualities status and for selection of the Best Management Practices (BMPs) to protect and improve down stream water quality. The Guelph Watershed Research Group in the University of Guelph is currently assessing the performance of different hydrologic models for Ontario condition. Ontario has exceptional hydrologic characteristics as 70% of the total stream flows and sediment in a year are occurring during the late winter and spring period. The main reason of this huge runoff and sediment loads within a short period of time is due to winter freezing and thawing of soil, which affects the soil erodibility and hydraulic conductivity, snow melting due to the temperature change, change in the soil structure etc. About 60% of the agricultural land in Ontario is under tile drain which also has a major effect on subsurface runoff from the agricultural land. Hence to apply any hydrologic model in Ontario needs a careful attention on the model's performance specially it's winter routing capabilities and water partitioning between the surface and subsurface part of the soil. Annual Agricultural Non-point Source (AnnAGNPS) is a daily time step non-point source watershed based hydrologic models and was applied to a watershed in Grand River Basin to evaluate it's performance to simulate the hydrology and sediment from non-point sources. The model was run for 10 years (5 years for calibration and 5 years for validation) and the results will be discussed in the this paper.

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WATERSHED-SCALE MODELLING OF PATHOGEN FATE AND TRANSPORT

Dorner, Sarah M., Anderson, William B., Slawson, Robin M, Huck, Peter M., University of Massachusetts

Abstract:

In recent years, a number of pathogens from animal sources capable of causing infection in humans, such as *E. coli* O157:H7 and *Campylobacter*, have emerged with respect to water. In watersheds experiencing an intensification of livestock operations in addition to urban growth, the need exists for assessing potential sources of microbial contamination. Distributed non-point source hydrologic models may provide the starting point for tools to examine the potential of migration of pathogens from land-based sources; however, most have been developed for

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modeling soil erosion, sediment and nutrient transport. Fundamental differences with respect to assumptions necessary for microbial transport modeling as compared to sediment or nutrient transport modeling must be considered and relate to: (1) the nature of the sources which tend to be clustered in space and in time, as opposed to continuous and unlimited (2) the role of sorption/desorption of pathogens to other particles, and (3) the importance of inactivation (and possibly growth) of various pathogens in the natural environment. Assumptions will be discussed in relation to a pathogen fate and transport model that was developed for Canagagigue Creek within the Grand River Watershed, Ontario. The model was created by extending the WATFLOOD hydrologic modeling system for pathogen fate and transport. Results from the watershed-scale transport model for several waterborne pathogens, including *Campylobacter* spp., *E. coli* O157:H7, *Giardia* spp. and *Cryptosporidium* spp. from agricultural land-based sources and wastewater effluent showed that tile-drainage was generally the primary pathway of microbial transport, and that the resuspension of pathogens from stream sediments was of great importance during periods of higher streamflow.

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PROPAGATION OF UNCERTAINTY IN AQUIFER VULNERABILITY MAPPING

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This study investigates the propagation of uncertainty in aquifer mapping. As a case study, we used the aquifers of Eastern Ontario, Canada, where a considerable amount of information is already available as a result of the Eastern Ontario Water Resources Management Study (EOWRMS). Municipality and county administrations within this region in partnership with the Government of Ontario sponsored the EOWRMS in recognition of the need to develop a regional water resources information system on a watershed basis. The EOWRMS and other similar studies in Ontario produce aquifer vulnerability maps that are used by municipal planners without the benefit of an estimate of the uncertainty associated with the information.

This poster describes three groundwater vulnerability models used in Ontario (DRASTIC; SAAT and ISI), highlighting the sources of uncertainty intrinsic to geographical data sources (sources of uncertainty). The poster describes the methodologies used to track the propagation of these uncertainties through each models (geographical application) and compares the final results (information products) to improve decision-making.

The first step is to identify the sources of uncertainty associated with the layers that are used in the vulnerability calculations. The principal components are uncertainty associated with measured point estimates (measurement error, associated with the process of abstraction or generalization about real world phenomena) and uncertainty resulting from the interpolation (interpolation error, from measuring the positions and attributes of geographical entities, or in sampling). These uncertainty components are combined to give uncertainty maps, expressed as variance, for each input parameter that enters in the vulnerability calculations. The next step is to propagate the uncertainty of the input parameters through the vulnerability calculations using the Error Propagation Theorem (used in standard statistical applications). The result is a map of uncertainty, expressed as variance, associated with the vulnerability map.

While an uncertainty map is certainly valuable information from a scientific standpoint, it is difficult to use for planning purposes. Consequently, the final step for the process consists of producing vulnerability maps that are classified and that are accompanied with a map showing areas where classifications could change as a result of uncertainty, for a given confidence level. From the planner's perspective, a decision can then be made to make further field measurements in areas of high uncertainty depending on the risk assessment.

A NETWORK APPROACH TO SOURCE WATER PROTECTION IN ONTARIO

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Abstract:

At the most basic level, "governance" refers to the means by which social coordination is pursued and collective action is achieved. Governance, a more encompassing notion than the term government, incorporates both governmental and non-governmental actors, and acknowledges the fuzzy boundary dividing the public and private sectors. Multiparty regulation, public-private partnerships and joint entrepreneurial ventures are some of the patterns of mutuality and interdependence between public and private organizations acting together as networks in specific policy areas.

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Governance can be particularly challenging in the case of the environmental policy field. Environmental issues are characterized by their complexity and uncertainty, by their ambiguity and by conflict. Despite these challenges, the approach to source water protection proposed by the Province of Ontario relies heavily on the capacity for inter-organizational collaboration of multiple watershed stakeholders, including the provincial and federal governments, municipalities, conservation authorities, agricultural groups and First Nations.

In this presentation, past and current events surrounding water quality issues in Ontario will be examined from the network perspective on governance. Special emphasis will be placed upon the role of institutional arrangements in facilitating or constraining collaborative management between agricultural and environmental networks. Insights provided by this analysis will be used to explore potential opportunities and threats posed by the source protection governance model advanced by Ontario's Drinking Water Protection Act.

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EXPLORING THE CHALLENGES OF SOURCE WATER PROTECTION IN AGRICULTURAL WATERSHEDS

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Management of fresh water resources poses governance challenges for rural areas in Ontario and throughout the world. Protecting the health of groundwater and aquatic ecosystems without compromising economic production and recreational demands requires integrated, collaborative approaches that recognize the interdependence of natural, political and socioeconomic systems, and emphasize stakeholder involvement in decision-making and implementation. The need for integration and collaboration is prominent in the watershed-based source protection program recently launched by the Province of Ontario, which involves regional multi-stakeholder source protection planning committees coordinating the development of source water protection plans for each of the province's watersheds.

The process of source water protection planning and implementation, therefore, will not occur in isolation of the particular interplay of ecological, social, economic and political relationships currently taking place in these watersheds. Furthermore, it can be argued that the success of the provincial source water protection program will depend, to a large extent, in its ability to accommodate and reflect the wide diversity of locally relevant perspectives, goals, values and policy styles of multiple watersheds' stakeholders. This is particularly important in agricultural watersheds, where ongoing efforts to reduce the environmental impacts of agriculture, while recognizing its production focus and its traditional role in the rural community, have long been a concern. This paper will provide an opportunity to discuss the main challenges for source water protection planning and implementation in agricultural watersheds, and to explore some potential strategies to address these challenges.

APPLICATION OF HYDROLOGICAL MODELING TECHNIQUE FOR ESTIMATION OF STREAMFLOW AND SEDIMENT YIELD

Gebremeskel, S., Rudra, R., Gharabaghi, B., Das, S., Singh, A., School of Engineering, University of Guelph,

Abstract:

Water quantity and quality issues have long been a serious concern in the Grand River basin. To address these kinds of issues a thorough up to date scientific investigation is necessary. The objective of this research is to apply and evaluate GIS based hydrological modeling for the assessment of streamflow and sediment yield in Grand River. The hydrological model applied for this purpose is the SWAT integrated with ArcView-GIS. The model is applied on a 53 Km² study area in the Grand River Valley in Ontario. Basin related parameters of the model are extracted from 10 m by 10 m digital elevation model (DEM), soil and land use map of the study area. The model is first calibrated from 1991 to 1995 on daily basis and validated for a period of 1996 to 2000 on daily basis. The evaluation results for both calibration and validation periods indicate that SWAT simulates both the streamflow and sediment yield very well.

Key words: Hydrological modeling, Sediment yield, SWAT, Grand River Valley.

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OCCURRENCE OF PHARMACEUTICAL PRODUCTS IN A MUNICIPAL EFFLUENT AND TOXICITY TO RAINBOW TROUT HEPATOCYTES.

