the partnership
for water sustainability in bc

IREI - Inter-Regional Education Initiative

Sustainable Watershed Systems: Primer on Application of Ecosystem-based Understanding in the Georgia Basin

Connecting Past and Present Research


Image source: Google

September 2016

ACKNOWLEDGMENTS: The Partnership for Water Sustainability in BC gratefully acknowledges the financial support of the Province of British Columbia through the Ministry of Community, Sport and Cultural Development; as well as the financial support of the five regional district partners in the Georgia Basin Inter-Regional Education Initiative.

About the Partnership for Water Sustainability

The Partnership for Water Sustainability in BC is a legal entity, incorporated in 2010 as a not-for-profit society, and delivers services on behalf of government. It originated as an inter-governmental partnership, formed in 2002 to fund and develop the Water Balance Model as a web-based decision support tool.

When the **Water Sustainability Action Plan for British Columbia** *(Action Plan) was released in 2004, the Water Balance Model for BC was the centrepiece initiative. Action Plan experience informed development of* **Living Water Smart, British Columbia's Water Plan***, released in 2008, as well as the parallel* **Green Communities Initiative***.*

The Partnership for Water Sustainability embraces shared responsibility, is the hub for a "convening for action" network in the local government setting, and is responsible for delivering the Action Plan program through partnerships and collaboration. This program includes the **Georgia Basin Inter-Regional Education Initiative***.*

The Partnership for Water Sustainability plays a bridging role between Province, local government and community; and is the steward for **Stormwater Planning: A Guidebook for British Columbia***, a provincial guidance document released in 2002.*

Sustainable Watershed Systems:
What the reader will learn from this Primer

Everyone learns about the water balance (water cycle) in elementary school, but by high school most have forgotten what they learned. So what does this mean for communities, the reader might well ask? Consider that: A legacy of community and infrastructure design practices has failed to protect the natural water balance (hydrologic integrity). Failure has financial, level-of-service and life-cycle impacts and implications for taxpayers. Consequences include expensive fixes.

Local governments are starting to recognize that natural assets have value, ecosystem services have a role in municipal service delivery, and so need to be integrated into their asset management programs. Hence, this Primer is written to help multiple audiences – whether elected, administrative, technical or stewardship – ask the right questions and ensure that "science-based understanding" is applied properly and effectively to implement practices that restore the hydrologic integrity of watersheds.

The Primer serves as a refresher on core concepts that underpin the vision for **Sustainable Watershed Systems, through Asset Management***, released by the Partnership in November 2015. We trust that readers will grasp WHY it is necessary to "stay true to the science"* ***IF*** *communities are to achieve a vision for Sustainable Watershed Systems. And we hope that readers will be inspired to learn more about the science behind the Water Balance Methodology. Restoring hydrologic integrity, and thus the water balance, is key to achieving a water-resilient future in urban areas.*

Kim A. Stephens, MEng, PEng,
Executive Director
Partnership for Water Sustainability in BC
September 2016

NOTE TO READER: In May-June 2016, the Partnership published a 4-part eNewsletter series branded as the **Ecosystem-based Understanding Series**. The series highlighted the importance of connecting dots between past and present research findings, and foreshadowed that the four parts would be consolidated and expanded in a stand-alone document. The result is this sixth in the "Beyond the Guidebook Primer Series".

A watershed is an integrated system. The need to protect headwater streams and groundwater resources in BC requires that communities expand their view from one that looks at a site in isolation to one that considers all sites, the watershed landscape, streams and foreshores, groundwater aquifers, and so on, as an integrated system.

Sustainable Watershed Systems: Table of Contents

[1]**Note to Reader:** The e-newsletters are replicated herein with their original look-and-feel. Also, each of the four parts is expanded from 2 pages to 5 pages to incorporate information that complements key messages presented in the originals. Each part introduces an aspect of the Water Balance Methodology to accumulatively build understanding.

Think and Act like a Watershed: Connecting Past and Present Research

Peter Law
Director

Partnership for Water Sustainability in BC

Chair (2002-2002), Steering Committee for *Stormwater Planning: A Guidebook for BC, 2002*

BC Ministry of Environment (retired)

"An interface is needed to translate the complex products of science into achievable goals and implementable solution for practical resource management. This interface is what we now call a ***science-based understanding****."*

"A science-based understanding of how land development impacts watershed hydrology and the functions of aquatic ecosystems provides a solid basis for making decisions to guide action where and when it is most needed."

Sustainable Watershed Systems, through Asset Management

Launched by the province and Union of BC Municipalities (UBCM) in 2015, *Asset Management for Sustainable Service Delivery: A BC Framework* is a game-changing initiative. It is a game-changer because it links directly to the requirements for grants under the Canada-BC Gas Tax Agreement.

Along with the new *Water Sustainability Act* and *Develop with Care 2014*, the BC Framework points the way to **Sustainable Watershed Systems**. This outcome would result from a "whole systems" approach to community development and infrastructure servicing. Implementation of "whole systems" thinking would include incorporating the benefits provided by nature into the delivery of local government services.

The vision for Sustainable Watershed Systems is the culmination of a building blocks process which cross-pollinated Washington State and BC experience. In the mid-1990s, Washington State research established the **primacy of hydrology** in either protecting or impacting stream health. In BC, this finding spurred development and evolution of the Water Balance Methodology.

Twenty years later, a convergence of initiatives and ideas is the catalyst for taking stock of past and current research. The purpose of this Primer is to connect the dots and disseminate information on the "science-based understanding" that underpins the vision for Sustainable Watershed Systems. The Primer consolidates the content from the 4-part eNewsletter series published by the Partnership for Water Sustainability in May-June 2016.

Ecosystem-based Understanding Series: Each eNewsletter had a theme. The four themes serve as the *Table of Contents* for this Primer:

Part 1 introduced new ecosystem-based adaptation (EbA) research in BC that may inspire a new generation to "think and act like a watershed".

Part 2 celebrated the 20th anniversary of publication of the seminal Washington State research by Dr. Richard Horner and Dr. Chris May.

Part 3 showcased breakthrough rain garden research by Dr. Jenifer McIntyre at Washington State University that builds on the work of Horner and May.

Part 4 introduced the parallel journeys of Washington State, California and BC; and how the Water Balance Methodology is the foundation for an ecosystem-based approach to protection of hydrologic integrity.

Vision: Re-Set the Ecological Baseline

Dr. Daniel Pauly
Global Fisheries Scientist

University of British Columbia

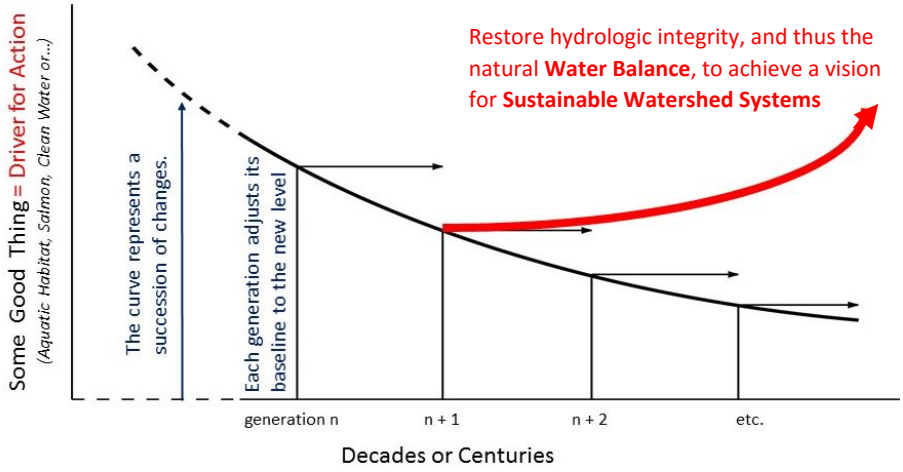
"We transform the world, but we don't remember it. We adjust our baseline to the new level, and we don't recall what was there."

With each new generation, the expectation of various ecological conditions shifts. The result is that standards are lowered almost imperceptibly.

Link to TED Talk:
http://mission-blue.org/2012/03/shifting-baselines-daniel-paulys-ted-talk/

In 1995, Dr. Daniel Pauly coined the phrase "shifting baseline syndrome" to describe why each new generation lacks direct knowledge of the historical condition of the natural environment, and how this lack of understanding plays out as a *failure to notice change*.

The flip side of an impact, however, is an opportunity. Over the past two decades, a series of teachable moments has set the stage to reverse the sliding baseline in the Georgia Basin. Communities could re-set the *ecological baseline* IF they would implement standards of practice that truly replicate and restore a desired watershed condition. This outcome requires a 'whole systems' approach to community planning and infrastructure servicing.



Faye Smith
Community Leader

Mid-Vancouver Island Habitat Enhancement Society

"The MVIHES experience demonstrates that positive outcomes are a result of strong community support for protection of small streams and their tributaries."

Why Stream Health Matters: In the early 1990s, the 'Coho salmon crisis' raised the alarm about the consequences of the sliding baseline. By 1996, the Province had established regulatory and program support for restoration of salmon freshwater habitats through Fish Renewal BC and the Urban Salmon Habitat Program. Meanwhile, in 1999 the United States listed Chinook salmon in Puget Sound under the Endangered Species Act. This game-changer was a catalyst for the Province of BC to reach out to Washington State to find out how their agencies would respond to the crisis. The push for cross-border collaboration came from the stewardship sector.

Across Vancouver Island and the Lower Mainland, salmon enhancement stewardship groups formed. They asked questions of their local governments about the linkages between small stream salmon demise and land developments. More than two decades later, most community-based groups still exist, providing thousands of volunteer hours to restore aquatic habitats.

