Sustainable Community Design

A New Approach to Rainwater Management

Rainwater management in North America and throughout the English-speaking world is undergoing a major sea change — and BC is in the vanguard of that change. Rainwater management is at the heart of a new approach to land development in balance with the natural environment.

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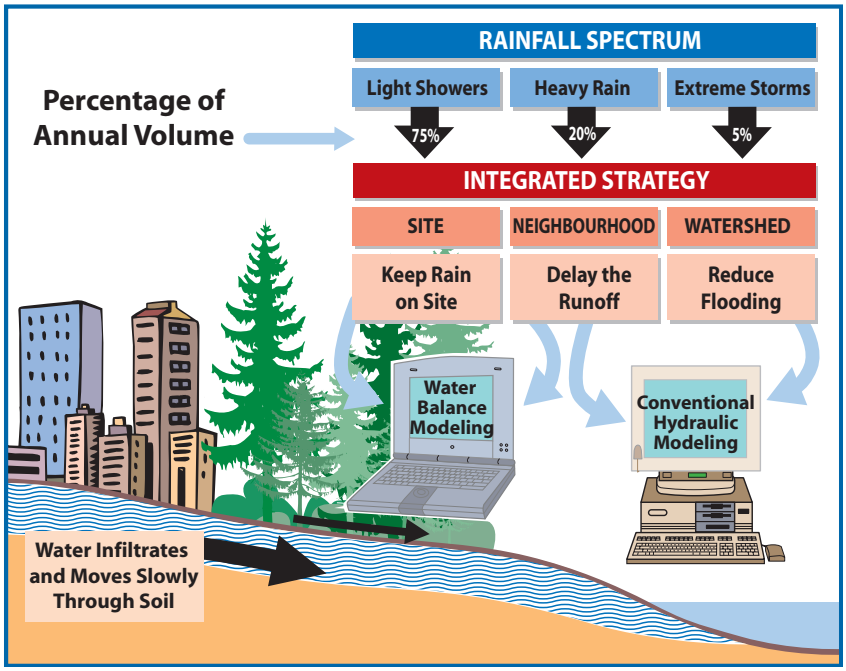
Rapid population growth, redevelopment of older neighbourhoods, and land use densification are creating opportunities to reverse past failures to prevent the creation of rainwater runoff and its negative environmental impacts.

Civil engineers are finally coming to grips with the root cause of flooding, loss of aquatic habitat and water pollution: the community design standards that dictate how land will be cleared, roads built, infrastructure services provided, building sites (re)developed and rainwater runoff managed. Using a free, web-accessible planning and decision support tool, engineers and others can now inform and evaluate land use planning decisions for their ability to meet rainwater management and watershed protection objectives.

This new tool, the Water Balance Model for BC (WBM), is facilitating a paradigm shift in the philosophy of and approach to urban hydrology. Built around established soil science principles, the WBM creates an understanding of how to get rainwater into the ground and/or absorbed by trees and landscaping under any combination of land use, soil and climatic conditions. The ultimate goal is a built environment that functions hydrologically like naturally forested or vegetated systems to the extent that is achievable.