Gagné, F., Blaise, C., André, C., St. Lawrence Centre, Environment Canada

Abstract:

Pharmaceutical and personal care products (PPCPs) are found in municipal effluents and represent the major source of such contamination for the aquatic environment. A preliminary chemical analysis of wastewater identified several compounds associated with PPCPs, including caffeine, ibuprofen, naproxen, oxytetracycline, novobiocin, carbamazepine, gemfibrozil, bezafibrate, trimethoprim, sulfamethoxazole and sulfapyridine. The purpose of this study was to examine the cytotoxic and oxidative effects of these products and other wastewater-related products (i.e. coprostanol, cotinine, estradiol-17 β , nonylphenol and cholesterol) in primary cultures of rainbow trout hepatocytes. The redox activity of various PPCPs in trout (*Oncorhynchus mykiss*) liver microsomes was investigated in vitro by following the rate of oxidation of NADPH and the formation of lipid peroxidation (LPO) after a 60-min incubation period. In addition, primary cultures of rainbow trout hepatocytes were exposed to various drugs identified in the municipal effluent for 48h at 15 $^{\circ}$ C. Our results show that most PPCPs (83%) accelerated the rate of NADPH oxidation in the presence of microsomes and 72% of them increased LPO in microsomal membranes. LPO levels was significantly correlated ($R = 0.5$; $p < 0.05$) with the number of functional groups on the molecule's backbone (i.e. number of O, S, N, P/number of C and H) and negatively so ($R = -0.44$; $p < 0.05$) with the octanol/water partition coefficient, suggesting that electrophilicity and hydrophobicity are related to oxidative activity for these compounds. Exposure of trout hepatocytes to these products leads in many cases to decreased cell viability, increased CYP3A-related monooxygenase activity (benzylether resorufin dealkylase), and LPO. No induction of CYP1A1-related activity (7-ethoxyresorufin O-deethylase) was observed. Moreover, municipal effluent extracts (ethanol) were able to increase all the above responses in a dose-dependent manner, suggesting the presence of drug-like effects in these complex mixtures. These results suggest that the basic redox properties of PPCPs could influence oxidative metabolism in liver cells and lead to oxidative damage. These products have the potential to produce a toxic response in aquatic organisms and the above biomarkers were shown to readily respond to PPCPs in aquatic organisms.

Key words: Pharmaceuticals, oxidative metabolism, lipid peroxidation, monooxygenase, benzylether resorufin dealkylase.

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ASSESSING THE EFFECTS OF PHARMACEUTICAL PRODUCTS TO AQUATIC ORGANISMS.

Gagné, F., Blaise, C. St-Lawrence Centre, Environment Canada

Abstract:

Pharmaceutical, personal care and veterinary products have been found in wastewaters and surface waters and are likely to contaminate the aquatic environment including groundwater. The purpose of this presentation was to examine current and new strategies to evaluate the toxicological effects of this special class of xenobiotics to aquatic species. At the present time, aquatic sentinel species that bioaccumulate some of these drugs are lacking but some studies with mussels and plants showed that significant accumulation in tissues is occurring with some antibiotics. Laboratory tests have been used with some success with many aquatic species ranging from bacteria, plants, invertebrates (molluscs and arthropods), and fish using single and mixture preparations of commonly found drugs. These toxicity tests generally indicate that acute lethal effects are not likely to happen in the environment but chronic or long-term effects cannot be excluded. In the attempt to measure the effects of pharmaceutical and personal care products, two types of biomarkers are proposed. The first class, defined as integrative biomarkers, consists in measuring ecologically relevant biomarkers that encompass the effects of drugs such as oxidative stress or DNA damage. The second class concerns those that measure the state or integrity of drug targets likely to impede and the organism's health and reproduction. Finally two case studies are presented to exemplify the use of biomarkers to assess the state of drug targets and tissue damage in aquatic species. In the first case study, primary cultures of rainbow trout hepatocytes were used to evaluate the cytotoxicity of carbamazepine (CBZ), a drug commonly found in municipal wastewaters at $\mu\text{g/L}$ range, after an exposure of 48 h at 18 $^{\circ}$ C. Results showed that CBZ induced the activity of cytochromes P4503A4 and 2B6 (benzyl ether resorufin as the substrate), known biotransformation enzyme for this drug class (iminostilbene), and was highly correlated with lipid peroxidation and cell viability at environmentally relevant concentrations. Lipid peroxidation and cell viability are considered as integrative biomarkers while cytochrome P4503A4/2B6 activity is a drug target-specific biomarker. The second case study concerns feral carp surviving for 4 years in one aerated lagoon that treats essentially a domestic

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municipal effluent. Results show that dibenzoyloxyfluorescein debenzoylase activity (another substrate specific towards cytochromes P450 3A4, 3A5 and 2C9), were readily induced in the post-mitochondrial supernatant of liver homogenates. ATP-dependant dopamine transport activity in synaptosome preparations of brain tissues was shown significantly reduced. Increased cytochrome P450-related activities and reduced dopamine uptake suggest the pharmacological effects of opiate-like substances. Preliminary findings suggest that some aquatic species could accumulate some drugs and these drugs are likely to produce effects at their designed biochemical targets and produce harmful effects. Further research studies are needed to validate these biomarkers and to relate changes in drug target integrity with the levels of drug residues in tissues.

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ENVIRONMENTAL CONTAMINANTS IN MUNICIPAL EFFLUENTS: FROM CONVENTIONAL CHEMICALS TO EMERGING SUBSTANCES

Gagnon, Christian, Centre Saint –Laurent, Environment Canada

Abstract:

Municipal effluents are, by volume, one of the largest sources of pollution of Canadian waters. The St. Lawrence River serves as both a receiving environment for wastewater effluents and a source of drinking water for many riverside municipalities. These effluents are the source of a variety of chemical contaminants. Metals and organic substances (such as PCBs, PAHs, and oils) are present in large quantities because most effluents in Canada are a combination of domestic and industrial wastewaters. Added to these conventional contaminants are a number of so-called emerging substances whose potential impacts on the receiving environment are poorly understood. A few years ago, researchers documented the occurrence and fate of the surfactant nonylphenols in municipal effluents and their receiving waters. Today, new emerging substances, in the form of pharmaceutical drugs like antibiotics, anti-inflammatory and anti-convulsive drugs, are being measured in these wastewaters. Some chemicals undergo major transformation at the treatment plant and again in the receiving waters, and thus their bioavailability and toxicity may be modified considerably. To better assess the impacts of all these contaminants on the environment and on human health, we need to understand the chemical and physical transformations occurring at the treatment plant and in the effluent receiving waters, and to quantify the contaminant loads being discharged.

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E. COLI FROM AGRICULTURAL LANDS; WHAT ARE WE MEASURING?

Gardner, Julie, Adrian Unc Dr., Springthorpe, Susan, University of Ottawa

Abstract:

Soils are complex ecosystems in which the biota is constantly in flux. Indicators of fecal contamination may be present naturally in soils as the result of defecation by resident fauna (e.g. rodents, cattle, etc.), or may be the result of prolonged survival from previous applications of organic fertilizers. Addition of organic residuals (manure and biosolids) to soils will, at least temporarily, augment the faecal bacteria. However, it will also add nutrients and possibly toxins that will favour some organisms and depress others, affecting the trophic interactions in soil, thus changing the structure and dynamics of microbial populations.

How do fecal bacterial indicators behave following land application of wastes? For example, will the E. coli present in the soil, which may not necessarily be cultivable, recover/grow on the addition of nutrients to give higher numbers of background organisms? Will the E. coli added in the wastes die off rapidly or survive for prolonged periods? Whether the numbers of faecal indicator bacteria detected in receiving waters following precipitation event-associated increases originate from the soil following nutrient augmentation, or directly as a result of the land-applied wastes is an important question that could affect how wastes are applied, and the mitigation measures taken to protect source waters. To address these questions, we will present data from a laboratory model using different soil layers to assess the kinetics of naturally-occurring soil E. coli after addition of treated municipal biosolids containing, or not, viable E. coli.

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SURFACE WATER PROTECTION PLANNING AND ADAPTIVE ENVIRONMENTAL MANAGEMENT – ESTABLISHING MANAGEMENT PRIORITIES USING THE ONTARIO PROVINCIAL WATER QUALITY MONITORING NETWORK DATABASE

Gorman, Barry E., Maunder, David E., Aquafor Beech Limited

Watershed studies and Adaptive Environmental Management (AEM) share many of the goals of Source Protection Planning. Adaptive Environmental Management is an iterative process of “learning by doing” whereby watershed management actions may be successfully implemented based on incomplete knowledge, provided that the consequences are closely monitored with a feedback mechanism that allows the action to be modified if predicted effects are not being realized. This feedback loop avoids “paralysis by analysis” – the rationalization that the lack of knowledge is a valid reason for inaction.

Long-term trends of surface water quality in AEM studies may be extracted from the Provincial Water Quality Monitoring Network (PWQMN), established by the Ontario Ministry of the Environment in the early 1960s. Sampling is intended to be random (in terms of weather conditions) and is generally conducted monthly.

Two examples of the application of PWQM data to watershed management are to be reviewed. As part of an AEM for the City of Mississauga, 30 years of PWQM data for the lower Credit River reveal a startling improvement of water quality following the federal restrictions on phosphate content in detergents in 1973. During a combined watershed and subwatershed study of the Carp River for the City of Ottawa, PWQM data (in conjunction with aquatic habitats and fluvial geomorphology) were used to assess spatial, temporal, seasonal, source-related and weather-related water quality trends in tributaries to the Carp River in order to establish management priorities to mitigate development impacts and to protect sensitive areas.