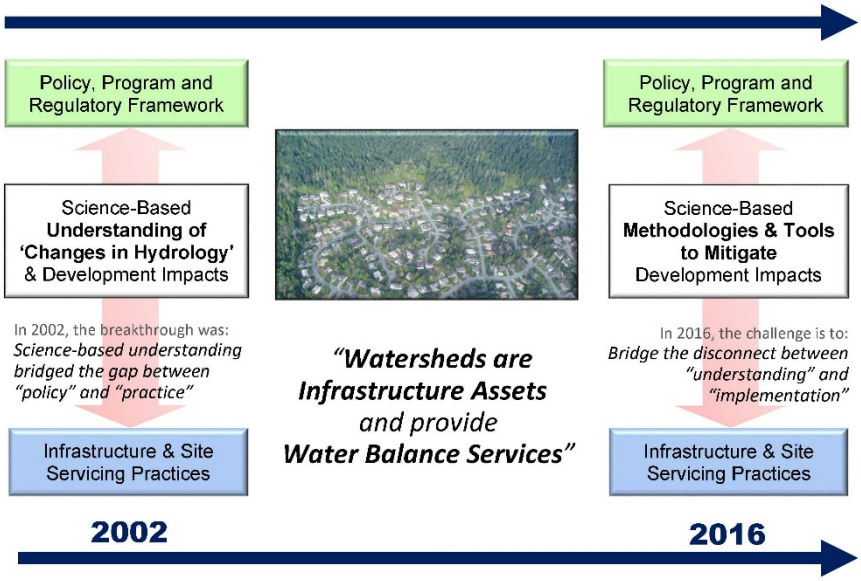
An outstanding example is the Mid-Vancouver Habitat Enhancement Society. The MVIHES coordinates efforts between agencies, private landowners and community volunteers in rebuilding salmon and their habitats in the Englishman River watershed.

Game-Changers

Wes Shoemaker
Deputy Minister
BC Ministry of Environment

"Moving beyond traditional engineered infrastructure asset management to also account for nature's services will help influence 'standards of practice' and represent a leading-edge evolution in how infrastructure is planned, financed, implemented and maintained in BC."

In 2002, release of *Stormwater Planning: A Guidebook for BC* was a major milestone in applying science-based understanding to community design. The Guidebook built on Washington State research to bridge a yawning gap between POLICY and PRACTICE. Fast forward to 2016. BC has a provincial policy, program and regulatory framework that enables local governments to move from UNDERSTANDING to IMPLEMENTATION of a "whole systems" approach keyed to the **primacy of hydrology**.



Moving from Understanding to Implementation: The Province has long recognized that communities are in the best position to develop solutions which meet their own unique needs and local conditions. Three landmark provincial initiatives came to fruition in 2014. Together they provide a platform for integrated and coordinated actions that would enable local governments to achieve *Sustainable Watershed Systems, through Asset Management*.

WHAT – The *Water Sustainability Act* connects land and water, and makes the link to desired water balance outcomes (that would be achieved by integrating watershed systems thinking into asset management).

SO WHAT – *Develop with Care 2014: Environmental Guidelines for Urban and Rural Land Development in British Columbia* makes the link between environmental function and resilience as communities grow.

THEN WHAT – *Asset Management for Sustainable Service Delivery: A Framework for BC* ("the BC Framework") makes the link between local government services, the infrastructure that supports the delivery of those services, and watershed health.

Glen Brown
General Manager
Victoria Operations
Union of BC Municipalities

"The BC Framework focuses on desired outcomes rather than prescribe methodologies. This gives local governments the flexibility to develop and implement measured and incremental approaches tailored to the needs and capacities of their communities."

Brian Bedford
Director,
Infrastructure & Engineering
BC Ministry of Community, Sport & Cultural Development

"The top-down and bottom-up approach relies on education, enabling tools, and collaboration to turn ideas into action. The BC Framework encourages local governments to think about what levels of service can be provided sustainably."

Asset Management Continuum

The new Water Sustainability Act ("the Act") plus the BC Framework are lynch-pins for looking at water and watersheds differently.

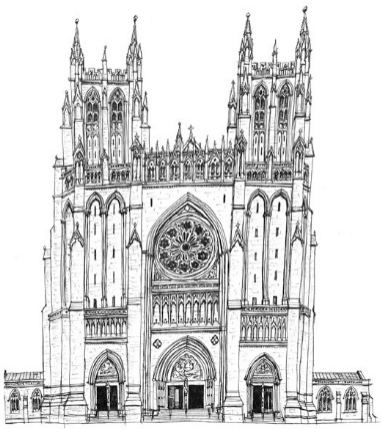
The Act allows for collaboratively developed plans that integrate water and land use planning and can be combined with other local, regional or provincial planning processes to mitigate risk to water quality, water quantity and aquatic system health or restore watershed function.

The BC Framework is a powerful tool for local governments to focus their community planning and infrastructure decision processes on beneficial life-cycle outcomes. The BC Framework encourages an appropriate balance of regulation and education. Simply put, the guiding philosophy is: "get it right at the front-end".

Pathway to a Water-Resilient Future: Asset management has traditionally been about hard engineered assets such as waterlines, sanitary and storm sewers, and roads. Yet, watershed systems are also "infrastructure assets". Trees, soil, green spaces and **Water Balance pathways** contribute to a municipal service function. These assets provide *hydrologic integrity* for a healthy watershed system. This is a driver for protecting and managing nature's services in the same way that engineered assets (and the services they provide) are managed.

Implementation of asset management along with the associated evolution of local government thinking is a continuous quality improvement process, not a discrete task. This ongoing process is incremental and scalable, involving: assessing capacity, demand and results; planning what needs to be done; and implementing the plans.

A way was needed to conceptualize this process diagrammatically, and thus communicate what the journey by a local government to a *Water-Resilient Future* would look like. This led to the concept of a continuum. Different local governments will always be at different points and different levels of maturity along the *Asset Management Continuum*.



Foundation for Cathedral Thinking: *A far-reaching vision, a well thought-out blueprint, and a shared commitment to long-term implementation.*

Cathedral Thinking

"Cathedral Thinking" aptly describes the vision for *Sustainable Watershed Systems, through Asset Management.*

In embarking on the journey to a water-resilient future, communities can learn from our ancestors. The grand creations of antiquity were not designed with a quarterly report or 4-year election term in mind.

The builders of great cathedrals in medieval times thought in terms of multiple generations carrying out their work, to complete a dream that would not be realised until long after the originator's death.

Achieving sustainable watershed systems through asset management will require long-term commitment by communities, successive municipal councils and regional boards, and generations of land and water professionals.

Mayor Darrell Mussatto
City of North Vancouver

The City's Rain Garden Program is a foundation piece for a long-term vision for restoring watershed health in a fully urbanized city

"A single rain garden will not make a material difference. But 1000s of rain gardens would be a different story. Restoring stream health requires a long-term commitment over decades by the community, successive Councils and City staff. We can turn the situation around over time."

Think and Act like a Watershed (part 1): Harness nature to adapt to a changing climate

In the late 1990s water resource practitioners in British Columbia, who learned from Washington State research, embraced an "ecosystem-based approach" to integrated stormwater management planning. Although this interdisciplinary way-of-thinking underpinned **Stormwater Planning: A Guidebook for British Columbia**, *released by the Province in 2002, use of the* ***ecosystem*** *term failed to take root in the drainage practitioner lexicon. Nevertheless, the ecosystem approach has had an influence on practice. Two decades later, research undertaken by Julia Berry at Simon Fraser University creates a window of opportunity to connect the present to the past, and build on historical knowledge and understanding to educate and inspire a new generation to "think like a watershed" and implement ecosystem-based solutions.*

Julia Berry
Graduate

School of Resource & Environmental Management, Simon Fraser University

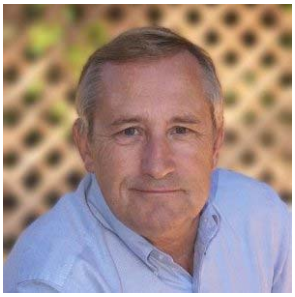
"Harness nature to adapt to a changing climate."

Historical Context

In 1996, Richard Horner and Chris May (University of Washington) published their seminal research that correlated land use, cumulative impacts and stream health. Their findings shook conventional stormwater management wisdom in the Pacific Northwest to its foundation. Their work became part of the curriculum for cross-border sharing via a workshop series conducted by Bill Derry and Kim Stephens for local governments over a five year period.

These workshops generated interest in the ecosystem-based approach and led to the SmartStorm Forums, four transformational events held between January 1999 and March 2001. Organized by a partnership comprised of federal, provincial and local governments, the SmartStorm Forums advanced **an ecosystem-based approach to stormwater management**. A notable outcome was *Stormwater Planning: A Guidebook for British Columbia*.

SmartStorm Forum Series *comprised events on Vancouver Island (Nanaimo in January 1999) and the Sunshine Coast (Sechelt in September 1999), and in the Fraser Valley (Abbotsford in February 2001 and Pitt Meadows in March 2001).*



Barry Janyk
Mayor (1999- 2011),
Town of Gibsons

Moderator,
SmartStorm Series

"The Stormwater Guidebook links directly to land use planning, policy and regulation. It provides context and a framework for the environmental, economic, social and governance values that shape communities and region."

HISTORY

BC's Stormwater Planning Guidebook, *released in 2002, was an outcome of the SmartStorm Forum Series.*

The genesis for the series was a focus group workshop held in October 1997. Convened by the Union of BC Municipalities, it was part of the launch for the ***Fish Protection Act (1997)****, the first of its kind in Canada.*

The coming together of a group of change agents in October 1997 set in motion a chain of events that has reverberated through time.

