Water Balance Model for British Columbia Now Incorporates Tree Canopy Module

Integrating the Site with the Watershed and Stream

May 2012

An initiative under the umbrella of the Water Sustainability Action Plan for British Columbia

British Columbia Partnership announces that Rebuilt "Water Balance Model" now incorporates Tree Canopy Module

2nd ANNOUNCEMENT IN A SERIES

Launched in 2003 by a British Columbia inter-governmental partnership, the web-based Water Balance Model *is a scenario comparison and decision support tool. In 2009, the partnership released a comprehensive document titled* **Water Balance Model for Canada – The Plan for the Future***. This laid out a road map for greatly increasing both the computational capabilities of the tool and its usability in visioning future alternatives for use of water and land.*

The federal-provincial Regional Adaptation Collaboratives (RAC) Program *then provided core funding over the past 3-year period to implement a substantial portion of* The Plan for the Future*. The RAC Program has supported coordinated action towards advancing regional climate change adaptation decision-making.*

The re-built Water Balance Model now incorporates modules for land use, rainfall capture, climate change, rainwater harvesting, tree canopy interception, stream erosion and drainage infrastructure. This second announcement in a series showcases the Tree Canopy Module. The article that follows tells the story behind the module.

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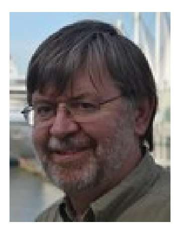

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Water Balance Model and Tree Canopy Interception

2nd Announcement in a Series

Mimic the Water Balance

The Water Balance Model (WBM) was developed as an extension of *Stormwater Planning: A Guidebook for British Columbia,* released in 2002. The purpose of the tool is to help communities establish watershed-specific performance targets, and 'design with nature', so that land development mimics the water balance.

The WBM is tailored to multiple levels of users who have a wide range of technical backgrounds, from hydrology experts to planners to stewardship groups. The WBM has launch buttons at three scales; SITE, NEIGHBOURHOOD and WATERSHED.

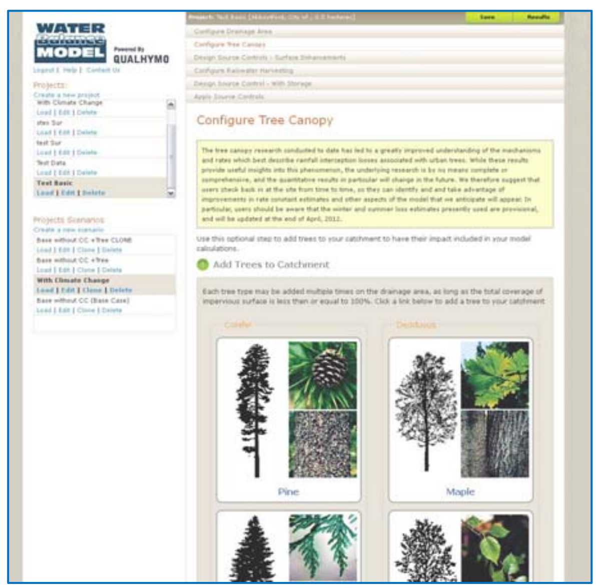
A Precedent-Setting Project

In 2005, and to enhance the capabilities of the WBM, the District of North Vancouver initiated a precedent-setting initiative in partnership with the University of British Columbia (UBC). The purpose of the *Urban Forest Research Project* was to quantify the proportion of rainfall intercepted by the tree canopy in an urban forest. Over time, this will inform urban planning by providing a science-based understanding regarding the benefits of maintaining a tree canopy in the urban environment.

In 2006, the District of North Vancouver, District of West Vancouver and City of North Vancouver formed a *North Shore Inter-Municipal Coordinating Team* to implement a network of "tree canopy climate stations" across the North Shore region of Metro Vancouver. The project received funding from the Province of British Columbia, Metro Vancouver, the Real Estate Foundation of British Columbia, and the Canada Water Network.

Implementation: Data collection was initiated in early 2007; and the research findings were published in a Master's thesis dated April 2010. The research has informed development of the Tree Canopy Module in the Water Balance Model for British Columbia.

According to Dr. Markus Weiler, former Chair of Forest Hydrology at UBC, "While considerable research has been undertaken in forest stands in the natural environment, very little has been done in an urban setting anywhere in North America." Dr. Weiler and Dr. Hans Schreier developed the project approach and the system for rainfall interception. They also recruited a graduate student, Yeganeh Asadian, to undertake the research in fulfillment of her Master's thesis.