Rethinking Urban Hydrology

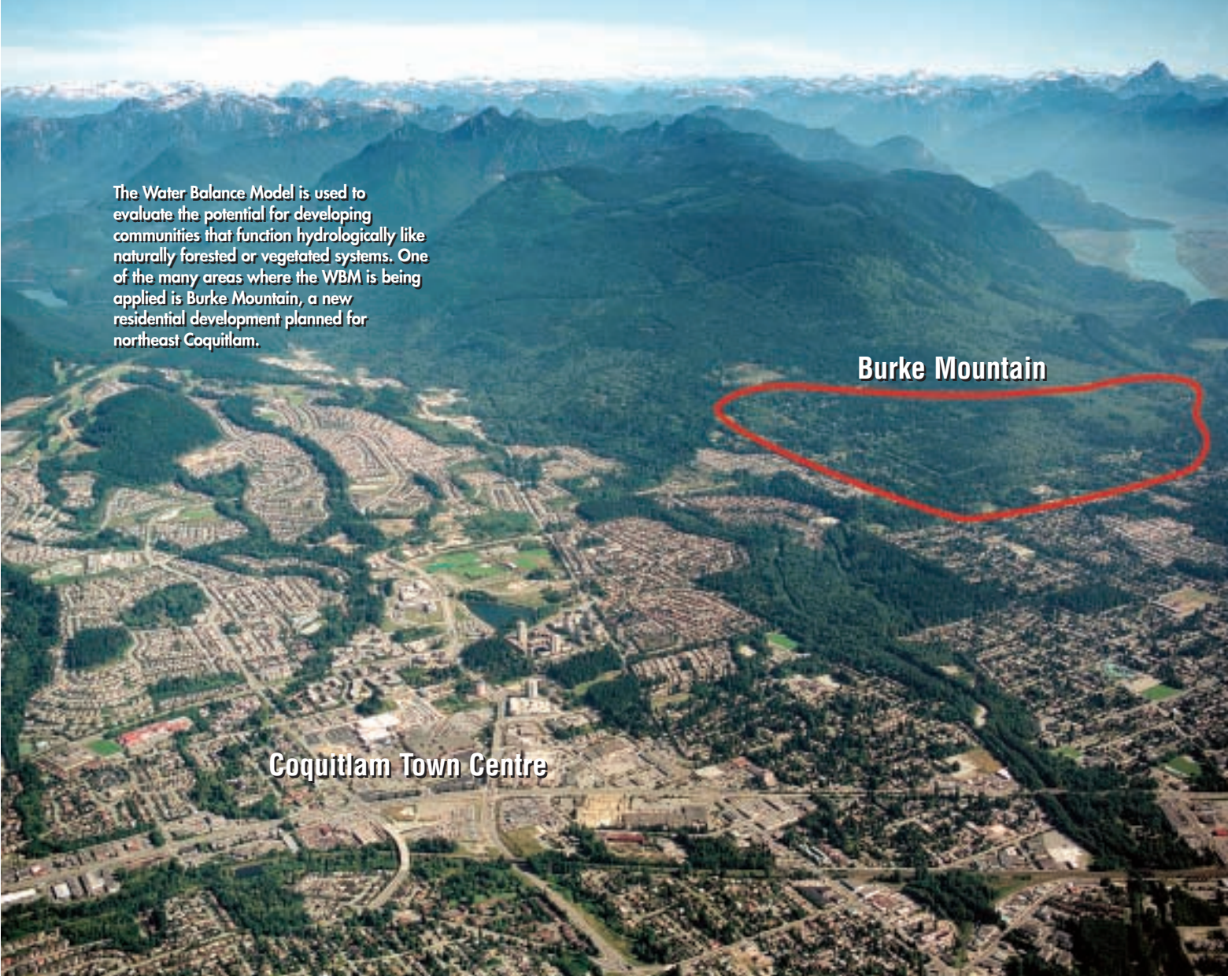
Runoff is created when human activities alter the natural water balance. As trees, vegetation and soils are replaced with roads and buildings, less rainfall infiltrates naturally into the ground, less gets taken up by vegetation and more becomes rainwater runoff.

Typically, the change is dramatic. For example, in many coastal watersheds there is as little as 1% annual runoff under a natural forested condition and as much as 70% annual runoff for an intensively urbanized watershed.

Drainage engineers have historically been concerned only with peak flows during infrequent storm events and therefore have approached the issue in terms of flow rates, not flow volumes. The emphasis on peak flow control by piping rainwater runoff to streams has all too often resulted in flooding and/or caused stream erosion that degrades fish habitat.

The unsustainability of this approach is evident in the fact that, increasingly, BC's urban regions are accommodating population growth through higher density (re)development. For example, 75% of the next two million people in the Greater Vancouver region will be housed in existing built-out watersheds. Redevelopment of these areas will, however, create the opportunity to restore watersheds over time.

