WATER Balance MODEL

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the partnership for water sustainability in bc

Convening for Action in British Columbia

Water Balance Methodology

Integrating the Site with the Watershed and the Stream

March 2012

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Look at Rainfall Differently

A decade ago, looking at rainfall differently led the Province of BC to develop the *Water Balance Methodology,* and initiate a paradigm-shift in the way rainwater is managed. The Province:

- ☐ Formalized the performance target methodology in *Stormwater Planning: A Guidebook for British Columbia*, a provincial guidance document released in 2002.
- ☐ Translated science-based understanding so that local governments could establish achievable and affordable performance targets for rainfall capture and runoff control.

BC was the first provincial or state government in North America to implement the Water Balance Methodology.

Historical Context

At the turn of this century, the *UniverCity Sustainability Community* atop Burnaby Mountain in Metro Vancouver was the genesis and first case study demonstration for the Water Balance Methodology. By 2002, the Province's decision to embed the Water Balance Methodology in the Stormwater Guidebook defined a turning point in the regulatory vision for drainage planning, from reactive to proactive.

In the mid to late 1990s, widespread changes in thinking about rainwater and stormwater impacts reflected new insights. Historical context is provided as follows:

- ☐ **In 1973:** A glimmer of understanding when Thomas Hammer publishes his research findings on the relationship between land use changes and stream erosion.
- ☐ **By 1996:** A year of breakthroughs by a number of pioneers results in a 'roadmap' for integrated rainwater management.
- ☐ **By 2000:** A mandate to re-invent urban hydrology in order to protect tributary stream health in the Brunette River urban watershed in Metro Vancouver leads to development of the Water Balance Methodology.
- ☐ **In 2002:** Province releases the Guidebook.
- ☐ **By 2007:** Beyond the Guidebook brings together all the pieces to link the site to the watershed to the stream.

The Water Balance Model, a web-based scenario comparison tool, was developed as an extension of the Guidebook. It enables assessment of how to meet performance targets for rainfall capture.

Evolution of the Methodology

The Water Balance Methodology is dynamic; and it is being enhanced over time to incorporate fresh insights resulting from science-based understanding. A key goal is to improve the technical basis for local government decisions. Three milestones in the evolutionary process are introduced below:

- ☐ First, in 2002, the Guidebook integrated hydrology and aquatic ecology. This built on Washington State research findings about the four factors limiting stream health.
- ☐ Then, in 2007, the 'Beyond the Guidebook' initiative added geomorphology to the mix. This addressed the relationship between volume control and resulting flow rates in streams; and correlated stream health with stream erosion.
- ☐ Now, in 2012, the understanding yielded by the Englishman River research on Vancouver Island has added a groundwater dimension to stream health.

The Water Balance Methodology is a foundation block for those tasked with developing a Master Drainage Plan, an Integrated Stormwater Management Plan (ISMP), the Rainwater Management Component of a Liquid Waste Management Plan, or a Watershed Blueprint.

Hydrologic Impact Assessment

1. Use continuous simulation to assess the mass balance of rainfall, runoff, infiltration and evaporation.

2. Graphically represent the mass balance analysis.

3. Use the continuous simulation to estimate discharge exceedances. These would be the values of runoff plus groundwater return to the system.