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UNCERTAINTY ANALYSIS OF DYNAMIC WELL HEAD PROTECTION

Graham, Douglas, Lønborg, Michael Juul, Madsen, Henrik

Abstract:

Well head protection areas (WHPAs) are a common planning tool for reducing the risk of contamination to drinking water supply wells. Typical WHPA delineation involves steady-state groundwater flow modeling with deterministic backward particle tracking. However, WHPAs based solely on steady-state groundwater models ignore or simplify processes outside of the saturated groundwater zone and neglect important dynamic and transient effects. In this paper, we present a comprehensive watershed-modelling tool MIKE SHE. MIKE SHE can treat many water management issues in an integrated fashion, at a wide range of spatial and temporal scales.

MIKE SHE is increasingly being used to determine more realistic WHPAs that take into consideration such factors as distributed seasonal variations in ET and net recharge, unsaturated zone storage and delayed recharge, dynamic surface water boundary conditions, high volume recharge during storms, variable pumping rates, and demand and land-use changes. Such models can be used for real-time, on-line management to ensure a safe and continuous water supply. MIKE SHE was recently used in Denmark to evaluate the uncertainty associated with WHPA delineation, which is ignored in traditional, deterministic WHPAs delineation. A sensitivity analysis was done to determine the 16 most sensitive parameters. Then, using MIKE SHE's automatic calibration and Monte Carlo utilities, nearly 1000 simulations were distributed across a local intranet to take advantage of idle computer resources at night. The results of this analysis were used to determine the areas that most likely contribute water to the wells and, thus, optimize planning restrictions for stakeholders.

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FIELD METHODS FOR THE ASSESSMENT OF WATER QUALITY – A CASE STUDY

Hall, Kevin, Cho-Chu, Michael, Centre for Water and the Environment, Queen's University

Abstract:

Field data is one of the most important pieces of information we can collect for a multitude of uses in investigating the health of a watershed. In order to ensure accurate complete data, a program must be carefully designed to capture both long term and short terms trends and fluctuations in desired parameters. This paper will discuss the application of statistical techniques and elemental project design for a field study of the Tay Watershed, located around Perth Ontario.

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The study was initiated as part of a larger study to develop and implement watershed management tools and models. The data collected will be used to:

- Support the calibration and verification of groundwater-surface water interaction models
- Determine the physical state of the Tay watershed
- Provide a basis for assessing collection, reduction and reporting techniques for watershed data management.

The paper will discuss the field program with particular emphasis on reliability of both the collection techniques and the data processing.

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ADVANCED AIRBORNE GEOPHYSICS FOR WATERSHED CHARACTERIZATION

Hodges, Greg, Brown, Bill, Fugro Airborne Surveys

Abstract:

Today's airborne geophysical systems have the ability to make accurate, high-resolution measurements of the ground conductivity in three dimensions to give hydrogeologists, scientists, and environmental engineers tools to map subsurface water resources. These geophysical data help develop a better understanding of surface and groundwater location and quality, contaminant flow and salt water encroachment. They contribute to improved watershed management practices, and aid efficient targeting of costly, high-resolution follow-up ground surveys and location of drilling sites.

Airborne survey systems can be used to rapidly characterize large watersheds. The benefits of airborne reconnaissance include minimal access issues and significant cost savings through fast data collection on large-scale surveys. In addition to the collection of electromagnetic data for ground conductivity measurement, magnetic and radiometric (gamma) are collected, as well as digital video, laser altitudes, and dual-frequency GPS.

Recent helicopter geophysical surveys will be highlighted. They include:

- Finding fresh water resources – examples from Michigan and Brazil, Asia and Africa
- Mapping the flow of contaminant plumes
- Mapping acid rock drainage
- Assessing groundwater resources and recharge areas
- Locating brine leaks from abandoned oil wells

Various types of data presentations and final products are used to integrate, present, and interpret these data. Two- and three-dimensional images of ground conductivity, and maps of magnetic anomalies and/or variations in natural radioisotope geochemistry are powerful aids to interpretation and aid in forming a comprehensive understanding of the soil characteristics, ground water location and flow, and bedrock structure and geology of an area - a vital part of any water exploration or land care management program.

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GOVERNANCE OF SOURCE WATER – A CONSERVATION ONTARIO PERSPECTIVE

Dick Hunter, Conservation Ontario

Abstract:

As a result of the incidents in Walkerton and the resulting initiatives of the Provincial Government, it is widely recognized that there is a need to protect drinking water, at its source, to ensure the protection of public health. Source protection prevents the entrance of contaminants into raw drinking water, recognizing that there is a direct link between protecting sources of water and protecting the health of watershed residents. Source protection is the first and most cost effective barrier, in a multi-barrier approach, to ensuring a sufficient supply of clean and safe drinking water.

Ontario's 36 Conservation Authorities will have a key role in coordinating the development of source protection plans across the province. Conservation Ontario is the non-governmental organization representing the collective interests of the Conservation Authorities. Conservation Ontario's role in source protection planning will be to support Conservation Authority initiatives and be the point of contact with the Province.

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This presentation outlines Conservation Ontario's perspective on why source protection is required and what needs to be done. The role of Conservation Ontario in source protection planning, the potential impact of source protection on the Ontario landscape, and key factors for success will also be addressed.

PHARMACEUTICALS IN THE ENVIRONMENT – ASSESSING HUMAN HEALTH RISK

Hussain, Moe, Director, Centre for Water and the Environment, Queen's University

Abstract:

Many pharmaceuticals are found in our environment. They enter the environment in various ways including wastewater and get into our drinking water because they are not fully removed either during wastewater treatment or during drinking water treatment. Before a pharmaceutical is approved by the Canadian or US government for human use, a data package has to be submitted by the proponent manufacturer to the government. This information is assessed and the pharmaceutical is either approved, not approved, or approved with restrictions for use. The data package is extensive as it consists of over 200 studies done by the proponent on the pharmaceutical. While these studies are used for assessing the safety and efficacy of the pharmaceutical for human use, many such studies can also be used to determine the fate and persistence of the pharmaceutical in the environment, possibility of bio-accumulating in fish or wildlife, and potential to have adverse impact on human health from consumption of drinking water or fish or wildlife, etc. In this presentation, those studies which can be used to assess potential human health risk will be explored.

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THE SOURCE WATER SUITABILITY INDEX; AN INDICATOR FOR SOURCE WATER QUALITY

Jiapizian, Paul, Environment Canada

Abstract:

Public health and water quality experts around the world agree that the multi-barrier approach (MBA) should be followed to ensure that drinking water is safe. The MBA consists of the management of the drinking water source, appropriate water treatment and management, and well-maintained and safe water distribution systems.

As the first barrier of the MBA, protection of the source water is critical. It is important to evaluate all activities that threaten the quality of the drinking water source. Source water protection extends beyond controlling individual sources of contamination to address problems and solutions on a regional or watershed basis. Many provincial and territorial jurisdictions, as well as local governments, are already managing water quality programs with a watershed approach. Currently, there does not exist a specific benchmark for measuring source water protection efforts and source water quality. The use of existing guidelines (Canadian Water Quality Guidelines for the Protection of Aquatic Life or the Guidelines for Canadian Drinking Water Quality) is not appropriate as a source water benchmark for various reasons.

Environment Canada along with the CCME Water Quality Taskgroup is currently considering a draft grading scheme for evaluation of source water protection activities and water quality. This grading scheme makes use of the formulation of the Canadian Water Quality Index to evaluate the source water quality and an additional grading component that evaluates the environmental protection measures in place in the watershed. The overall grade conveys the appropriateness of the given water source for use as drinking water given a specific level of treatment. It is displayed as a colour, making it very intuitive and easy to communicate to the public. The associated report would provide details on specific weaknesses or areas for improvement as well as pointing out what protection efforts are functioning well.

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IMPACTS OF WINTER ROAD SALTING ON MUNICIPAL GROUNDWATER SUPPLIES – EVALUATION TOOLS FOR SOURCE WATER PROTECTION PLANNING

Johnston1,C.T., Rudolph2,D.L., Bester3,M., Robinson4,J., Hodgins4,E.

Abstract:

The impact of road salting on the environment has been investigated by a number of Canadian and International agencies over the past decade. The Regional Municipality of Waterloo (RMOW), alerted by elevated chloride

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concentrations at some of their urban well fields in 1997, recognized that work was required to be done before a decision could be made regarding the long term management of key urban well fields within the RMOW.

A GIS based mass balance model was developed for the key well fields to provide an indication of future chloride concentrations under a variety of management scenarios. The model utilized particle tracking data from ground surface to the production wells developed from existing groundwater flow models to provide travel time estimates. This data was combined with detailed road salt application data, recharge rate estimates, and soil and groundwater chloride profiles to calibrate the loading source function for the mass balance model. Using an integrated mass balance model, chloride within the well field capture zones was allowed to travel to the well field, providing an estimate of chloride concentrations over time.

Following calibration to the observed historical chloride concentrations, the model was used to evaluate future chloride concentrations under a variety of management options, including the complete elimination of road salting within a variety of travel times around the well field. The results of the mass balance modeling were compared with detailed 3-D numerical solute transport modeling completed using the University of Waterloo flow model WATFLOW and the transport model WTC.