Looking back, much of what has played out in BC can be traced back to those who participated in the 1997 Fish Protection Act focus group.

Flashback to the 1990s

The 'Coho salmon crisis' in the 1990s was a driver for intergovernmental action in both BC and Washington State. The decade was characterized by collaboration and cross-border sharing and learning at the provincial and local government scales. In 2000, Canada and the United States signed a *Joint Statement of Cooperation on the Georgia Basin and Puget Sound Ecosystem.* The two countries agreed on the need to maintain sustainable ecosystems and communities in the face of continuing population and economic growth.

Connect the Dots: In the second half of the 1990s, several streams of thinking converged, with a key trigger for action being the Fish Protection Act (1997). Implementation led directly to the SmartStorm Forum Series (1999-2001) and Stormwater Guidebook (2002). This program built on insights and lessons learned from Washington State experience and research.

In the late 1970s and 1980s, Washington State jumped out ahead of most of the United States because several stormwater utilities were formed (the first in the nation). Puget Sound leadership resulted in financial, technical and staff resources that were focussed on dealing with the root causes of stormwater issues. Local government managers recognized the need for more technical information to help make more informed stormwater management decisions. They pooled resources to create the Center for Urban Water Resources Management at the University of Washington, headed by Richard Horner.

Washington State research into "root causes" explained **WHY** communities need to mimic the Water Balance to protect aquatic habitat and ecosystems. The impact of "science-based understanding" was transformational. Development of communication tools to explain the science opened minds and moved the conversation beyond rhetoric. In 2002, BC's Stormwater Guidebook provided early direction on **HOW** to mimic the Water Balance.

1980s Approach		Vision for 2000s
Drainage Systems	→	Water Balance Systems
Reactive (Solve Problems)	→	Proactive (Prevent Problems)
Engineer-Driven	→	Interdisciplinary Team-Driven
Protect Property	→	Protect Property ***and*** Habitat
Pipe and Convey	→	Mimic Natural Processes
Limited Consultation	→	Extensive Consultation
Local Government Ownership	→	Partnerships with Others
Extreme Storm Focus	→	Rainwater Integrated with Land Use
Peak Flow Thinking!	→	**Volume-Based Thinking!**

Source: Chapter 3, Stormwater Planning: A Guidebook for British Columbia, 2002

Key elements of the transition from a 1980s drainage-centric approach to an ecosystem-based approach in the 2000s are captured in the above comparison

Sean Markey
Associate Professor
& Senior Thesis Supervisor

School of Resource & Environmental Management, Simon Fraser University

"Julia did a great job of integrating concepts and testing the evaluation framework on her two case cities. Hopefully the work continues to advance our understanding of EbA - particularly how to make these concepts accessible and measurable to help guide and promote implementation."

Kim A Stephens
Co-Supervisor
Thesis Committee

"The research by Julia Berry provides rainwater and adaptation planners with an overview of ***Ecosystem-based Adaptation*** *(EbA) from principles to practice in British Columbia."*

Fast Forward to 2016

In May 2016, at a meeting of the Metro Vancouver Stormwater Interagency Liaison Group (SILG), a forum for local government representatives, Julia Berry presented the findings from her Master's thesis on harnessing nature to adapt to a changing climate. A graduate of the School of Resource and Environmental Management, Simon Fraser University, Julia Berry applied original thinking to apply core concepts and produce:

- **Ecosystem-based Adaptation to Climate Change in Urban Areas: An Evaluation of Rainwater Management Practices in Metro Vancouver**

The core concept of the research project, EbA, is a combination of two other significant concepts: EBM (ecosystem-based management) and climate change adaptation. The value of the work by Julia Berry is two-fold: picks up threads from the 1990s; and reminds practitioners to focus on outcomes not output – *What does the community want? What is the goal? How will actions restore hydrologic integrity?*

Ecosystem-based Adaptation (EbA)

"Adapting to climate change will require a combination of approaches, from man-made infrastructure to holistic approaches. British Columbia's Stormwater Planning Guidebook promotes a holistic approach to rainwater management, which views rain as a resource and aims to mimic the natural hydrological cycle by allowing rainwater to return directly to the ecosystem," notes Julia Berry.

"Ecosystem-based adaptation (EbA) is a novel approach to planning and adaptation that prioritizes ecosystem services, enhancing biodiversity, as well as human health and wellbeing. My research uses a framework of EbA principles to evaluate select watershed plans from the cities of Surrey and Coquitlam in the Metro Vancouver region."

"While the intended purpose of *Integrated Stormwater Management Plans* (ISMPs) is not directly to address climate change, the results of my research show that these two municipalities are already successfully implementing the principles of EbA through ISMPs in the urban context," concludes Julia Berry.

Application of an Evaluation Framework

JULIA BERRY THESIS RESEARCH QUESTIONS:

Are Ecosystem-based Adaptation (EbA) principles implemented through ISMPs in Metro Vancouver?

Do Integrated Stormwater Management Plans (ISMPs) facilitate ecosystem-based resilient infrastructure in urban areas and what

METHODOLOGY:

The EbA Evaluation Framework is a comprehensive matrix (and presented on next page).

It comprises a set of 11 principles structured in 5 parts. Each principle is complemented by one or more indicators.

The goal is to elicit a yes/no binary response for each indicator.

The measurement score of 0-1-2 is based on whether an indicator is 'not mentioned' (0), 'generally mentioned' (1) or 'explicitly mentioned' (2).

TO LEARN MORE:

Download "Ecosystem-based Adaptation to Climate Change in Urban Areas: An Evaluation of Rainwater Management Practices in Metro Vancouver"

http://waterbucket.ca/wscblog/files/2016/05/Berry-REM-699-Final.pdf

The Horner and May research (1996), the Fish Protection Act (1997) and the Guidebook (2002) may be viewed as 'watershed moments' in a journey. Ecosystem-based thinking resonated. A decade and a half later, application of the **EbA Evaluation Framework** developed by Julia Berry provides local governments with a way to quantitatively assess how deeply EbA principles have taken root over time.

"Through desk research, I developed an evaluative framework to assess select ISMPs for their inclusion of EbA principles," states Julia Berry. "ISMP experts and practitioners reviewed the evaluative framework. I evaluated four ISMPs, two from the City of Coquitlam and two from the City of Surrey. I used NVivo software to assist in coding documents based on the evaluative criteria." The results of her analysis are distilled in the summary table below:

	Watershed Plans		Planning Documents		
	Coquitlam	Surrey	Municipal	Regional	Provincial
Total Score/68	49	57	46	16	32

Pathway to a Water-Resilient Future: Two decades ago, viewing the drainage engineering function through an ecosystem lens initiated a transformational shift in approach. In 2016, BC local government has arrived at another 'watershed moment' on the pathway to a water-resilient future.

Asset Management for Sustainable Service Delivery: A BC Framework is the catalyst for viewing watersheds through an asset management lens. Simply put, a watershed system is an infrastructure asset and contributes to 'municipal services'. There is growing awareness in local government of the need to protect and value a watershed system in the same way that engineered assets (and the services they provide) are managed.

Not all ecosystem services associated with a watershed provide a specific municipal function – but trees, soil, green spaces and **Water Balance pathways** do. They contribute a valuable municipal function by maintaining the *hydrologic integrity* that is essential for a healthy watershed system. The branding for this evolution of an ecosystem-based approach is **Sustainable Watershed Systems, through Asset Management**. As shown below, this is the desired outcome when natural systems thinking and climate change adaptation are integrated into asset management.

Ecosystem-based Adaptation (EbA) Evaluation Framework

(as developed by Julia Berry, 2016)

DISCUSSION:

"The holistic approach outlined in the BC Guidebook is similar to the principles of ecosystem-based adaptation outlined by Huq, Renaud, and Sebesvari (2013)."

- Julia Berry thesis
  Introduction, p. 2

"The results of this study indicate that EbA principles are incorporable into urban planning contexts, especially for sustainable rainwater management that is responsive to climate variations both present and future."

- Julia Berry thesis
  Introduction, p. 3

"A main facet of EbA is the consideration of existing ecosystem services and how they are utilized for human wellbeing (Huq et al, 2013; Munang et al, 2013.

Climate change adaptation in urban areas is increasingly concerned with protecting public and private assets from destructive climate change impacts.

Ideally, through proactive planning, urban areas can utilize existing or restored natural systems to deliver ecosystem services that duplicate or complement hard infrastructure in mitigating climate change impacts."