4. Present results of flow exceedance analysis results in tabular or graphical format.

5. Use BMP's to achieve the desired objectives.

Establish Targets

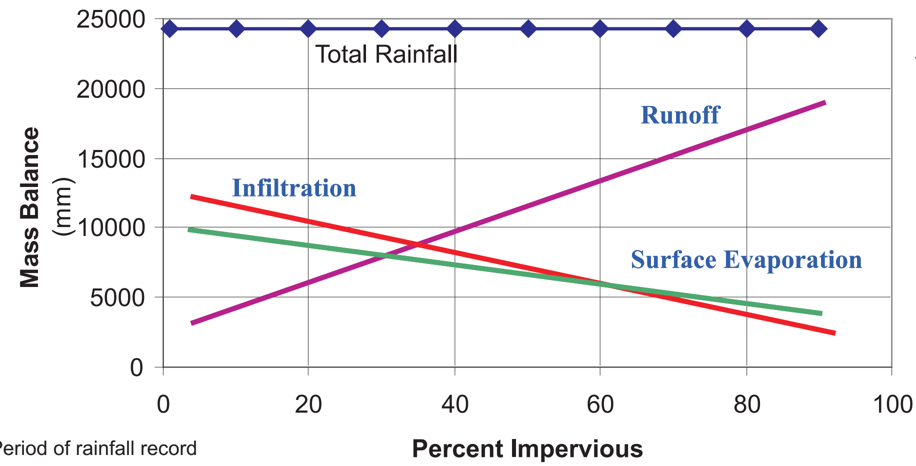
Two methods can be used to establish targets used for design of runoff volume reduction systems and facilities.

1. Use the volume of runoff from redevelopment or existing watershed conditions, or

2. Use the stream flow duration and exceedance analysis combined with the stream erosion potential to establish discharge rate and volume targets.

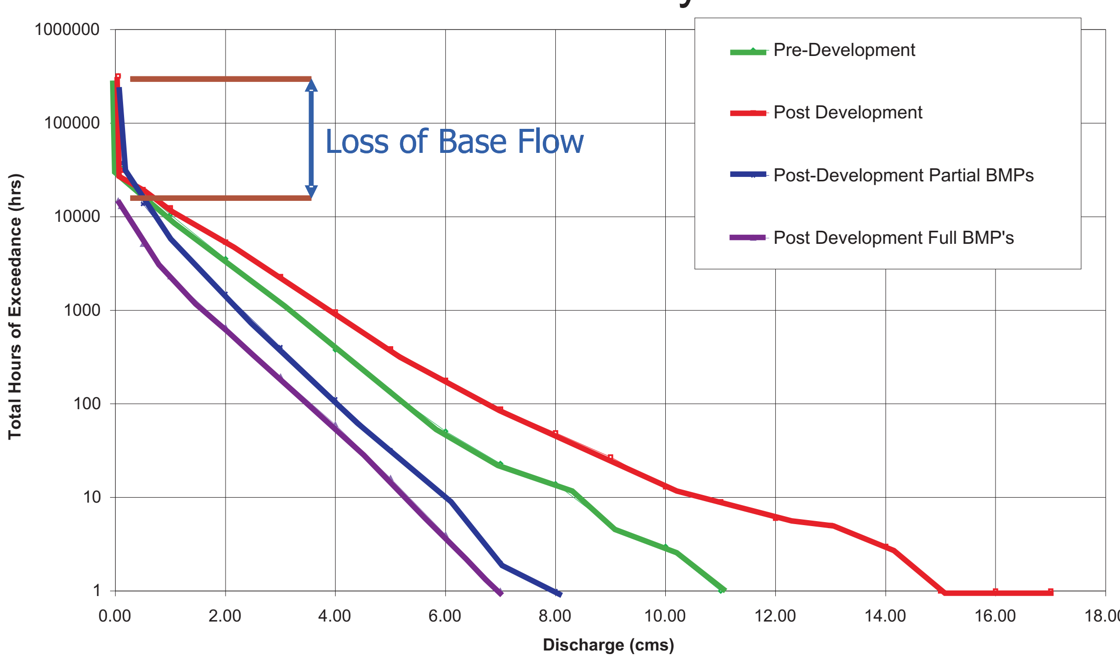
Test and optimize the size and the operation of the runoff volume reduction systems and facilities in the watershed to achieve the desired objectives and targets.