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LEACHEM MODEL STUDY IN THE TRANSPORT OF NITROGEN IN SOIL APPLIED WITH MUNICIPAL WASTEWATERS

Kunjikutty, Sobhalatha, Shiv O Prasher, Sobhalatha Kunjikutty

Abstract:

The leaching of NO₃-N from soil to groundwater can cause water pollution and is of major concern. The pollution of groundwater by nitrate nitrogen is usually high in the wastewater irrigated areas. The measurement of NO₃-N leaching through the soil requires much time and cost. Modeling could be used as an alternative to in-situ measurements. In this study the LEACHM model was used for NO₃-N simulation at different soil depths.

Secondarily treated wastewater was applied to field lysimeters filled with sand under three different flow rates of 10, 30, and 50 L d⁻¹. The experiment was conducted in an unsaturated constant flow condition in the summers of 2003 and 2004. The 2004 data set with highest flow rate (50 L d⁻¹) was used for the model calibration. The model validated with other five data sets (10 and 30 L d⁻¹ in 2004 and all the three flow rates in 2003). Rapid nitrification and the lack of a crop cover for

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A MUNICIPAL PERSPECTIVE ON DRINKING WATER SOURCE PROTECTION GOVERNANCE

Lloyd Lemon, M.Sc., P.Geo.

Abstract:

There is universal agreement that a formal process for providing Drinking Water Source Protection will help to ensure that sufficient clean, safe water is available for future generations. In concept, this is very simple – keep all potential threats away from the water sources and don't use more water than is available. On a local scale, this concept is common sense and has been applied for generations.

On a larger scale, the ability to achieve Drinking Water Source Protection is more challenging, particularly when trying to retrofit a process into an established, growing society. The first challenge is to establish what we need to, or want to, protect and why. The second challenge is to balance competing interests and affordability to achieve this protection.

A successful governance structure for Drinking Water Source Protection must establish clear roles for all levels of government and ultimately create Source Protection Plans that are fair and equitable to all parties who share resources. These roles may even change as the process advances.

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Municipalities play a leading role in providing drinking water to residents and therefore have a substantial stake in helping to guide the community to establish the level of protection that is desired, or sufficient, and can be afforded. This role must consider the balances and trade-offs necessary to ensure that economic health and growth targets can be accommodated while providing the necessary confidence that adequate supplies of safe drinking water will continue to be available.

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CASE HISTORY - SOURCE WATER THREATS TO THE ELGIN AREA SCHEME WATER SUPPLY IN SOUTHWESTERN ONTARIO

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Andrew J. Henry, Andrew J., P.Eng. City of London

Abstract:

Trace levels of polynuclear aromatic hydrocarbons (PAH) and elevated levels of mercury were unexpectedly found in water intake sediment samples during an investigation concerning sediment accumulation at the Elgin Area water treatment plant. Neither pollutant was detectable in raw or finished drinking water at the plant. The plant is located on Lake Erie about 1km east of Port Stanley, Ontario. Kettle Creek flows through Port Stanley and its outfall plume is known to drift over the water plant intake.

Through an extensive sampling program of sediments across the lakebed, the PAH contamination was traced back to Port Stanley harbour and lower Kettle Creek. Environment Canada has documented the presence of coal tar contamination in the harbour that may be the source of PAH. The coal tar may have come from an industrial enterprise at Port Stanley harbour that has long since left the harbour area.

The mercury concentration was found in samples from two intake sampling stations at twice the Provincial Sediment Quality Guidelines - Lowest Effect Level. This was a one-time occurrence and occurred when whole Zebra mussel bodies were present in the samples. The mercury may have originated from a harbour industry or Kettle Creek watershed activities and been concentrated from ambient water and suspended sediments by the filter feeding Zebra mussels.

This paper documents the discovery of the contamination and explores possible sources of the pollutants from a Lake Erie watershed as a source water threat to a major area scheme water supply serving a population greater than 100,000 in seven municipalities.

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PHARMACEUTICALS AND PERSONAL CARE PRODUCTS IN CANADIAN MUNICIPAL WASTEWATER

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Abstract:

Pharmaceuticals and personal care products (PPCPs) have been the center of environmental research in surface waters in North America and Europe. It has been postulated that the largest source of PPCP releases to the environment is effluent from municipal sewage treatment plants (STPs). There is concern that these compounds, many of which are designed to produce a biological impact, will have adverse effects on aquatic ecosystems; thus there is also concern that regulatory measures may be necessary to protect receiving waters and ultimately drinking water sources.

SOURCE WATER PROTECTION 2005 - ABSTRACTS

A collaborative research program has been established between Environment Canada and the Ontario Ministry of Environment to investigate various aspects of the occurrence and fate of PPCPs in municipal sewage, and effects in the aquatic receiving environment. Two initiatives under this research program included a one-time survey of 12 STPs along the Thames River and a 4-season survey of 6 STPs along the Grand River in southern Ontario. The objectives of these surveys were to expand our understanding of the sources and fate of PPCPs in municipal sewage under typical Canadian conditions. This presentation will provide an overview of some of the results of these two large surveys, including:

The range of selected PPCP concentrations encountered in influents from large and small communities. Seasonal fluctuations in loadings of PPCPs to treatment plants. Seasonal variations in effectiveness of removal of PPCPs from the liquid wastewater stream.

Preliminary observations on removal of PPCPs from the liquid wastewater stream as a function of treatment plant characteristics.

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ARE VETERINARY PHARMACEUTICALS FINDING THEIR WAY INTO ONTARIO WATERSHEDS? AN EXPOSURE ASSESSMENT OF PHARMACEUTICALS IN SURFACE WATERS WITHIN A MODEL WATERSHED IN ONTARIO.

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An exposure assessment for pharmaceuticals within a model watershed in Ontario characterized the spatio-temporal distribution of drugs in surface waters receiving predominately agricultural inputs. Samples taken at 2-week intervals from 7 sites were analyzed for a wide range of drugs and characterized for water quality parameters indicative of agricultural runoff. A broad range of pharmaceuticals was detected in the surface waters, the most pervasive of which include monensin, lincomycin, and carbamazepine. Residues were extracted from surface waters by solid phase extraction, followed by analysis using liquid chromatography/tandem mass spectrometry. The concentrations of drugs detected were generally in the low ng/litre range. Water quality parameters indicative of agricultural run off, such as total dissolved organic carbon, nitrate/nitrite and total phosphate, were also determined for all samples. Little correlation was seen between these parameters and the concentrations of animal production drugs detected in the surface water samples. Preliminary effects assessment for bacteria exposed to environmentally relevant concentrations of antibiotics were performed using the Microtox acute toxicity test and the surrogate bacterium, *Vibrio fischeri*. Results comparing toxicity of individual drugs, drug mixtures and surface water extracts, highlight the need to characterize the occurrence of chemical mixtures when performing exposure assessments and not just individual chemicals. Data from these studies will be used to characterize pharmaceutical exposures in the environment ultimately to be applied in a risk assessment framework.

AGRICULTURAL NON-POINT SOURCE POLLUTION: THE ROLE OF WATER PROBLEMS AND BEST MANAGEMENT PRACTICES FOR REDUCTION

Madramootoo, Chandra A. McGill University, Montreal

Abstract:

There is widespread recognition that intensive agricultural practices lead to excessive loadings of nutrients and bacteria in watercourses, rivers and lakes. Intensive cropping systems as well as very high animal densities in many regions of Canada are the primary causes of the high rates of sediment, N, P and bacteria encountered in agricultural runoff. This situation has led to the development and implementation of nutrient management plans in many Canadian provinces. Furthermore, there is now evidence that most soils, especially in eastern Canada, are either saturated or over-saturated in phosphorus. The result is that phosphorus is the limiting factor in several nutrient management plans. This presentation will explore the factors that contribute to the problems of agricultural non-point source pollution. The effects of climate and soils will be discussed. Data from various field sites that look at the climate-soil-fertilizer and manure application interactions will be presented. New studies are being conducted by the Brace Centre that examines the role of agricultural water management systems on source water protection. Best management practices that include water table management and improved drainage will be discussed. Finally, the paper will introduce some new tools aimed at assessing P loads in agricultural watersheds, and the use of these tools to select best management practices.

DEVELOPING SOURCE WATER PROTECTION STRATEGIES IN SW ONTARIO AND A TRCA WATERSHED AREA

Marsden, Catherine F. M.Sc., Dillon Consulting Limited

SOURCE WATER PROTECTION 2005 - ABSTRACTS

Abstract:

Dillon Consulting Limited in association with Golder Associates completed three regional groundwater studies in Southwestern Ontario. Dillon is also currently working with the Toronto and Region Conservation Authority (TRCA) on the development of a Drinking Water Source Protection Plan for two watersheds in Durham Region. For the SW Ontario studies, the initial focus was on characterization of regional groundwater resources and aquifer vulnerability mapping. The final step was development of Groundwater Protection Strategies. The intent was to define regulatory measures, non-regulatory programs and best management practices for source water protection, and to provide direction for land use planning. The Groundwater Protection Strategies were developed, with stakeholders, within the context of the existing

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INTEGRATED WATER AND WATERSHED SCIENCES FOR SUSTAINABLE CLEAN AND HEALTHY WATER AND COMMUNITIES

Mazumder, Asit Water and Watershed Research Program, University of Victoria, Victoria, BC, Canada.