The Goal: Bridge a Knowledge Gap

"Given the huge knowledge bases that the sciences have built up around the hydrology of urban watersheds, it can come as a surprise when we realize how little is known about some of the basics. The urban tree canopy is an example," states Dr. Charles Rowney, Scientific Authority for the Water Balance Model Partnership.

"This is a technical area where the fundamentals are well understood, but the empirical basis, the availability of actual observations, is still in its infancy. When it comes to the urban canopy, we just don't have a lot to go on. Considering the importance of urban trees, we're not sure why this knowledge gap has persisted. But when we began our research, it quickly became clear that there is a lot to learn about some of things that are important in dealing with the tree canopy. And it became just as clear that to improve this aspect of the practice of watershed management, we had to improve the science."

"When we consider a typical urban lot we might picture a classic home on a grassy lot, with a mature tree spreading shade and providing all kinds of benefits. And if we were to think of it, most of us would intuitively expect the tree to be a much larger factor in evapotranspiration than the grassy patch it sits over. Yet available model modelling tools generally don't explicitly account for this factor. They just lump the tree in with the grass. They are both simply treated as something 'green' or 'pervious'."

What We Need to Know

"The questions that need to be answered today demand a better approach than that. If a tree on an urban lot is cut down, how big is the net loss on that lot? Or if a tree is planted, how big is the benefit? If a tree overshadows grass on one side and a rooftop on the other, how does it compare to a tree simply spreading over a lawn? The unfortunate situation is that until now, answering these kinds of questions was largely based on what we might call informed guesswork - if they were answered at all," adds Yeganeh Asadian.

"Yet these questions are exactly the ones that need to be dealt with if we are going to properly manage this vital resource. We need more than good principles and concepts. To make well founded decisions, we need to be able to put numbers on the results of the decisions we make."

"The need for numbers is what motivated development of the Tree Canopy Module in the Water Balance Model," states Ted van der Gulik, Chair of the Water Balance Model Partnership. "We needed a way to improve the basis for decisions. This is a big technical challenge, so we knew we couldn't cover all the bases all at once. But we knew we could make a material improvement on what was known, and that is what we set out to do. The technical team, including Yeganeh, Dr. Rowney, Jim Dumont (Engineering Applications Authority for the Water Balance Model Partnership) and Richard Boase (District of North Vancouver), set out to complete basic research on tree canopy interception losses on one hand, and to develop a useful analytical capability on the other."

How Tree Canopy Monitoring Was Implemented

"Yeganeh conducted the physical research, which focused on directly measuring rainfall and throughfall associated with trees in the urban area. The scattered or clustered trees characteristic of an urban setting are the ultimate target, and single trees were the starting point for research," reports Richard Boase, Partnership Co-Chair. "We installed measuring devices which detected rainfall passing through the tree canopy, and compared that amount with the rainfall in nearby open areas. Canopy capture was taken as the difference between these two amounts."

"There is a human interest side to this part of the story. The District of North Vancouver partnered with the North Shore Mentally Handicapped Association to mass produce the wooden support structures for the tree canopy climate stations. The District was really gratified to see this partnership featured prominently in the local media."

A Unique Methodology

"We applied a unique methodology for measuring rain/throughfall under 54 different urban trees using a system of PVC pipes hung beneath the canopy to capture the throughfall where it drained into a rain gauge attached to a data logger," explains Yeganeh Asadian. "To ensure that the study adequately captured the range of throughfall variability, trees were selected to sample different landscape sites (streets, parks, and natural forested areas), elevations, tree type, health condition and species, including Douglas-fir, Western red cedar, Bigleaf maple, Oak, Copper beech, Horse chestnut, Cherry, and Poplar."

"Measurements were simple, but efficient and direct," adds Dr. Rowney. "The capture device was a long pipe with a slit along its length, placed horizontally under the tree. This provided a transect that represented throughfall across the diameter of the canopy, and accounted for variations in canopy throughfall. Rainfall in open areas was simpler to measure, because traditional rain gauges could be used. Eventually, enough data was developed to provide useful estimates of event by event rainfall, throughfall, and capture. A welcome and immediate benefit of this research, and a testament to the credibility, is that it was successfully used by Yeganeh as the basis for her Master's degree thesis."