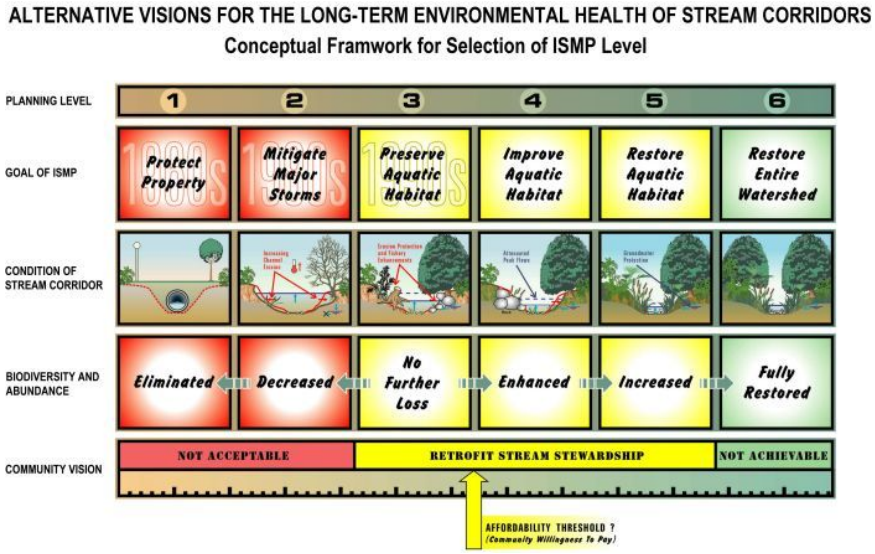
- Julia Berry thesis
  Literature Review, p. 10

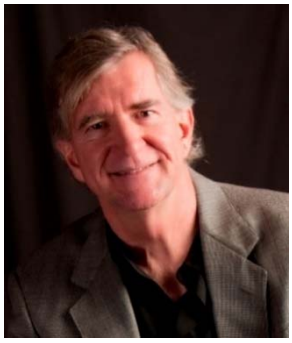
Principles	Indicators	Score
Fact Base		
Knowledge-Based Adaptation	Climate Change As An Issue	*0-1-2 coding*
	Impacts Of Climate Change	
	Vulnerability Assessment	
	Best Available Science	
	Local Climate Change Projections	
Goals		
Address Climate Change	Adaptation	
Multi-scale Operations	Integration With Development Strategies	
	Sectoral Adaption Planning	
	Multiple Geographic Scales	
Process		
Maximum Stakeholder Involvement	Stakeholder Engagement	
	Involving Local Communities	
	Collaboration And Trust	
	Commitment Of Financial Resource	
Variety	Explore A Wide Variety Of Rainwater Management Options	
	Work With Uncertainties	
	Understanding Trade-Offs	
Communication	Public Education And Awareness	
Implementation		
Integrating Development	Cost Effectiveness	
	Providing Social, Economic and Environmental Benefit	
Governance	Accountable And Transparent Decision Making	
	Roles and Responsibilities	
Monitoring		
Adaptive Management Approaches	Monitoring Timeline	
	Monitoring Actions	
	Manage Climate Variability	
Resilience Building	Resilience versus resistance	
	Manage long-term climate change	
	Promote disaster risk reduction	
	Reducing non-climate stresses	
Maintaining Ecosystems	Promote resilient ecosystems	
	Maintain ecosystem services	
	Enhancing biodiversity	
	Resource Conservation	
	Avoid Mal-Adaptation	
TOTAL SCORE/68		

Think and Act like a Watershed (part 2): Get the hydrology right and residential water quality typically follows along

*In 1996, Richard Horner and Chris May (University of Washington) published their seminal research on the cumulative impacts of land use change on stream health. Their findings shook conventional stormwater management wisdom in the Pacific Northwest to its very foundation. The legacy of Horner & May resides in their science-based **ranking** of four limiting factors. In British Columbia, science-based **understanding** has been translated into a road map for science-based **action** to restore watershed health. The work of Horner & May is integrated into Stormwater Planning: A Guidebook for British Columbia and drives the Water Balance Methodology. With release of Beyond the Guidebook 2015, the Horner & May legacy is once again at the forefront.*

In the 1990s, this "fish picture" translated scientific findings on the impact of land use change into a decision-making tool for green infrastructure goals and objectives. It captured the evolution of drainage planning philosophy over the past half-century. This provided stakeholders with clear visual choices regarding outcomes.





Bill Derry
Stormwater Pioneer,
Innovator & Champion

Chair, Washington State
Stormwater Managers Committee

Historical Context for "Get the Hydrology Right"

In the 1990s, Kim Stephens and Bill Derry (Washington State) led a workshop program for BC local government, and provided cross-border sharing of the latest research.

One of the first stormwater utility managers in Washington State, Bill Derry believed strongly in the need for scientifically-defensible research, In the 1980s, he convinced his fellow utility managers to fund a university-based research centre, founded by Richard Horner at the University of Washington in 1990. Bill Derry served as Chair into the 2000s.

In 1996, Richard Horner and Chris May published their seminal research. Two decades on, we still celebrate their accomplishments.

Richard Horner
Professor Emeritus

Founding Director (1990-1995), Center for Urban Water Resources Management, University of Washington Seattle

"S*imply put, hydrology hits first and hardest."*

"Mimic the natural water balance!"

TO LEARN MORE:

The most complete reference to all stream research undertaken by Richard Horner and Chris May is their final report to the United States Environmental Protection Agency, published in 2004. Follow this link:

http://waterbucket.ca/cfa/files/2015/02/Ecological-Effects-of-Stormwater-and-Controls-on-Small-Streams-final-report_Mar-2004.pdf

Communication of Science-Based Understanding: Early access to the research findings allowed Derry and Stephens to create what became known as the "fish pictures". These graphics translated the science, served as education and communication tools to create a common understanding, and informed decision-making by municipal, regional and provincial governments in BC as well as in Washington State. Workshops conducted by Derry and Stephens fueled interest in the ecosystem-based approach. This resulted in the **SmartStorm Forum Series**, four transformational events held between January 1999 and March 2001. The Stormwater Guidebook was an outcome.

The Test of Time: Released in November 2015, *Beyond the Guidebook 2015* has set the stage for BC moving towards **"Sustainable Watershed Systems, through Asset Management"**. This would be the next bold leap forward in the application of science-based understanding. The goal in restoring the hydrologic integrity of a watershed is to forestall an unfunded taxpayer liability flowing from "changes in hydrology". A cornerstone of this approach is the legacy work of Richard Horner and Chris May. Two decades on, water resource peers still celebrate their accomplishments. Their seminal work is standing the test of time.

Understand the Watershed as a Whole System

The research by Horner and May made it clear that stormwater (rainwater) management was as much or more about land use decisions as engineering solutions. The research also showed that communities needed to address transportation choices. Horner and May taught practitioners that **changes in hydrology**, not water quality, must be the primary focus of their efforts. If one gets the hydrology right, water quality typically follows takes care of itself in a residential development.

"So many studies manipulate a single variable out of context with the whole and its many additional variables," states Dr. Richard Horner, now a professor emeritus at the University of Washington. "We, on the other hand, investigated whole systems in place, tying together measures of the landscape, stream habitat, and aquatic life."

Mimic the Natural Water Balance: "Unless and until land development practices mimic the natural water balance, communities cannot expect to restore the biological communities within streams. Simply put, **hydrology hits first and hardest** - one could pour an equivalent volume of distilled water into a stream, and the consequences for stream health would be the same as if it was urban runoff."

Richard Horner stresses that, "When the goal of land servicing practices is pre-settlement hydrology, however, this reduces the quantity of urban runoff discharged into a stream. It also improves the quality of the remainder of that which is discharged. In short, mimicking the natural water balance has a dual benefit.

The Primacy of Hydrology: "We were not the first researchers to realize that hydrology is the controlling factor. Around 1981 there was a project at the University of Washington that should get credit for being first. That project got it going. We then built on that early research and moved the subject along," recalls Richard Horner.

"My personal realization of the primacy of hydrology started with my wetlands research in the 1980s. I started with a water quality focus in Pennsylvania but soon learned my 'hydrological lesson' when I moved to Puget Sound. With this background, it was not a big leap to come to the same realization once I turned my attention to stream work."

REFLECTIONS:

"When I look back 20 years, and reflect on how we saw things at the time, I offer this hindsight: the significance of our research findings was in gaining recognition of the primacy of hydrology. Until then, it was all about water quality."

- Richard Horner
June 2016

Action at Multiple Scales in Kitsap County

Chris May
Division Director
Surface & Stormwater

Kitsap County Public Works
Washington State

"The key to the Whole Systems approach is understanding how rainfall reaches a stream via three flow paths in a watershed – surface runoff, lateral interflow in shallow soils, and deep groundwater. Unlock that key and we can successfully implement appropriate measures to mimic the natural water balance," continues Dr. Chris May.

Twenty years later, he is Surface & Stormwater Division Director with Kitsap County Public Works in Washington State. His local government work has allowed him to put theory into practice.

Make Things Better: "At Kitsap County we have applied this Whole Systems concept to develop our strategy for watershed retrofit and rehabilitation – it is not sufficient to do only a single (or even a few) things – it is necessary to do everything! We know we need to work at multiple scales and multiple levels to improve conditions in our small stream watersheds – that's our strategy. Kitsap is at a manageable scale. The County is big enough to effect change and make things better. That is our goal – have a positive impact on the community!"

Patience plus Time: "Now it is a matter of wait and see in order to be able to show the positive effects of the retrofit program. Everyone wants instant gratification, but realizing the benefits takes time. It took 100 years to get here. It will take 100 years to turn the situation around. The initial signs are good. The monitoring shows that Kitsap County may be 'holding the line' in areas where development is occurring," concludes Chris May.

"Working at multiple scales and multiple levels is really key. But, so many people in local government are just too busy these days to even contemplate what needs to be done to repair and restore at multiple scales and levels. As a result, in the big urban cities it is just too difficult for local government staff to work concurrently at multiple scales."

SALISH SEA

Georgia Basin comprises the lands draining into the Strait of Georgia portion of the Salish Sea – east coast of Vancouver Island and Lower Mainland

Image Credit:
Washington State University

Protect Stream Health

Washington State and British Columbia are geographically similar, with a wet coast and a relatively dry interior separated by mountain ranges. On the coast, Washington State's Puget Sound and BC's Strait of Georgia together comprise the Salish Sea.

A Road Map for Integrated Watershed Management: In 1996, the seminal paper by Richard Horner and Chris May synthesized a decade of Puget Sound research to identify the factors that degrade urban streams and negatively influence aquatic productivity and fish survival. Horner and May demonstrated that the four factors limiting stream health are, in order-of-priority:

1. **Changes in Hydrology –** Greater volume and rate of surface runoff caused by increased impervious area and road network densification.
2. **Disturbance and/or Loss of Integrity of the Riparian Corridor** – Clearing and removal of natural vegetation in riparian (streamside) areas.
3. **Degradation and/or Loss of Aquatic Habitat within the Stream** – Caused by erosion and sedimentation processes, bank hardening, and removal of large organic debris; aquatic habitat degradation is a direct result of 'changes in hydrology'.
4. **Deterioration of Water Quality** - Increased fine sediment load due to more runoff volume causing channel erosion. Pollutant wash-off from land uses, deliberate and accidental waste discharges.