Abstract:

As we entered the 21st century, the ability of global communities to support healthy ecosystems for healthy drinking water is seriously threatened. Globally, waterborne diseases caused by pathogens and contaminants are a major killer. The ecosystems and watersheds used as source for drinking water are facing a variety of stresses, including withdrawals, inputs, and changes in land use, all driven by conflicting policy and stakeholder interests. Ecosystems and watersheds integrate natural processes and anthropogenic impacts that together determine water quality. Change in excess of what can be accommodated by natural processes lead to ecosystem deterioration, poor water quality, and negative impacts on human health. Drinking water quality in most communities is managed through the construction and operation of expensive water treatment facilities. The quality of drinking water and human health can also be sustained and improved by protecting, managing and regulating land use and activities in source water ecosystems. This presentation will address the challenges and approaches to integrating natural, engineering, social and health sciences into robust water and watershed protection and management strategies for sustainable clean and healthy water and communities.

SOURCE WATER PROTECTION POLICY AND SCIENCE IN BRITISH COLUMBIA

Meays, C. R. N. Nordin, K. Broersma¹, M. Samadpour² and A. Mazumder. Water and Watershed Research Program, University of Victoria, Victoria, BC V8W 3N5, Canada. ¹Agriculture and Agrifood Canada, Kamloops BC, ²Institute of Environmental Health, Seattle WA.

Abstract:

BC has a recent history of contamination of source water. Rates of waterborne illness are higher than other parts of Canada and a series of reports have warned of a high risk of a major public health problems. *Cryptosporidium* outbreaks in Cranbrook and Kelowna in the 1990's caused illness in more than 10,000 people. Recent provision of Drinking Water Protection Act provides a framework for considerable improvement, however there is still a need to identify and agree on a set of principles to guide water protection policy as well as priorities and direction for government agencies. We suggest that policy formation should be guided by the use of scientific knowledge and technologies.

The resolution of watershed conflicts and the adoption of better management practices and policies require solid scientific data on the sources of fecal contamination and pathogens. As an example, Bacterial Source Tracking (BST) is a scientific advance that could be used as a tool for prioritizing and managing watersheds. Most drinking water source watersheds have multiple uses and many issues arise from the conflicts of uses and the lack of a clear means of identifying the sources of bacterial contamination (human, wildlife or cattle).. The use of BST in BC is seen as a way that science might link directly to improvement of practices and creation of good public policy related to source water protection.

SOURCE WATER PROTECTION: THE LOCAL APPROACH

Meek, J.W. Raisin Region Conservation Authority, Cornwall, Ontario, Carruthers-Coleman, A. South Nation Conservation, Berwick, Ontario

Abstract:

SOURCE WATER PROTECTION 2005 - ABSTRACTS

The Raisin Region Conservation Authority (RRCA) and South Nation Conservation (SNC) have developed a partnership to prepare for Source Water Protection (SWP) in eastern Ontario. The RRCA and SNC have a long history of collaboration on watershed management projects ranging from forestry to fish habitat to groundwater protection. Both Conservation Authorities will build on this collaboration through a coordinated approach to SWP in our watershed region. Together, the RRCA and SNC will share expertise and resources to coordinate the development of source water protection plans which will assist in protecting our valuable drinking water resources. This presentation will provide an overview of how the RRCA and SNC are working together to prepare for source water protection. The role of the Conservation Authorities will be explained within the context of eastern Ontario municipalities and stakeholders.

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WATERSHED CHARACTERIZATION IN EASTERN ONTARIO: OVERVIEW OF INFORMATION REQUIREMENTS

Meek, John, Raisin Region Conservation Authority, Cornwall, Ontario, DiIorio, T.A. South Nation Conservation, Berwick, Ontario, Alamgir, S. Raisin Region Conservation Authority, Cornwall, Ontario

Abstract:

Watershed characterization is a key component of developing source water protection plans. It involves describing the characteristics of the watershed(s), identifying water resource issues related to quantity and quality, identifying threats and vulnerable areas. In Eastern Ontario several studies have been undertaken that will provide information to the watershed characterization activities for SWP. This presentation will outline the key components for watershed characterization and the current status of information in the South Nation and Raisin Region watersheds.

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REGIONAL SCALE ASSESSMENT OF INHERENT NUTRIENT CAPACITY ON AGRICULTURAL EXPANSION AND/OR INTENSIFICATION

Mercier, Pierre, Stantec Consulting Ltd..
Jarvis, Ian, Agriculture Canada,
McTavish, Gary, Ontario Ministry of Agriculture and Food and

Abstract:

With present environmental challenges and growing population pressures, water quality and quantity concerns have become key planning issues for the rural residents and their municipalities in Eastern Ontario. Tied to these concerns are the local society's increased demands for more environmental responsibility on behalf of the farm community. This trend is cast within the current reality of the rural area where demand for agricultural production will continue to increase while the area available for agricultural intensification and/or expansion is decreasing. The project develops an integrated assessment of inherent nutrient capacity and nutrient balance with an assessment of the impacts of current land use policy on the distribution of agriculture. The final analysis provides a comprehensive, regional scale policy and bio-physical overview of the potential and relative risk of livestock intensification in the United Counties of Prescott and Russell.

This research was conducted under partnership between the Ontario Federation of Agriculture (Prescott and Russell), The Ontario Ministry of Agriculture, Food and Rural Affairs, The United Counties of Prescott and Russell and the scientific lead of Agriculture and Agri-Food Canada.

Mr. Pierre Mercier
Stantec Consulting Ltd..

THE ROLE OF THE FEDERAL GOVERNMENT IN ONTARIO'S SOURCE PROTECTION PLANNING INITIATIVES

Merriman, John, Environment Canada

SOURCE WATER PROTECTION 2005 - ABSTRACTS

Abstract:

Division of responsibilities for water is complex and often shared. Although the Drinking Water Protection Act, 2002 is an initiative of Ontario's Provincial Government, the legislation has implications at the federal government level.

Under The Constitution Act , the provinces have the primary responsibility for the management of water resources, which includes both surface and groundwater, and are generally responsible for ensuring potable community water supplies. Federal responsibilities are in areas that have the potential for significant national economic impact such as navigation and fisheries, international and interprovincial carriers, federal lands and installations, and First Nations. The federal government also has responsibility for boundary and transboundary waters. Shared federal-provincial responsibilities include interprovincial water issues; agriculture; significant national water issues; and health.

The Federal Water Policy is a statement of the federal government's philosophy and goals for the nation's freshwater resources and of the proposed ways of achieving them. The federal government has expressed its commitment to ensuring safe drinking water within areas under its jurisdiction and to promoting and encouraging a consistent approach to protection and improvement of the nation's drinking water by provinces, territories and local governments.

The Canadian Council of Ministers of the Environment (CCME) Source to Tap document contains an outline for developing a Source Water Protection Plan. The CCME has stated that "To be effective, the multi-barrier approach requires commitment and co-operation from everyone involved. This includes elected officials and government employees, members of the water industry and the public. Governments work together, and with other partners, to protect our water resources by encouraging best management practices and making appropriate policies, regulations or laws. Through CCME, governments have committed to working together on research, monitoring and guidelines and best management practices."

The question remains... just how will this be achieved on the landscape. We will hear from a representative of Environment Canada's Ecosystem Health -Ontario Region office in Burlington

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GROUNDWATER RECHARGE IN THE GNEISSIC TERRAIN UNDERLYING THE CENTRAL PART OF THE TAY RIVER WATERSHED

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Abstract:

Groundwater recharge in fractured bedrock environments is widely recognised to be strongly localised and heterogeneous. To date, however, there are virtually no studies reported in the literature on surface water/groundwater interactions in fractured bedrock aquifers and there is little information on what a reasonable and defensible value of the recharge parameter might be. In order to manage groundwater abstraction and determine regional groundwater flow, broad estimates based on very little science are currently used. Thus, the objective of the study described in the present paper is to directly measure and model infiltrating precipitation in a discretely fractured bedrock aquifer at the local scale. By scaling up, the results of the study will provide water managers with a reliable estimate of the volume of water likely to recharge bedrock aquifers on a regional basis.

To conduct the study, a test site has been developed in a small (12 hectare) hay field, adjacent to the Tay River near Perth, Ontario. Typical bedrock of the Frontenac Terrain is exposed in several gneissic outcrops evenly distributed throughout the site. One to two meters of overburden blanket the remainder of the site and the site conditions are similar to other fields in the surrounding environs. In order to study infiltration and groundwater recharge in this setting, direct response of the groundwater flow system to precipitation events is measured. To characterise the fracture network, four, 30-m boreholes were drilled and then hydraulically tested using a straddle packer system having a 2-3 m packer spacing. Following the testing, each borehole will be completed with a multi-level monitoring system. To date two of the boreholes have been completed. To measure changes in hydraulic head, each multi-level zone is instrumented with a pressure logging transducer recording every 15 minutes. During the winter of 2005, background measurements were obtained from three zones on a continuing basis. During the approaching field season, continuous measurement will be obtained in six intervals simultaneously. Various combinations of the discrete fracture zones will be monitored for temporal and quantitative response to major precipitation events. These responses will be correlated to real precipitation data for the local sub-watershed. A tipping bucket rain gauge and a dedicated weather station will monitor daily weather parameters over the field site.