To achieve this outcome, a "design with nature" approach strives to capture



The Water Balance Model is used to evaluate the potential for developing communities that function hydrologically like naturally forested or vegetated systems. One of the many areas where the WBM is being applied is Burke Mountain, a new residential development planned for northeast Coquitlam.

and retain most of the annual rainfall volume on development sites and along roadways. The focus is on preserving the natural rainwater absorption characteristics of a site slated for (re)development.

The key to implementing the strategy is that most of the annual rain volume falls as light showers. Although daily rainfall amounts range from light showers to heavy rain to extreme storms, only a handful of long duration downpours occur in any year and extreme storms are rare.

At the site level, a "design with nature" strategy optimizes the use of soil, plants and trees, and surface treatments to capture rain where it falls. Recognizing that there is a practical limit to what can be achieved at the site scale once land clearing has altered the water balance, the integrated strategy for managing the complete rainfall spectrum has three tiered components. As shown in the figure, these correspond to three scales — site, neighbourhood and watershed — to achieve two goals:

- Protect aquatic habitat through site and neighbourhood solutions that keep rain on site and delay runoff, respectively.
- Protect life and property through watershed-scale solutions that reduce flooding.

When landscape-based solutions are implemented at the site level, success is evident at the neighbourhood and watershed scales.

What the WBM Does

Before the WBM (www.waterbalance.ca) was developed, the missing link in urban hydrology was a tool that could easily quantify the benefits, at a neighbourhood or watershed scale, achieved by reducing rainwater runoff volume at the site level.

Developed by an Inter-Governmental Partnership (IGP) with the financial support of the Real Estate Foundation of BC, the WBM promotes a planning level understanding of the physical hydrology of a site as it relates to the fate of the total mass of rainfall that occurs throughout the year. It enables users to quantify and evaluate the effectiveness of site planning that incorporates source controls like absorbent landscaping, infiltration facilities, green roofs and (eventually) rainwater harvesting.

The model provides a user-friendly, continuous simulation of the drying and wetting of soil and also allows one to view the existing situation and compare it to what may have been in the past and what may be in the future. This is the real value of the tool as it allows informed decisions about the fate of the streams within watersheds that are undergoing (re)development.

The WBM helps users to achieve performance targets that represent the syn-

thesis of biophysical and hydrologic understanding. To accomplish multiple outcomes, the volume target for development sites is to limit annual runoff to 10% of annual rainfall. Analysis of rainfall patterns shows that 90% rainfall capture is typically within reach. In assessing the achievability of 50-year plans for watershed retrofits, the focus is on what is feasible and affordable over time.

The financial benefits that result from implementing source controls to maintain the natural water balance fall primarily into three categories of "costs avoided" through 1) elimination of conventional "big pipe" solutions, 2) reduction in wear and tear on watercourses, and 3) demonstration of due diligence that protects cities from liability arising from litigation. In other words, effectively managing rainfall volume through small-scale onsite solutions can eliminate the need for large-scale, multimillion dollar offsite solutions.

Above: **The UniverCity sustainable community being developed near SFU spurred the development of the Water Balance Model for BC;** ***left:*** **landscape-based solutions to control runoff at the site level include terracing on sloping lots, which enhances rainwater infiltration.**

Evolution of the WBM

The genesis of the WBM's development was UniverCity, the sustainable community being built adjacent to Simon Fraser University atop Burnaby Mountain. Translating high expectations for this "green" development into practical design guidelines meant revisiting accepted drainage engineering practice; this need for innovation led to the WBM's development.

In 2001 the Stormwater Interagency Liaison Group (SILG), a technical committee of the Greater Vancouver Regional District, recognized the value of the water balance approach and funded the development of a working model to assess the affordability and feasibility of site design solutions for achieving performance targets.

The results of this applied research were incorporated in *Stormwater Planning: A Guidebook for British Columbia* funded by Environment Canada and published by the BC Ministry of Water, Land and Air Protection in June 2002. This guidance document, founded on BC case study experience, formalized a science-based understanding to set performance targets for reducing rainwater runoff volumes.