A KEY FINDING:

When the watershed goal is protection of aquatic resources, Richard Horner and Chris May proved that a water-quality driven program would not achieve the goal.

The limiting factors and order-or-priority identified by Richard Horner and Chris May provided a 'road map' for rainwater management in a watershed sustainability context. In BC, the Horner and May findings provided a reason and a starting point to 'reinvent urban hydrology' and develop the Water Balance Methodology, adopted by the Province as the technical foundation for *Stormwater Planning: A Guidebook for British Columbia*.

The Partnership describes this approach as 'mimic the natural water balance'. The Water Balance Methodology is founded on standard scientific and engineering principles. The innovation is in the integration and application of these principles.

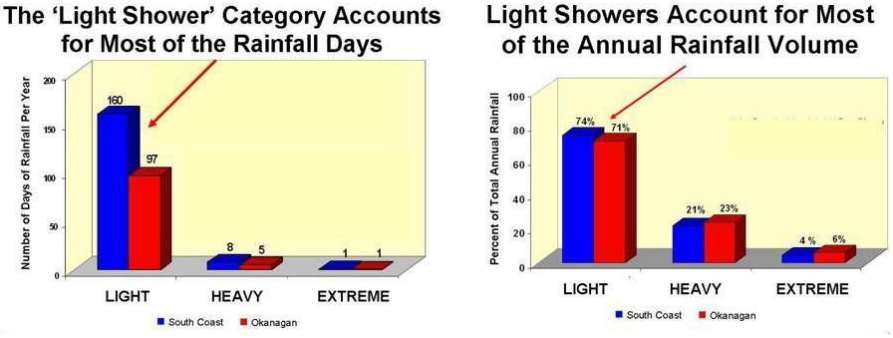
As a result, this has focussed attention on the rainfall interception role of trees as well as how water moves through soil. In turn, this has led to development of standards of practice that are guided by a 'design with nature' philosophy.

Look at Rainfall Differently

Water Balance Methodology *links actions at the site scale with desired outcomes at a watershed scale.*

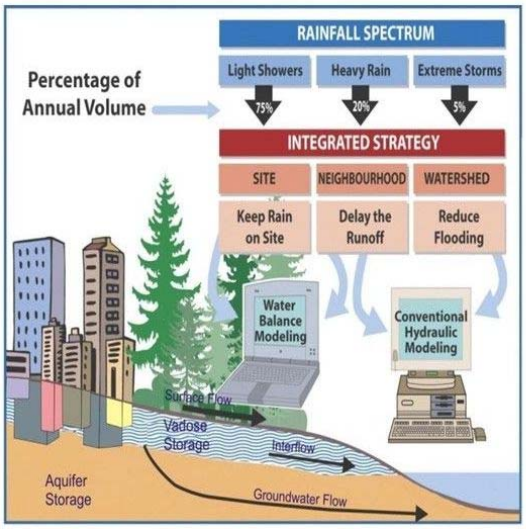
Circa 2000, the images below were among the keys to changing the core beliefs of drainage practitioners so that they looked at rainfall differently. In fact, the images proved to be a powerful educational tool because they demonstrated that 'light showers' account for most of the annual rainfall volume. This, in turn, promoted an understanding that infiltration and tree interception are readily achievable for much of the year.

Rainfall Spectrum Concept *demonstrated achievability of 'rainfall capture'. And this helped overcome 'fear and doubt'.*



Water Balance Methodology *is evolving as science-based understanding grows. A key goal is to improve the technical basis for decisions.*

The Integrated Strategy: The Water Balance Methodology is founded on the concept known as the Rainfall Spectrum. This is a universal relationship. The number of rainfall-days and the rainfall volume per year may vary by region, but various regional analyses show that the distribution of that volume has a consistent pattern. The methodology accounts for all the rainfall-days in a year. It links rain that falls on a site, to the water leaving the site via three Water Balance pathways, to the flow in a stream. The image below illustrates the elements comprising the *Integrated Strategy for Managing the Rainfall Spectrum*:



TIME SCALE OF WATERSHED FLOWS:

Watershed protection starts with an understanding of how water gets to a stream, how long it takes, and whether there are impacts along the way.

Surface runoff
from minutes to hours

Interflow
from days to seasons

Deep Groundwater
from years to decades or more

Maintain the proportion of rainwater entering the stream via each pathway

Think and Act like a Watershed (part 3): A journey to a water-resilient future starts with the first rain garden

In 1996, Richard Horner and Chris May (University of Washington) published their seminal research on the cumulative impacts of land use change on stream health. Their findings shook conventional stormwater management wisdom in the Pacific Northwest to its very foundation. The significance of their research findings was in gaining recognition of the ***primacy of hydrology****. Get that right and both stream restoration and residential water quality typically follow along. Twenty years later, new research by Dr. Jenifer McIntyre (Washington State University) demonstrates the dual benefits of rain gardens when they mimic the natural Water Balance and eliminate toxicity from urban runoff.*

FOLLOW THE LINK TO WATCH YOUTUBE VIDEO:

https://www.youtube.com/watch?v=BNruLbD2sP8

In the video, Dr. Jenifer McIntyre describes new findings about how Coho salmon die when exposed to urban drainage. Her lecture is titled: "Stormwater detox: How natural infrastructure can help save salmon" (April 2016). The video provides a detailed explanation of why rain gardens eliminate toxicity.

Team members are mainly from the National Marine Fisheries Service (formerly known as NOAA Fisheries) and the US Fish & Wildlife Service

Rain Gardens Eliminate Toxicity

Coho salmon spend half their lives in freshwater. This makes them sentinels whose health speaks well for the food web, the quality of its streams, and the rainwater runoff that does or does not flow into them. More than a decade ago, unintended consequences for a City of Seattle stream restoration project in Longfellow Creek led to discovery of a phenomenon called Pre-Spawn Mortality (PSM), caused by road runoff.

Salmon exposed to toxic rainwater runoff can die in a matter of hours. But preliminary new findings by the Washington State University research team led by Jenifer McIntyre suggests that bioretention systems, such as rain gardens, that filter out contaminants from rainwater runoff are key for preventing lethal impacts on fish.

MULTIPLE SCALES / LEVELS:

"The damage is at multiple scales. Therefore, repair and restoration must also be at multiple scales, and at multiple levels. We cannot do just one thing and expect change. We must retrofit old development. We must also do riparian, in-stream and floodplain restoration as well."

- Chris May
June 2016

Pre-Spawn Mortality: "The City of Seattle built it (stream restoration), the coho salmon came, the salmon died. Subsequent research resulted in discovery of PSM," recalls Chris May, Surface & Stormwater Division Director with Kitsap County Public Works. Previously he was Urban Watershed Manager with Seattle Public Utilities. "PSM is a phenomenon where more than 60% of adult coho salmon die before they get a chance to spawn. This has been observed across much of the Puget Sound region."

"Research has been in progress for more than a decade. While PSM appears to be a water quality effect, the research cannot pin it down. As Rich Horner has observed, *it is the urban cocktail that kills the salmon*."

"Jenifer McIntyre has extended the research by taking highway runoff and demonstrating that rain gardens eliminate toxicity. This dual benefit rounds out the case for retrofitting rain gardens to mimic the natural Water Balance. Water quality is not the culprit until a watershed is well up the development scale. Physical impacts of a changing landscape is THE issue. Then riparian, in-stream and water quality – in that order," emphasizes Chris May.

Saving Salmon: A Message of Hope

TRANSFORMATIONAL FINDING:

"Our research shows that for all experimental combinations, the bioretention system ELIMINATED the toxicity. Not reduced. Completely eliminated!"

"Even though we no longer have the forest we once had, with Green Infrastructure we can help the urban landscape act more like a forest."

Dr. Jen McIntyre

Washington State University Research & Extension Center in Puyallup

"At Washington State University, I study urban stormwater runoff and its impacts on aquatic animals. The really exciting thing about the research that we are doing, and the results we are getting, is that it gives people hope. Green stormwater infrastructure really can be part of the solution," continues Jenifer McIntyre, an Aquatic Ecotoxicologist at Washington State University (WSU).

Her Ph.D. research in 2010 at the University of Washington helped pass legislation in Washington and California that phases out copper and other metals in brake pads.

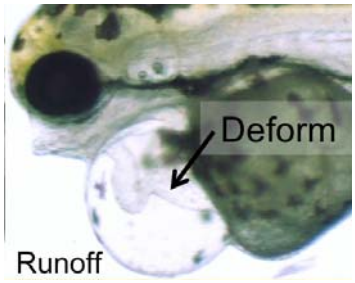
"Urban stormwater runoff carries a complex mixture of hydrocarbons, some of which are toxic to the cardiovascular system of animals, into fish habitats," McIntyre said. "We have seen that stormwater runoff can kill adult Coho salmon in urban creeks, and we know that it can cause defects in the heart of developing fish."

She studies Coho salmon in particular because they spend a significant amount of their lives in freshwater compared to other types of salmon.

Episodic Exposure in the Real World: At the WSU Innovator Lecture, Jenifer McIntyre also presented initial results on the ability of bio-retention to prevent toxicity in Coho embryos that have had acute and intermittent exposure to runoff during development.

"Episodic exposure is what happens in the 'real world' – which is what we were trying to approximate over the course of the three-month-long embryonic development of Coho embryos," she said.