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Results obtained to date show that the upper 30 m of bedrock is dominated by no more than 2 to 3 major fracture features. Response to precipitation appears to be rapid and of significant magnitude. To estimate the actual volume of recharge, the response in hydraulic head to rainfall will be calibrated using the finite-element model HydroSphere.

NOVEL WATER QUALITY MONITORING TECHNOLOGY USING LASER FLUORESCENCE

Moskoff, Harry, Ewatertek Inc.

Abstract:

I describe the processes used at eWaterTek to deliver our radical new technology to the marketplace using the XP (Extreme Processing) method, otherwise known as Radical Application Development. Although the product is based on current technologies, it represents a novel use of these technologies. I have devoted several years to developing detailed plans, applying for patents worldwide, and am in the midst of designing the just-in-time technologies that would use the new convergence of computing and communications. EWaterTek is in the early stages of company development for the Southern Ontario region. This state-of-the-art technology could quickly make it the industry leader in this field. We recognize that the product falls into a niche between two well-established industries: domestic drinking water filter systems and the residential alarm and security business. As such, the high end of the market provides the opportunity to create zero maintenance optional components for both of these industry channels to market to new water industry contractors and residential security installation companies. Note that the government-sponsored Walkerton Inquiry here in Ontario has expressed keen interest in any new sensory technology applications that will reduce hazardous contaminants and provide an early-warning mechanism. This is precisely the market that has been identified here.

For each stage the requirements have been gathered and analyzed, specifications produced, components designed and researched. Also by keeping the whole system in mind when designing each stage we were able to avoid backtracking if a deliverable was deemed unacceptable and needed redesign. This approach also serves to mitigate risk as at each stage we have a functional (stand-alone) system. My company will give the consumer the ultimate control over their home drinking water safety. One would be able to choose what they want monitored, set monitoring levels, determine when they want their water monitored, and finally to obtain all relevant results of analysis over the website within minutes. The near future will see the development, deployment and testing of a prototype system (including a section that deals with new applications for chromatography and UV. eWaterTek is an American Water Works Association (AWWA) member with plans to contribute in the upcoming Water Tech Conference in Seattle later this year.

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TEHRAN AQUIFER VULNERABILITY ASSESSMENT USING ARCGIS AND DRASTIC INDEX

Niknam, Ramin, Tarbiat Modarres University, Dayyanidardashti, Shadi, McGill University, Kourosh Mohammadi, Tarbiat Modarres University

Abstract:

Groundwater is the main source of water in arid and semi-arid regions. Therefore, pollution of groundwater is a major issue because aquifers and the contained ground water are inherently susceptible to contamination from land use and anthropogenic impacts. In recognition of the need for effective and efficient methods for protecting groundwater resources from future contamination, scientists and resource managers have sought to develop aquifer vulnerability assessment techniques for predicting which areas are more likely than others to become contaminated as a result of activities at or near the land surface. This research is focused on the evaluation of Tehran groundwater vulnerability to pollution. Among several assessment methods, DRASTIC has been selected for this study. Tehran aquifer is nearly covered by Tehran city the Capital and largest city of Iran. Almost fifty percent of city drinking water is supplied from groundwater. Therefore, vulnerability assessment of the aquifer to domestic pollution is important for protecting the water quality and sustainability. ArcGIS has been used to overlay and calculate different layers and obtain the vulnerability map. In addition, groundwater balance has been evaluated in order to obtain the net recharge parameter in DRASTIC index. About 50 percent of the aquifer has been classified as moderate and almost 20 percent has very low and low vulnerability potential to pollutions.

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SOURCE WATER PROTECTION 2005 - ABSTRACTS

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FATE AND TRANSPORT OF THREE HERBICIDES IN AGRICULTURAL SOIL IRRIGATED WITH MUNICIPAL WASTEWATER

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Abstract:

In many countries all around the world, municipal sewage and industrial wastewaters are typically treated or sometimes only partially treated prior to their discharge into surface water bodies. A major anionic surfactant, Linear Alkyl benzene Sulfonate (LAS) and degraded product of non-ionic surfactant Nonylphenol (NP) are frequently found in municipal wastewaters. When wastewater containing surfactants and their degraded products is used for irrigation, it can affect the sorption/desorption and movement of pesticides in soils. Therefore, a lysimeter study was conducted to assess the effect of LAS and NP on the movement of three agricultural herbicides through a sandy loam soil. Nine lysimeters, irrigated with water containing LAS and NP concentrations, similar to those commonly found in municipal wastewater, were used to evaluate the fate and transport of three common herbicides, atrazine, metolachlor and metribuzin. The degradation of three herbicides was studied over a ninety-day period. Herbicides were found to be degraded faster in lysimeters within the top 20 cm soil profile. The results indicate that irrigation water with a concentration of 12 mg L^{-1} of LAS and NP had almost no effect on the leaching of atrazine, metolachlor, and metribuzine. The concentrations of less than $0.02 \text{ } \mu\text{g L}^{-1}$ were found in water samples taken 90 cm below the soil surface. To confirm these results, a laboratory experiment was undertaken to estimate the adsorption coefficients (k_d) of the three herbicides with water containing the same concentration of LAS and NP. No significant difference on k_d was observed in this sorption experiment. Hence, these results would eliminate the concerns regarding pesticide leaching brought on by LAS and NP in wastewaters for irrigation, which is becoming more important due to increasing water scarcity in the dry regions of the world.

BIOSOLIDS AND VERTICAL TRANSFER OF MICROBES THROUGH SOILS; EXPERIMENTAL RESULT

Passmore, Joanna, Unc, Adrian, Gross, Michael J., Springthorpe, Susan V., Sattar, Syed, A.

Abstract:

Vertical transfer of micro-organisms from land applied organic fertilisers can impact the quality of groundwater or affect surface waters through tile drainage discharges. Conventional belief considers the soil as a protective layer that retains most of the surface applied microbial contaminants and thus limits the risk for contamination of groundwater resources. However, not all soils are equal. Transport capability and transport patterns vary among soil types and this may lead to variable degrees of groundwater contamination risk. Soil transport properties of microbial particles also differ from those of soluble chemical contaminants (e.g. nitrate).

We tested the risk for vertical transport of microbial particles on three distinct soil types. The soils were collected in undisturbed lysimeters and tested in the laboratory under controlled conditions. Liquid and dewatered municipal sludge biosolids were applied to their surface followed by repeated rain simulations. The drainage was analysed for its volume, cross-sectional distribution across the soil profile, concentration of several naturally occurring biosolids microorganisms (bacteria and phages), and added tracers (bacterial spores and artificial microspheres). Results show differences in transport properties among soils and indicate the need for soil-type associated management practices and the need for the regulations that acknowledge differences in transport properties among soils and types of contaminant.

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MERCURY CONCENTRATIONS AND DEPOSITION AT TWO SITES ALONG THE ST. LAWRENCE RIVER.

Poissant*, Laurier, Conrad Beauvais and Martin Pilote

SOURCE WATER PROTECTION 2005 - ABSTRACTS

Abstract:

The first objective of this study is to measure the mercury concentration in precipitation at two sites along the St. Lawrence River. The second objective is to estimate the spatial-temporal evolution of mercury concentration and deposition in precipitation along the St. Lawrence River. These objectives are conducted within the Mercury Deposition Network (MDN).

Mercury concentrations in precipitation are taken at two sites along St. Lawrence River, respectively at St. Anicet and Mingan. These two sites represent the southern and northern part of St. Lawrence River. The mercury concentrations in the precipitation at the both sites showed an important spatial and temporal variation along the St. Lawrence River. The concentrations are higher at St. Anicet. The urban and industrial air stream, normally with higher mercury concentration, can affect the mercury concentration in precipitation. However, the spatial variations of mercury deposition are less important between the two sites due to the high precipitation records in Mingan.

This paper will be presented as Poster.

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THE ROLE FOR ECONOMIC ANALYSIS IN DRINKING WATER SOURCE PROTECTION. THE MISSING LINK?

Renzetti, Steven Department of Economics, Brock University, St. Catharines, Ontario

Abstract:

The presentation will examine the opportunities and challenges for applying economic valuation methods to support DWSP decision-making. To date, much of the discussion surrounding DWSP has been concerned with developing the scientific understanding of the linkages between land use practices, water quality and human health. Calls for restrictions upon land use practices in order to promote human health, however, are hindered because of the absence of a way of comparing the costs of the former with the benefits of the latter. Economic analysis, on the other hand, provides a framework within which decisions regarding drinking water source protection can be made. The principle advantage of this approach is that many aspects of DWSP such as the costs of altering land-use practices and the benefits from reduced water treatment requirements and enhanced health outcomes can be valued and employed to support rational DWSP decision-making. In particular, the presentation points out that recent advances allow economists to link the outputs of scientific models of ecosystem and human health with valuation techniques in order to assess the social significance of changes to ecosystem functioning and water quality.

SOURCE WATER QUALITY ISSUES IN LAKE ST. LAWRENCE.