"The innovative throughfall gauges confirmed that the design worked effectively in capturing a good representation of throughfall from individual tree canopies," explains Yeganeh." Our results suggested that 1.17 times more throughfall was captured by the pipes when compared to bottles installed underneath the canopies for interception validation. Based on the previous methods/research (roving bottles and rain gauges), the obtained interception losses from the throughfall data attained from the pipes should be higher than what we estimated."

Comparison of Interception Results: "The inter-species variation on interception was evident as Western red cedar showed higher interception losses, longer time delays and lower throughfall intensities when compared to Douglas-fir and deciduous trees during event analysis. It is important to note that Douglas-fir followed by Western red cedar showed the highest interception losses during both summer and winter. Interception losses for coniferous and deciduous trees averaged to be 76.5% and 56.4%, respectively. On average control trees located in forested areas showed 1.12 times less interception loss than urban trees," reports Yeganeh.

How the Research Has Been Translated Into a Practical Tool

"Accompanying the physical explorations was research to develop a practical model of the canopy capture processes that were being measured. After some debate, Jim Dumont and Charles Rowney concluded that the most reasonable approach was to represent canopy capture as an interception loss," reports Ted van der Gulik.

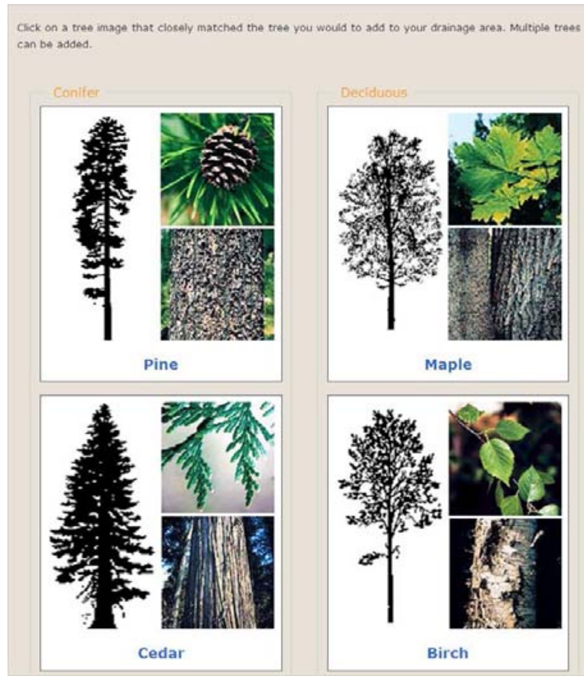
Model Capture as an Interception Loss

"Rainfall over the tree would be simulated as being soaked up by this interception up to some maximum amount during the course of the rainfall event," explains Dr. Rowney. During dry periods, the available interception amount would recover over time due to evapotranspiration. This is a model which can be used to represent what was learned from the data available. It is not only a good starting point, but is an approach that can be extended and evolve over time, as new data on the underlying physical processes become available."

"With a basic model in hand, it was then possible to extend the analysis to accommodate the geometry on an individual lot, we considered a variety of options," continues Jim Dumont. "The module which was developed incorporates basic information on the impervious and pervious areas of the lot, and the degree to which the tree canopy overhangs each of them. Trees are therefore simulated independently of the grassed area from a mass balance point of view, and can be simulated individually or in groups. With this capability, this module is able to answer the questions framed by Yeganeh, and many more besides."

About the Calculation Engine

"Because it has been built into the QUALHYMO calculation engine as a new computational module, the net result of this program is to provide the Water Balance Model with a solid capability to represent isolated or clustered trees in the urban environment," states Dr. Rowney.



"Because of the way the code was developed, a wide range of urban species can potentially be dealt with, including hedge rows, ground cover or other characteristics that may be of interest. For the present, the basic data deal with these species as evergreens or deciduous species because the data don't justify subdividing the content further. However, since the team is confident that continued research will bring with it an increasing understanding of the differences between species, the model has been built with a simple local database that will allow the continued addition of new tree or bush types without the requirement to overhaul the code."

"Of course, the code can be updated and expanded as well when and if new understanding of the processes emerges, but in the mean time, the model is robust, effective and easily expanded. That is an outstanding first step in the ability to represent and usefully model the effect of trees on urban hydrology," reflects Dr. Rowney.

Looking Ahead

"Now we are looking forward to seeing how the homeowner, planners or builders might choose to use this tool. Ultimately, if it promotes land owners and developers to maintain and better manage urban trees, it will have achieved the goals we had in mind," concludes Ted van der Gulik.