In July 2002 the IGP was formed to develop the WBM as an extension of the *Guidebook*. It began as a subgroup of SILG and quickly expanded to become a provincial group with municipal representation from four regions: Greater Vancouver, the Fraser Valley, Vancouver Island and the Okanagan Valley.

The IGP is now a consortium of 18 local, regional, provincial and federal agencies and is cochaired by the BC Ministry of Agriculture, Food and Fisheries and Environment Canada. Its mission is to enable local governments and landowners to make informed land development decisions and meet performance targets for rainwater volume capture and runoff rate control under a variety of land use, soil and climate conditions. The goal is that use of the WBM will become standard practice for land development decisions throughout BC.

To accomplish this, the IGP has partnered with the Real Estate Foundation of BC to build broad-based support for the "design with nature" approach to rainwater management via an outreach and continuing education program. Launched at the 2003 annual conference of the Union of BC Municipalities, the program comprises seminars and training workshops for a range of audiences. The IGP is also collaborating with the Urban Development Institute to provide hands-on training for the land development community.

Case Study Experience

Chilliwack is widely recognized as "leading the pack" in BC in promoting and implementing changes in the philosophy of, approach to and standards for rainwater management. Rainwater source control (eg, infiltration facilities) is at the heart of Chilliwack's proactive and integrated approach to development planned for the city's Eastern Hillsides, an area slated for significant growth over the next 10 years and located upstream from rich agricultural lowlands.

Because BC drainage case law is based on lowland farmers litigating against municipalities over the runoff and flooding impacts resulting from urbanization, Chill-

Left: **Recent development in Chilliwack has concentrated on the hillsides above agricultural lowlands; all new subdivisions are constructed in accordance with the WBM methodology to achieve runoff volume reduction targets.** ***Below:*** **Before and after views of a new subdivision using an infiltration trench to control runoff; road standards are also relaxed for a curbless and narrower pavement.**

iwack has tackled the liability issue by requiring land developers in the uplands to protect the natural water balance.

There are now several dozen innovative development projects where the WBM has or will be applied. Practical experience and performance data from these demonstration projects will enable constant improvement to land development and rainwater management practices. The primary objective is to reduce rainwater related costs while still achieving defined goals for protecting downstream property, aquatic habitat and receiving water quality.

Surrey is applying the WBM to "close the loop" on the performance assessment for the East Clayton sustainable community, whose plan envisions higher than average densities, a mix of housing types, an interconnected street network and a natural drainage system. The WBM was used to establish the sizing criteria for onsite infiltration systems; monitoring data are now being used to verify the original design assumptions.

On Vancouver Island, the understanding provided by the WBM is the reason that ***Courtenay*** is implementing a policy requiring a minimum soil depth on development sites.

In ***Coquitlam,*** a key feature of planned residential development at Burke Mountain is the natural systems approach to rainwater management. Developers have committed to incorporate practical strategies for rainwater volume and rate reduction at three scales: site; subdivision and neighbourhood. The eventual population of Burke Mountain at 24,000 persons represents 12% of the anticipated population of Coquitlam in the year 2021.

Conclusion

BC stormwater criteria and tools are receiving increasing recognition across North America because of their unique emphasis on solving both flooding and environmental problems at the source. This rethinking of traditional approaches to urban hydrology is helping to achieve higher levels of watershed and stream protection by integrating land use planning with volume-based analysis of rainwater management strategies.

Through the development and application of the Water Balance Model for BC, civil engineers are playing a leading role in promoting changes in the philosophy, approaches and standards that shape the urban landscape. Many agencies now recognize this commonsense approach to rainwater management as having triggered one of the most significant advances in urban hydrology in a generation.

Kim Stephens PEng, who is IGP Project Coordinator, has been involved in a series of pioneering initiatives over the past decade in BC related to watershed-based stormwater management, low impact development and water conservation. He was project manager for Stormwater Planning: A Guidebook for British Columbia.

Tim Pringle is Executive Director of the Real Estate Foundation of BC, which provided substantial financial support for the WBM development and IGP outreach program.