Ridal¹, Jeff, Susan Watson² and Brian Hickey¹.

¹ St. Lawrence River Institute of Environmental Sciences, Cornwall, ON, ² Environment Canada, Burlington, ON and University of Calgary, Calgary, AB

Abstract:

The upper St. Lawrence River is generally considered a very high quality source of drinking water, with low turbidity and high clarity, low nutrient levels, and moderate alkalinity and hardness. However, like all surface waters, multiple inputs can influence and degrade source water quality. We investigated two issues of particular interest for the City of Cornwall Water Purification Plant (CWPP), local sources of taste and odour compounds, and bacteria and other contaminants from high densities of bird populations. The source water for the CWPP is Lake St. Lawrence, a relatively deep (up to 35 m) fluvial lake formed by the Moses-Saunders Hydroelectric Generating Stations. The intake for the CWPP is situated on the reservoir wall at approximately 17 m depth. Chemical and hydrological data collected suggest that the source water for the CWPP is influenced by a slow moving counter clockwise eddy formed as a result of the horseshow geometry of the reservoir and the strong currents in the main channel. High concentrations of MIB and geosmin in epiphytes indicate that dense beds of macrophytes in Lake St. Lawrence are local sources of taste and odour compounds, contributing to the background levels from upstream sources. While *E.coli* levels generally met provincial water quality objectives, levels were statistically higher within

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the gyre near the reservoir than in the main channel and upstream sampling stations. Dense colonies of waterfowl inhabiting Strachan Island, located at the upstream end of the gyre, are likely important sources of coliform bacteria to the surrounding waters. Continued investigation of the influence of bird colonies from Strachan Island on CWPP source water quality as well further characterization of the hydrology in the vicinity of the water intake is recommended.

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"SMART DISPOSAL": PROVINCE-WIDE AND SUSTAINABLE OPTIONS FOR THE SAFE AND RESPONSIBLE DISPOSAL OF ON-FARM GENERATED MEDICAL WASTE.

Richardson, Craig, Animal Care Specialist, Ontario Ministry of Agriculture and Food.

Abstract:

The Environmental Farm Plan advocates safe and responsible disposal of on-farm generated medical wastes. The Ontario Livestock Medicines Education program also supports this practice. Both programs advise following local municipal by-laws regarding disposal of medical wastes as hazardous waste. However, few municipalities in Ontario have hazardous waste facilities at their landfills. In addition, landfills in this province operate differently regarding these hazards - some accepting all types of this waste, some taking all waste except 'sharps' (such as needles and scalpel blades) and some rejecting all of it. This situation results in farmers coping with their medical wastes in many different ways across Ontario. Some on-farm and off-site disposal choices have put these wastes into situations where they can threaten both public and ecosystem health. In July of 2000, the Ontario Ministry of Agriculture and Food launched the pilot program *Bring It Back!* in 5 licensed livestock medicine retail locations in Eastern Ontario. Producers were given the opportunity to safely dispose of unwanted livestock medicines and sharps. Anticipating the discontinuation of the pilot project, a list of options was developed in consultation with commodity associations in 2004. The concept of 'central depots' and partnering with a regular rural private drinking water testing program is a preferred choice. This presentation will describe the history of the *Bring It Back!* pilot, lessons learned, and the options; options that are designed to lead to a province-wide and sustainable disposal of on-farm generated medical waste to prevent source water contamination by animal health products.

ESSENTIAL INGREDIENTS FOR SOURCE WATER PROTECTION MODELS

Rudra, Ramesh & Dickinson, Trevor School of Engineering, University of Guelph

Abstract:

It is vital that models selected for use for resolving Source Water Protection issues include hydrologic concepts that are key to this area of water management. For rural conditions in Ontario, it is essential that model concepts generate surface runoff, groundwater recharge and tile outflow correctly in both time and space. With reference to hydrologic data bases and example model outputs, this paper presents seasonal and spatial patterns of runoff and suspended sediment yield fundamental to Ontario watersheds. Implications of these patterns for Source Water Protection are discussed.

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EFFECT OF SUGARCANE DISTILLERY SPENTWASH ON GROUNDWATER IN LALGUDI BLOCK, INDIA

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ABSTRACT

In India, there are about 579 sugar mills and 285 distilleries producing sugar, alcohol, by products, and other waster materials. In the distillery industry, for every liter of alcohol produced, about 15 litres of distillery spentwash (distillery effluent) is released as waste water. Approximately 40 million m³ of distillery effluent is discharged annually from the 285 distilleries. The disposal of wastes from industrial source is becoming a serious problem for the agro-eco system.

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The distillery effluent is acidic in nature; dark brown in color with pH 4.4 and contains high level of organic carbon. Being plant originated, the distillery effluent contains considerable amount of plant nutrients. Since it is basically an agricultural waste containing huge amount of essential ingredients like organic carbon, K, Ca, Mg, and S and moderate levels of N and P and traces of micronutrients, it is used by the farmers on their fields in India. It reduces the use of chemical fertilizers and it does not contain any hazardous materials detrimental to soil health and plant growth. However, the BOD and COD are in the order of 5000 and 40,000 mg/l which are above the permissible limits of pollution control standards. The high amount of BOD and COD of distillery effluent cause pollution problems when disposed in land and water immediately.

An investigation was carried out to find out the interaction of various ionic contents of the effluent with ground water so that the impact of spentwash on the water quality could be assessed. Twenty five wells located on the northern direction of River Coleroon, a tributary of River Cauvery, in Lalgudi block of Tamilnadu (where a sugar mill is functioning) were studied. The general topography is sloping towards Coleroon river. The identified wells were grouped into five categories based on the direction and distance towards the river. These wells are identified in the sites where distillery effluent was already applied by the farmers for agricultural fields. The water samples were analysed for the determination of pH, EC as well as the ionic composition namely CO₃, HCO₃, Cl, SO₄, Ca, Mg, Na and K. The results revealed that the pH of water samples ranged from 7.8 to 8.79 and EC between 0.69 to 5.55 dSm⁻¹, which clearly indicated the wide variations in the quality of groundwater due to the application of distillery effluent on fields. However, these values are within the range of Guidelines for interpretation of water quality for irrigation prescribed by FAO (1976). Sodidity hazard is observed from the increase in Sodium Adsorption Ratio and Soluble Sodium Percentage values in some of the water samples. The possible reasons for these due to antecedent soil problems are under investigation.

THE NIAGARA WATER QUALITY PROTECTION STRATEGY: SETTING THE STAGE FOR IMPLEMENTING WATERSHED-BASED SOURCE PROTECTION PLANS

Scheckenberger, Ron, and Agnew, Paige Philips Engineering Ltd

Abstract:

Conservation Authorities and Municipalities have been entrusted with a daunting task. On November 17, 2004 the Provincial government announced a commitment of \$12.5 million dollars to enable Conservation Authorities across the province to secure staff, conduct water budgets and other technical studies to begin the cursory phases of Source Protection Planning.

Watershed-level Source Protection Planning will require inter-agency, cross-jurisdictional collaboration and public participation; which if managed ineffectively can become an entangled bureaucratic mire of inefficiency. Past models of water resource governance have largely embraced 'stovepipe' philosophies of management, unable to provide the flexibility, adaptability and level of collaboration required for watershed-level Source Protection Planning.

In 2002, the Regional Municipality of Niagara, Niagara Peninsula Conservation Authority (NPCA) and the Ontario Ministry of Environment (MOE) undertook a collaborative, consultative process to develop an integrated approach to the management of Niagara's water resources-The Niagara Water Quality Protection Strategy (NWQPS). The NWQPS was prepared in concurrence with the O'Connor Commission Report recommendations and provides a fresh approach to watershed-level water resource governance. The NQWPS will serve as a case study in a broader discussion of the management challenges faced by municipalities and Conservation Authorities in governing the development of Source Protection Plans, with an emphasis on the vision, goals, key issues and challenges faced during its development.

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RIPARIAN WETLANDS FOR SOURCE WATER PROTECTION

Singh, Amanjot, Rudra, Ramesh, Yang, Wanhong, University of Guelph

Abstract:

Southern Ontario lost about 65% of its wetlands in past two centuries after draining land to bringing more area under agriculture and other land uses. Presently, the fast growing Southern Ontario is resulting in more urbanization and intensive agriculture to cater expanding population. Stress on land, disposal of effluents and use of agrochemicals is increasing concerns on deteriorating water flowing through creeks which ultimately drain in to the Grate Lakes. The changed practices affected in two ways, one the natural filtration system provided by the wetlands got destroyed, and second, drained water reached the creeks containing entire containment load with it. Realizing the loss due to draining of wetlands, Ontario Government has come up with a policy to conserve the un-drained wetlands and is also reviewing construction of new wetlands for natural cleaning of water. The present study was initiated to model and assess the role of riparian type wetlands, which are most common type of wetlands in southern Ontario, in sequestering runoff and sediments for their possibility to be considered as best management practice for source water protection. The results reveal that upto 45% of runoff and 90% sediments sequestration could be achieved with the introduction of riparian wetlands along the creeks.

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MICROBIAL INDICATORS OF WATER QUALITY – WHAT ARE WE MEASURING?