The bio-retention filtration system used was able to remove contaminants that caused the worst effect: death.



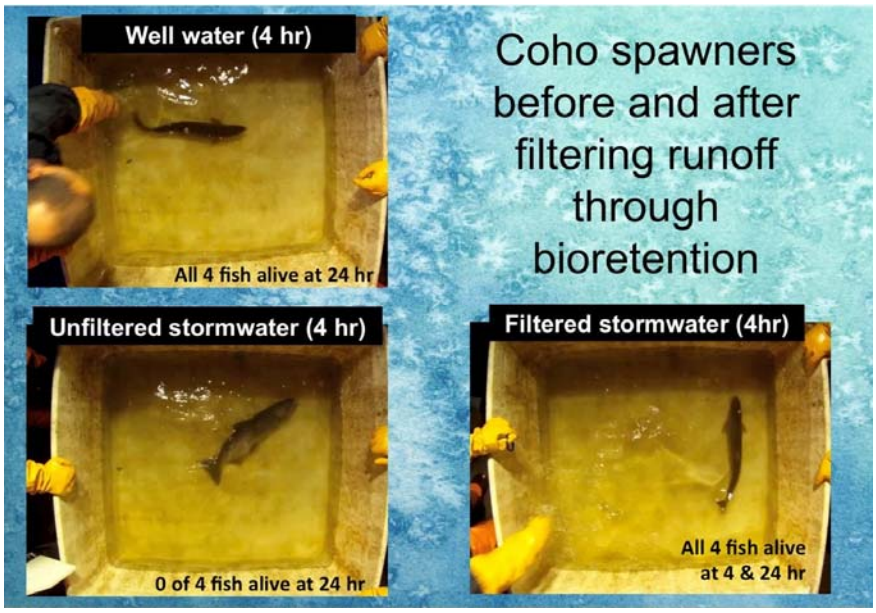
The heart is a target for road runoff contaminants

A focus on road runoff because…

"Five years ago when we started our research, we chose to work with road runoff because roads are the common denominator across all urban land uses. It turns out that road runoff can cause mortality in juvenile and adult salmon, and heart defects in developing fish," explained Jenifer McIntyre.

"We also wanted to know whether toxic effects could be prevented. One of the potential solutions is green stormwater infrastructure, such as rain gardens, to soak the water into the soil and filter out contaminants."

"We don't need to know everything about how toxic runoff is, or how it causes toxicity, to be able to do something about the problem. To date, the experimental results are pretty impressive – for example, 100% fish dead in polluted runoff compared with 100% fish survival in the same water after it had been filtered."



TO LEARN MORE:

The results of the research were published in the August 2015 issue of the Science Direct Journal, the world's leading source for scientific, technical, and medical research.

*"**Soil bioretention protects juvenile salmon and their prey from the toxic impacts of urban stormwater runoff**"*

http://waterbucket.ca/wscblog/files/2016/06/Jen-McIntyre_WSU-journal-article_2016.pdf

Published under a Creative Commons license.

A Path Forward

"Get the hydrology right and water quality typically follows along."

Dr. Richard Horner
Professor Emeritus
University of Washington

"One of the new results I am most excited about is the cause-of-death research," state Jenifer McIntyre. "For more than a decade we have been studying pre-spawn mortality in Coho returning to urban areas. For the first time, we have a real path forward for figuring out what about urban runoff is causing the problem."

"The cause-of-death research has shown that, based on blood gas and blood chemistry, Coho exposed to urban runoff appear to suffer from a lack of oxygen at the tissue level."

"We know there is oxygen in the water, and oxygen is in the fish's blood, but that oxygen either isn't getting to their tissues or their tissues aren't able to use it. With this new information, we can start tracking down the precise mechanism causing the hypoxia, which we hope will help us identify the responsible contaminants."

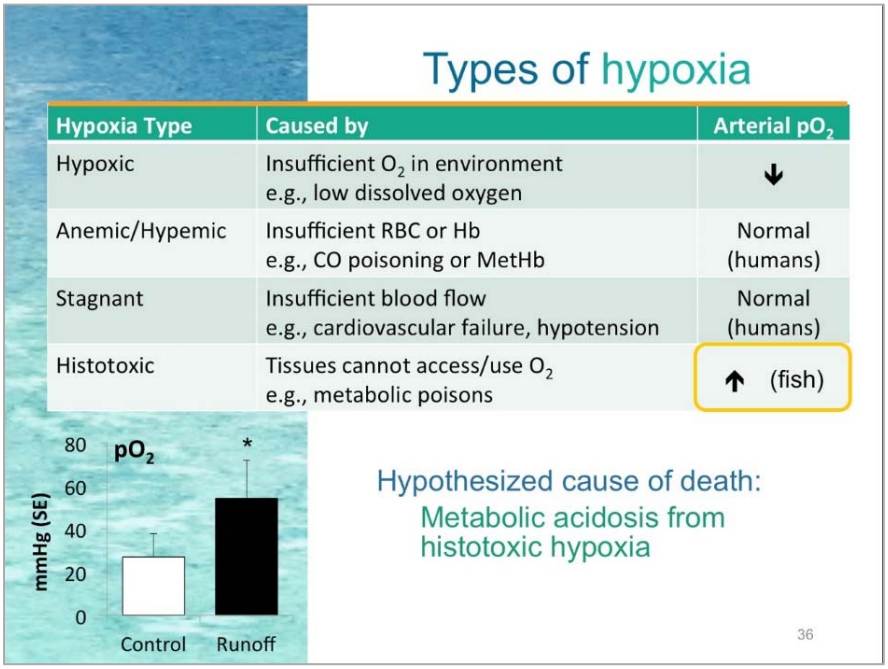
Jim Dumont
Engineering
Applications Authority

Partnership for Water
Sustainability in BC

Whole Systems Approach: "Hydrology and chemical habitat quality are intricately linked in the urban environment. Without an appropriate water flow regime the physical habitat cannot sustainably support salmon and their food web. And when water is running untreated off of impervious urban surfaces, it carries with it contaminants to which salmon are exceptionally sensitive. To regain and maintain healthy salmon populations, we need appropriate physical and chemical habitats," concludes Jenifer McIntyre.

"This has been our message all along, that implementation of the Water Balance Methodology will take care of the water quality along with the water balance, stream flow, and flood protection"

May 2016



How to Restore Watershed Function

A journey to a water-resilient future starts with the first rain garden

The flow of rainwater from cloud to stream is via three *Water Balance pathways*: surface runoff, interflow and deep groundwater. An over-arching objective in applying the Water Balance Methodology is that urban development would maintain the proportion of flow via each pathway. In other words, an integrated design for land development, rainwater management and groundwater recharge would balance the annual volume necessary for interflow storage with the annual volumes necessary to sustain the duration of interflow and allow infiltration to groundwater.

Application to Rain Garden Design: Application of the Water Balance Methodology yields three watershed-based performance targets for Retention Storage Volume, Base Flow Rate and Infiltration Area. The three correspond to the design elements of a rain garden (below). A single rain garden would not make a material difference to a city's water balance. But thousands would. Hence, a journey to a water-resilient future starts with the first rain garden.

Visualize the Design Elements of a Rain Garden

Retention Volume *for interflow storage*

Flow Release *from storage to sustain duration of interflow (shallow groundwater)*

Infiltration Area *to allow for deep groundwater recharge*

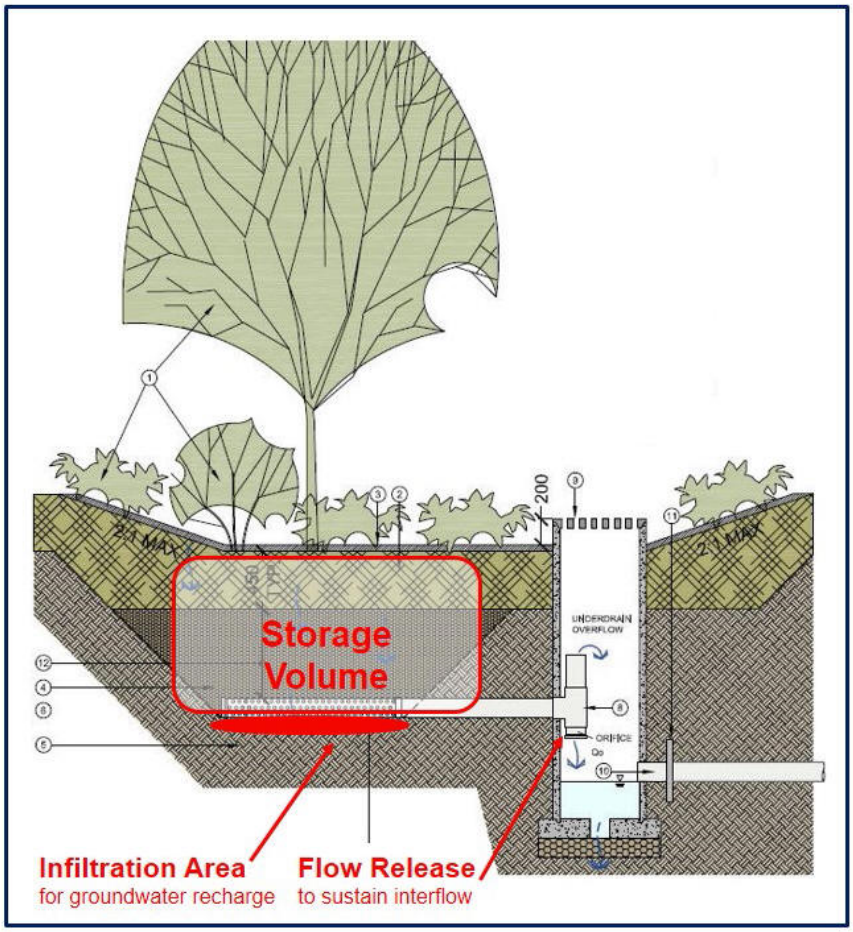


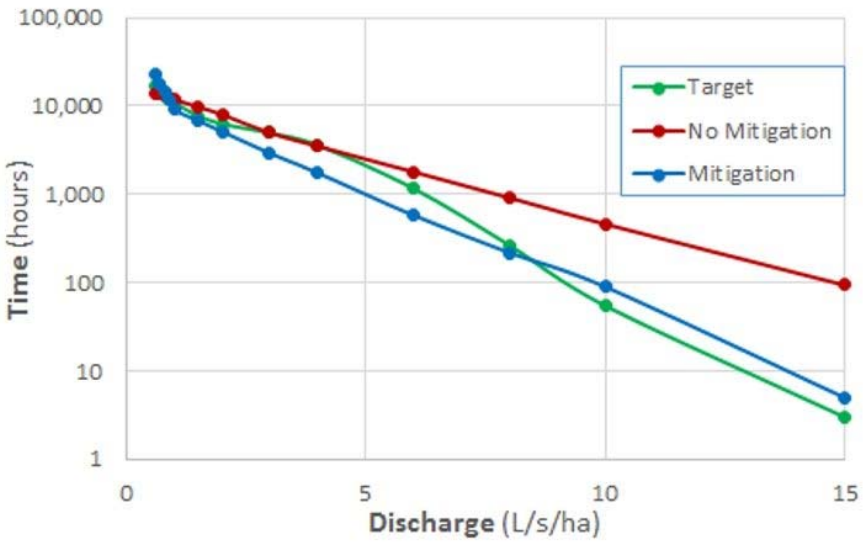
Image Source: *Stormwater Source Control Design Guidelines 2012 (Final Report), Metro Vancouver*

Think and Act like a Watershed (part 4): Water balance pathway to a water-resilient future

*In 1996, Richard Horner and Chris May (University of Washington) published their seminal research on the cumulative impacts of land use change on stream health. This established the **primacy of hydrology**. This recognition then led to development of the **Water Balance Methodology**, adopted by the Province of BC in 2002. The methodology is evolving as science-based understanding grows. It is the foundation for an ecosystem-based approach to protection of hydrologic integrity, and hence stream system resilience. Recently implemented regulatory requirements in Washington State and California apply the same **flow-duration science.** Replicating the flow-duration pattern is the way to mimic the natural Water Balance.*

This graph illustrates the flow-duration relationship:

Analysis begins with calibration of continuous simulation models using long term climate records, not just selected storms or typical years. The effects of urban development are then estimated and required mitigation measures are sized and optimized.



"The Water Balance Methodology provides a logical and straightforward way to assess potential impacts resulting from urban development and analytically demonstrate effectiveness of proposed mitigation methods."

Jim Dumont
Partnership for
Water Sustainability in BC

What Happens on the Land Matters!

The Water Balance of watersheds in urban areas is out of balance. A legacy of community and infrastructure design practices has failed to protect the water balance. Restoring hydrologic integrity, and thus the Water Balance, is the pathway to a water-resilient future.

Everyone learns about the water cycle in elementary school, but by high school most have forgotten what they learned. In a natural watershed, for example, the primary Water Balance pathway is shallow horizontal flow through the surface soil 'sponge'.

Parallel Journeys in BC, Washington State and California

Dr. Eric Stein
Principal Scientist

Southern California Coastal Water Research Project

Early Adopter & Champion for Hydromodification Assessment & Management

"In 2005, we first recognized that replicating flow-duration is key to preventing erosion impacts. ....Collaboration with Derek Booth (of Washington State) was critical to development of a research agenda to create tools and capacities."

Dr. Derek Booth
Adjunct Professor (since 2011)
Univ of Southern California
Santa Barbara

Director (1995-2004),
Center for Urban Water Resources Management
&
Affiliate Professor (since 2006)
University of Washington

"BC, Washington State and California are travelling along parallel pathways," states Jim Dumont, Engineering Applications Authority, Partnership for Water Sustainability in BC.

"Each region has its own terminology, such as *hydromodification* in California, yet the analytical methodologies have a common 'flow-duration foundation'. This leads to the same outcome: **mimic the Water Balance**. A shared vision is to mimic streamflow and duration to limit stream erosion, prevent flooding and improve water quality."

Flexibility and Effectiveness: "The innovation in BC's Water Balance Methodology is found in the integration and application of proven scientific and engineering principles. The methodology provides a logical and straightforward way to assess potential impacts resulting from urban development; and analytically demonstrate the effectiveness of the methods proposed for preventing and/or mitigating those impacts."

"The Partnership for Water Sustainability is evolving the Water Balance Methodology as our understanding of HOW to restore hydrologic integrity grows. The methodology now synthesizes fundamentals of hydrology, flood protection, aquatic ecology, geomorphology and hydrogeology."

"Our guiding philosophy for application of the Water Balance Methodology emphasizes flexibility, and effectiveness, in optimizing and reducing the costs of the solution."

Flow-Duration Analysis: "We integrated Flow-Duration Analysis in 2007. Washington State and California have gone a step further and mandated Flow-Duration Analysis as a regulatory requirement in 2012 and 2015, respectively. A commonality is that all three regions are addressing impacts to the stream," stresses Jim Dumont.

"The environmental flows objective of the new Water Sustainability Act opens the door to requiring Flow-Duration Analysis in BC," adds Peter Law, a founding Director, Partnership for Water Sustainability in BC. Formerly with the Ministry of Environment, Peter Law was Chair (2000-2002) of the inter-government steering committee responsible for BC's Stormwater Guidebook.

"Within the next few years, the Act will establish regulations pertaining to stream health and aquatic environments. Currently, the Province's effort is being directed into groundwater protection and regulation, which is of course an important part of the Water Balance."

Ray Linsley
(1917-1990)

Professor at Stanford University, author, innovator & pioneer modeller

Pioneered development of continuous hydrologic simulation as the foundation for water balance modelling

"To be useful...the simulation model must be physically based and deterministic, and it must be designed to simulate the entire hydrological cycle...hence it must be a water balance model."

Establish Watershed Targets with Verifiable Calculations

"The flow-duration relationship is the cornerstone of the Water Balance Methodology," continues Jim Dumont. "By maintaining flow-duration, stream erosion is not increased during wet weather and 'environmental flows' are sustained during dry weather. When homeowners slow, sink and spread rainwater runoff on their property, urban streams benefit."

"Protection of streams and fish is an important public expectation in BC, creating a driving force altering our perceptions, aspirations, and treatment of the urban landscape. Water Balance Methodology objectives start with the stream and end with the stream, thereby providing a true measure of success for environmental protection."

"Understanding how precipitation makes its way to the stream via three pathways, each with a different time scale, allows one to assess how a watershed and stream operate while analytically demonstrating impacts of development and the effectiveness of mitigation works."

"Managing watersheds as an integrated Water Balance system means: *establish watershed targets with verifiable calculations*. Then mitigation systems, such as rain gardens, can be optimized for both cost and function," concludes Jim Dumont.

Linking Rainfall, the Landscape, Streamflow, Groundwater and Sustainable Service Delivery has been a building blocks process

"The role of local government is to deliver services. Achieving sustainable service delivery is the end goal of asset management."

David Allen
CAO, City of Courtenay

Co-Chair
Asset Management BC
July 2016

2002 – How to reduce runoff volume
("Stormwater Guidebook: A Guidebook for BC)

2007 – How to mimic flow-duration
(City of Surrey - Fergus Creek Watershed Plan)

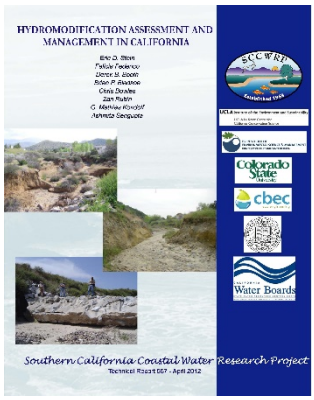
2012 – How to sustain deep infiltration
("Primer on Integrated Rainwater & Groundwater Mgmt")

2013 – How to integrate performance targets
(Cowichan Valley & North Vancouver - case studies)

2014 – How to downscale targets to a site level
("Primer on Water Balance Methodology")

2015 – How to view water balance pathways as infrastructure assets providing services
("Beyond the Guidebook 2015: Sustainable Watershed Systems, through Asset Management")

GUIDANCE DOCUMENT



DOWNLOAD FROM **LINK:**

http://waterbucket.ca/rm/files/2016/06/Eric-Stein_hydromodmgmt_2012.pdf

Implementation of Hydromodification Assessment and Management in California

"Hydromodification refers to alterations in natural watershed hydrology associated with changes in land use or cover," states Dr. Eric Stein, Principal Scientist – Biology Department, Southern California Coastal Water Research Project. He was an early champion for a science-based approach to development of an assessment methodology. His agency is an independent public agency funded by 14 other agencies.

"My agency works with federal, state, and local partners to develop strategies and approaches for more effectively assessing and managing the health of aquatic ecosystems. Our goal is to facilitate consensus around the science. We have no policy authority."

"The genesis for hydromodification assessment and management dates back to 2005 and introduction of the Water Quality Regulation. Because it specified protection of beneficial uses of water, the regulation triggered development of regulatory tools."

Dr. Brian Bledsoe
Inaugural Professor in Resilient Infrastructure
University of Georgia

Brian Bledsoe's research is focused on the interface of hydrology, ecology and urban water sustainability with an emphasis on the sustainability and resiliency of green infrastructure including streams, floodplains and stormwater systems.