Springthorpe, V. Susan, University of Ottawa

Abstract:

Escherichia coli numbers in watersheds can be governed by a wide range of factors that influence water quality. Interpreting data and accounting for its fluctuations can be difficult, and is usually approached with only simplistic explanations that ignore the many variables in play. This may be especially true in larger streams and rivers where upstream land use may be more influential than in the immediate local area. E. coli is primarily used as an indicator of human health risk. Can it also be used to understand something about the water quality from an environmental standpoint? This presentation will discuss the many ways in which E. coli numbers can be influenced by the water matrix and particular local and upstream conditions as well as the climatic events that may bring increased turbidity and nutrients, including conditions that modulate natural predation. How these issues may affect water quality at beaches as well as the implications for source water protection will also be discussed.

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A METHOD FOR TESTING SURFACE SEALS OF DOMESTIC WELLS USING INFILTROMETRY

St-Germain, Pascale, Robin, Michel J.L., University of Ottawa

Abstract:

Faulty well seals and improper well abandonment are believed to be a threat to groundwater because they offer direct pathways for surface contaminants, particularly pathogens, to enter the groundwater system. Few methods exist for determining the integrity of well seals, and all are difficult to apply safely for domestic wells or are simply impractical. The objective of this study is to develop and validate a simple and inexpensive methodology that can evaluate the seal integrity of private water wells at ground surface. This paper presents encouraging preliminary results at 4 private wells in Québec.

The hypothesis of this study is that a faulty seal could be detected by statistically comparing the vertical hydraulic conductivity (K) at the well to the K in the vicinity. A series of steady-state, single-ring infiltrometry measurements were carried out and the resulting K contrasts were used to infer possibly faulty seals. In all wells suspected of having a faulty seal, K values at the well were higher by a factor of four; in contrast, wells known to be properly sealed showed K values that were lower than the surroundings and in one case showed no measurable infiltration at all. Attempts were made to confirm leaks in the leaky wells with distilled water as a tracer. The results were inconclusive because of technical difficulties. This methodology appears promising for detecting faulty seals at ground surface but it needs to be corroborated with additional tracer experiments.

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SOURCE WATER PROTECTION – A CASE STUDY OF POOR WELL CONSTRUCTION

John St. Marseille, M.Sc., P.Eng, P.Geo. Senior Environmental Engineer and Hydrogeologist, The Thompson Rosemount Group Inc.

Abstract:

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The Thompson Rosemount Group Inc. (TRG) was retained to provide hydrogeological expertise regarding groundwater contamination following a fire at a residence in a rural area. The contamination ingresses the local bedrock contact-zone supply aquifer (about 20m deep) via an uncapped supply well (which was level with the floor) in the basement of the residence.

The resulting contamination affected about 20 wells within a 300 m radius of the residence. Water supplies were contaminated with firefighting foam (glycol, nutrients, surfactant), combustion by-products (aliphatic and aromatic hydrocarbons), and other organic compounds possibly associated with various plastics, solvents, paints, and fuel products present in the home. Well water usage was restricted for several weeks while remedial efforts and comprehensive testing occurred.

The groundwater remediation required purging some 5,000 m³ of groundwater from strategically located wells. A purge well and several nested monitoring wells were also drilled on the site. The contaminated groundwater was pumped on a 24/7 basis into tankers for off-site treatment. Groundwater flushing, using municipal supply water, was also used to remediate the aquifer. Monitoring continues.

This presentation describes the problem, the remedial strategy, and lessons learned from a source water protection perspective.

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STRATEGIC ISSUES IN WATERSHED SOURCE PROTECTION PLANNING

Stiebel, William M.Sc, Wilson, David, CD, M.A.Sc., Jacques Whitford Limited

Abstract:

The implementation of more stringent regulations to protect public water supply safety, to manage water resource usage, and to plan on a watershed basis is a provincial initiative focused on ensuring water of appropriate quality and sufficient quantity for all users today and in the future. As the broadest barrier of the multiple barrier approach towards water supply protection to receive regulatory acceptance, implementation of source protection planning promises to be challenging. There will be continuing public discussion and debate as to how water resources should be shared, conserved and protected. The issues will affect industry, individuals, land use and the natural environment. This presentation will review the issues and key elements of strategic planning, and discuss who has to be engaged, their perspectives and roles, to achieve a successful balance of integrated land use and water resource management – the key to watershed source protection planning.

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WATER SUPPLY ISSUES, LIABILITIES AND COSTS FOR RURAL HEALTHCARE FACILITIES

Triebe, Robert, M.A. Sc., P. Eng.; Driscoll, Nicole, M.A. Sc., P.Eng.; Stiebel, William, M.Sc., P.Geo. Jacques Whitford Limited

Abstract:

Healthcare facilities are often located in rural areas of the country where their water supply is obtained from a non-municipal source, and their sewage treated in and disposed of through onsite systems. The health of residents and patients of these facilities is extremely sensitive to poor water quality. Deterioration of water quality or a decrease in water quantity will have profound impacts on facility operations. While a heightened awareness of these important issues has occurred, there is still a general misunderstanding of the requirements and practices that must be undertaken. The operation of non-municipal potable water supply and onsite sewage treatment systems imposes specific responsibilities on the facility operator. In addition, the facility can be exposed to potential liability through the systems' operations. Facilities obtaining water through municipal systems but with onsite backup wells can also be in a position of increased vulnerability due to regulatory gaps and the breakdown in the multi-barrier approach to drinking water quality. Providing good quality water and meeting regulatory requirements for both water and wastewater systems can incur significant capital and operational expenditures. Nevertheless, a properly planned, constructed and operated water supply system will limit financial liability resulting from damage to persons or property. This presentation examines key issues, liabilities and costs affecting private water supply in rural health care facilities and outlines operational and risk management practices to ensure a safe water supply is maintained.

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SOURCE WATER PROTECTION 2005 - ABSTRACTS

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GOVERNANCE OF SOURCE WATER PLANNING – A CONSERVATION AUTHORITY PERSPECTIVE

Wood, Gayle D., CMM III, Lake Simcoe Region Conservation

Abstract:

Under the Province of Ontario's Drinking Water Source Protection Act, the Minister of the Environment has established watershed based source protection areas as the vehicle for development of source protection plans.

Where Conservation Authorities exist in Ontario, they will be requested to facilitate the development of the plans. Key to this will be securing the technical expertise to complete the plans, in addition to ensuring the appropriate governance is in place to guide the plan development.

This session will review the basic components of a Source Protection Plan and outline some factors for successful plan development.

This session will also explore the importance of community and stakeholder involvement in the planning process as well as outline the composition of Source Protection Planning Committees and Source Protection Planning Boards.

Implementation of the Plans will be facilitated by municipalities and potential roles of both municipal and conservation authority partners will be reviewed.

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EFFECTS OF TILE DRAIN EFFLUENT ON BENTHIC INVERTEBRATE COMMUNITY STRUCTURE AND FUNCTION IN AGRICULTURAL HEADWATER STREAMS : IMPLICATIONS FOR PLANNING AND MANAGEMENT

Wright, Bradley, University of Waterloo

Abstract:

Tile drainage is a commonly used water management practice in over 80% of the agricultural land in southern Ontario. While it is widely known that tile drainage improves conditions for agriculture, these subsurface drains are important for the transfer of bacteria, sediment and pollutants to receiving streams. However, the downstream impact of tile drain effluent on benthic ecology is relatively unknown. This thesis examines the effects of tile drain effluent on benthic invertebrate community structure and function in eight agricultural headwater streams in southern Ontario. Artificial substrates were deployed above and below tile drain outlets and removed after a seven week colonization period. Biota and sediment on each substrate were used to determine twenty one biotic indices, sediment mass, median particle size and percent organic matter.

The number of individuals, taxa richness, Ephemeroptera and Chironomidae were the most consistent biotic indices with lower numbers immediately downstream of tile drain outlets. At seven study sites, organic matter content decreased and median particle sized increased downstream of tile drain outlets. Tile effluent chemistry was not measured but the literature suggests that pesticides and the synergistic effects of nutrients, pesticides and sediment from tile drains impact benthic invertebrate community structure and function. Therefore, planning and management of headwater streams and agricultural best management practices (*e.g.*, conservation tillage and vegetated buffers) are imperative for source water protection and ecological function. Recognition of this agricultural practice as a pathway for nutrient and contaminant transport is needed in regulations such as the Nutrient Management Act.

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BASEFLOW TO BANKFULL: INTEGRATING CHANNEL FLOWS BELOW THE TWO-YEAR RETURN INTO WATERSHED MANAGEMENT

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SOURCE WATER PROTECTION 2005 - ABSTRACTS

Abstract:

Historically, hydrology and hydraulic considerations associated with watershed management have focused on flows larger than the two-year return. This, in part, is associated with how traditional flow models have been calibrated, their greater sensitivity to large flow events and the importance of flood planning in watershed management. Unfortunately, many of the flows that are significant with respect to aquatic habitat, stream geomorphology and source water protection tend to be smaller than the two-year event. This paper defines different significant flows that occur below the two-year return and highlights their importance to stream geomorphology, aquatic habitat and source water protection. Different methods to characterize these flows and a conceptual framework for their integration into the planning process, particularly through the establishment of flow targets is proposed.

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