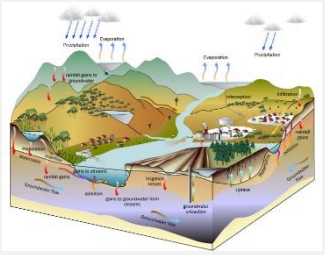
Prevention of Erosion Impacts: "In 2005, we first recognized that replicating flow-duration is key to preventing erosion impacts. We convened a 2-1/2 day workshop that resulted in a research agenda to move the state to develop tools and build capacity to use the tools," continues Eric Stein.

"Collaboration with Derek Booth (Washington State), Brian Bledsoe (then at Colorado State; currently at University of Georgia) and other experts was critical to development of a consensus-based road map of projects. Booth and Bledsoe are co-authors of our 2012 guidance document."

"Hydromodification assessment and management is becoming a standard requirement that cascades down through regulatory and management programs across Southern California. Most jurisdictions in California address the effects of hydromodification through either a municipal stormwater permit or the statewide construction general permit."

Science-based principles as applied in BC (since 2007) for restoring hydrologic integrity are now required in Washington State (2012) and in California (2015)

1. Address impacts to the stream
2. Use "Flow-Duration Analysis"
3. Apply continuous simulation to model entire hydrologic cycle for multiple years
4. Recognize that single-event modelling does NOT work



Water Balance in a West Coast Watershed

The table below summarizes where the water goes naturally before urban development changes the Water Balance distribution:

Water Balance Methodology *is based on maintaining the natural proportions of rainwater entering the stream via each Water Balance pathway.*

Replicating the flow-duration pattern is the science- based way to mimic the natural Water Balance.

PRECIPITATION = 100%		
LOSSES = 20%		
	Surface Evaporation	= ~10%
	Loss to Deep Groundwater	= ~ 5%
	Plant Transpiration	= ~ 5%
STREAMFLOW = 80%		
Water Balance Pathways	Direct Runoff	= ~10%
	Groundwater from Aquifers	= ~15%
	Interflow	= ~55%

Development eliminates interflow, in turn reducing 'environmental flows' that sustain the urban fisheries resource during dry-weather periods.

Coming in Fall 2016…..

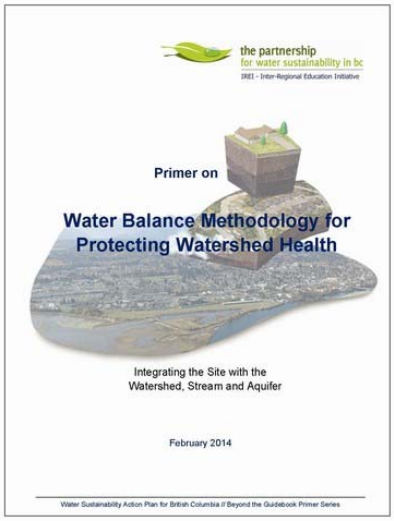
Peter Coombes

Australian Water Champion & Water Advisor to Governments

"A commonality of understanding between BC and Australia is that we are managing a water balance in a connected system of human endeavour and ecosystem processes."

In 2014, the Partnership for Water Sustainability released the *Primer on the Water Balance Methodology for Protecting Stream Health*. Later in 2016, the Partnership will release an updated Primer that elaborates on parallel journeys in Washington State, California and Australia.

The updated Primer will also incorporate a **Peer Review / Perspective** by Dr. Peter Coombes, former Chief Scientist, State of Victoria, Australia. "It is an exciting story of parallel endeavour - not exactly the same, but similar fundamental principles with opportunities to learn from each other on the differences," foreshadows Dr. Coombes.

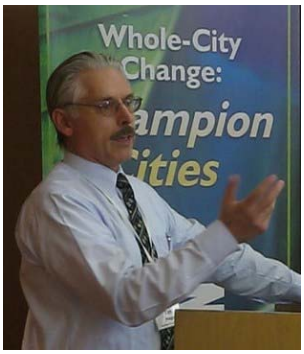


To download the Primer, follow this link:
http://waterbucket.ca/wp-content/uploads/2012/05/Primer-on-Water-Balance-Methodology-for-Protecting-Watershed-Health_February-2014.pdf

How the Pieces of the Picture Fit Together

The road map graphic opposite illustrates how the work of the Partnership for Water Sustainability fits within the provincial framework for Living Water Smart and Building Greener Communities.

*The graphic conceptualizes the multiple land water processes that can be at play in a region. Going forward, the twin pillars of the Georgia Basin Inter-Regional Education Initiative (IREI) will be the Water Balance Methodology (existing) and the **Ecological Accounting Protocol** (to be developed).*



Tim Pringle

Chair, Ecological Accounting Protocol Initiative

Partnership for Water Sustainability in BC

"The best blend of engineered assets (infrastructure) and natural assets (that provide ecological goods and services) would support a robust long-term asset management plan and the required financial commitments."

A GOAL: **Build Greener Communities**

LIVING WATER SMART CASCADING OBJECTIVES:
Deal with Uncertainty
Manage the Water Balance
Adapt to a Changing Climate

AN OUTCOME: **Settlement, Economy and Ecology in Balance**

Water Sustainability Plans

What We Want Our Regions to Look Like in 50 Years

We define our communities based on what we allow on the ground

Every community has a different motivation and is working at different levels towards sustainability. There are various points of entry depending on where a community is with its water planning efforts.

Other Land & Water Planning Processes

Such as:
- Local and senior government initiatives
- Land use, zoning and development directives
- Water management plans
- Watershed protection initiatives

Partnership for Water Sustainability in BC

Water Sustainability Action Plan for BC
Georgia Basin Inter-Regional Education Initiative

Sustainable Watershed Systems, through Asset Management

Water Balance Methodology

Ecological Accounting Protocol

Appendix –
Beyond the Guidebook Primer Series

Core concepts presented in the *Beyond the Guidebook Primer Series* provide an educational foundation for rainwater management in a watershed context. Copies of the five previous Primers in the series may be downloaded by following the links provided on the page opposite.

Genesis of Water-Centric Planning in British Columbia

Published in March 2002 by Metro Vancouver, *A Watershed / Landscape-Based Approach to Community Planning* was developed by an interdisciplinary working group under the aegis of Metro Vancouver's Technical Advisory Committee. In its simplest expression a watershed / landscape-based approach is aimed at the:

- Protection of people and property from natural hazards.
- Protection and conservation of self-sustaining ecosystems.
- Continuation and growth of resource-based economic activity.
- Provision of an affordable, sustainable and maintainable infrastructure.

The underpinning premise is that resource, land use and community design decisions will be made with an eye towards their potential impact on the watershed. Hence, the *Watershed/Landscape-based Approach* was incorporated as an original element of the Water Sustainability Action Plan for British Columbia.

This element subsequently morphed into *Water-Centric Planning*. By definition, this means planning with a view to water – whether for a single site or the entire province. At the core of water-centric planning is a water balance way-of-thinking and acting.

Stormwater Planning: A Guidebook for British Columbia is a prime application of the watershed / landscape-based approach. In the Guidebook context, what happens at the scale of the individual parcel and street affects what happens at the watershed scale.

Released in 2002, the Guidebook was the catalyst that resulted in BC being recognized internationally as a leader in implementing a natural systems approach to rainwater management. The Guidebook's premise that land development and watershed protection can be compatible represented a radical shift in thinking in 2002.

Beyond the Guidebook[1] Primer Series

Integrating the Site with the Watershed, Stream and Aquifer

Primer on Rainwater Management in an Urban Watershed Context (2011)
http://bc.waterbalance.ca/files/2011/12/1_Primer-on-Rainmwater-Management-in-Urban-Watershed-Context_November2011.pdf

Provides engineers and non-engineers with a common understanding of how a science-based approach to rainwater management has evolved since the mid-1990s.

Primer on Urban Watershed Modelling to Inform Local Government Decision Processes (2011)
http://bc.waterbalance.ca/files/2012/05/2_Primer-on-Urban-Watershed-Modelling-to-Inform-Decision-Process_November2011.pdf

Provides engineers and non-engineers with guidance in three areas: setting performance targets, defining levels-of-service, application of screening / scenario tools.

Primer on Integrated Rainwater and Groundwater Management for Lands on Vancouver Island and Beyond (2012),
http://waterbucket.ca/rm/files/2013/07/3_Primer-on-Integrated-Rainwater-Groundwater-Management-for-Lands-on-Vancouver-Island_April-2012.pdf

Provides engineers and non-engineers with a common understanding of the links between rainfall, groundwater movement and surface flows in sustaining aquatic life.

Primer on Land Development Process in BC: Industry Standards of Practice in Implementing Rainwater Management (2013)
http://waterbucket.ca/cfa/files/2013/09/4_Primer-on-Land-Development-Process-in-BC_September-2013.pdf

Provides context and general guidance for implementing rainwater management systems at the site, subdivision, neighbourhood or community scales.

Primer on Water Balance Methodology for Protecting Watershed Health *(2014)*
http://waterbucket.ca/wp-content/uploads/2012/05/Primer-on-Water-Balance-Methodology-for-Protecting-Watershed-Health_February-2014.pdf

Provides guidance on how to apply the Water Balance Methodology and quantify three performance targets, namely: storage volume, infiltration area and flow release rate.

Mimic the Natural Water Balance to Reduce Risk, Protect Watershed and Stream Health, and Comply with Regulatory Requirements!

[1]Stormwater Planning: A Guidebook for British Columbia
http://www.env.gov.bc.ca/epd/epdpa/mpp/stormwater/guidebook/pdfs/stormwater.pdf