Mass Balance Analysis

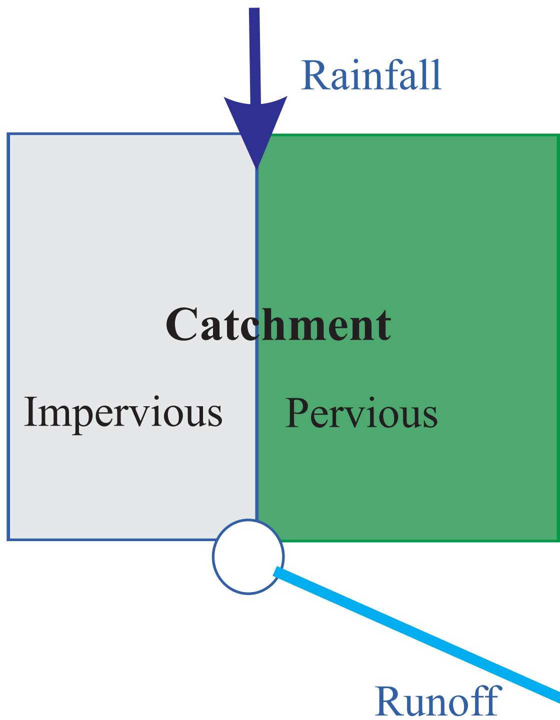


Period of rainfall record
1982 through 1999

Flow Exceedance Analysis



Hydrologic Change Assessment



Watershed Discharge

Changing the watershed surface characteristics, or catchment parameters, can provide an assessment of changes in hydrologic function of watersheds resulting from development.

Several volume reduction methods can also be assessed using altered catchment parameters. Facilities or systems falling into this category consist of augmented or enhanced surface conditions that include:

- increased top soil depth
- soil porosity or moisture holding capacity
- surface infiltration rates
- vegetation and ground cover
- imperviousness
- surface roughness

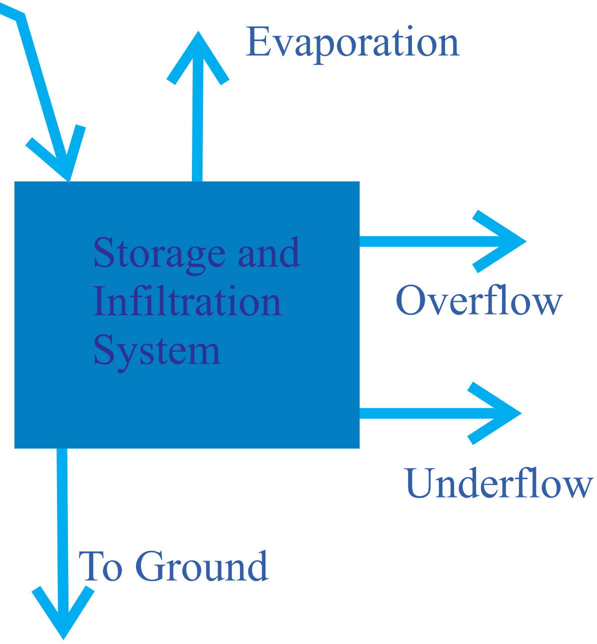
Similarly, alterations of the surface conditions such as increased imperviousness can also be analyzed using these techniques.

Discharge Volume Reduction Systems

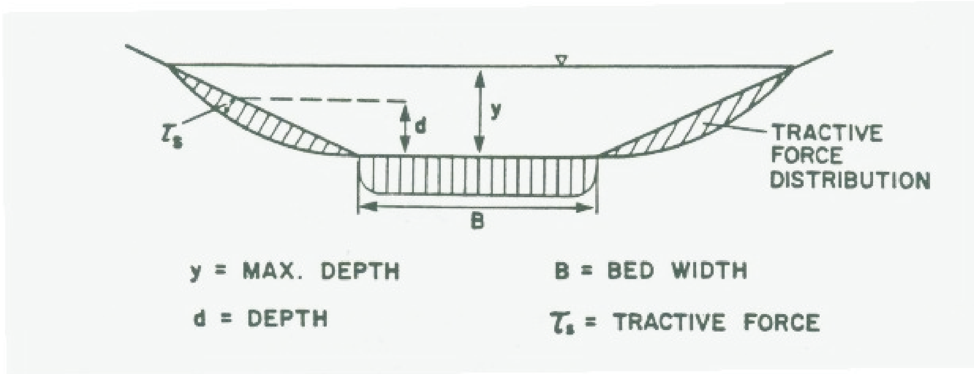
Any runoff control facility or system that provides discharge control or reduces surface runoff volumes must be analyzed following the calculations of catchment hydrology. These systems typically include a storage volume and can include infiltration to ground. The infiltration will be in addition to the surface infiltration calculated for the catchment. Systems falling into this category include:

- infiltration galleries
- rain gardens
- retention ponds
- some forms of green roof
- most bio-filtration swales

The key to this analysis involves a reduction of surface runoff after it occurs and there is a volume of stored water within the systems.



Detention Ponds can be added to control discharge rates and limit potential flooding impacts to downstream areas.



Steps in the stream assessment

1. Estimate the Tractive Force applied to the stream bed and banks for a range of discharge values.

2. Estimate the critical tractive force below which erosion will not occur. Use only the tractive forces in excess of the critical in the next steps.

3. Use the continuous simulation to estimate the duration of discharge for a range of occurring stream flows.

4. Estimate the Impulse by applying the discharge and estimating the tractive force applied at the section over the duration of the simulation. The impulse is the sum of the tractive force over time

5. Present results for different watershed conditions or runoff volume reduction system alternatives in tabular or graphical format.

Tractive Force

$\tau = \sigma R s$, where

σ = unit weight of water

R = hydraulic radius of flow, and

s = slope of channel

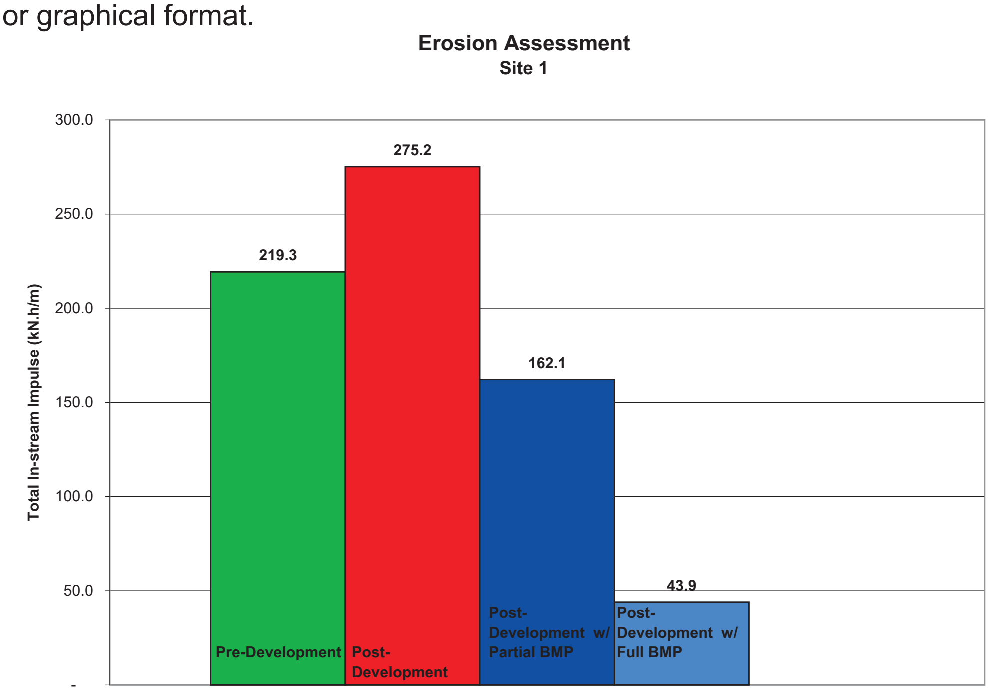
Impulse

$I = \sum(\tau P T)$, where

τ = Tractive Force

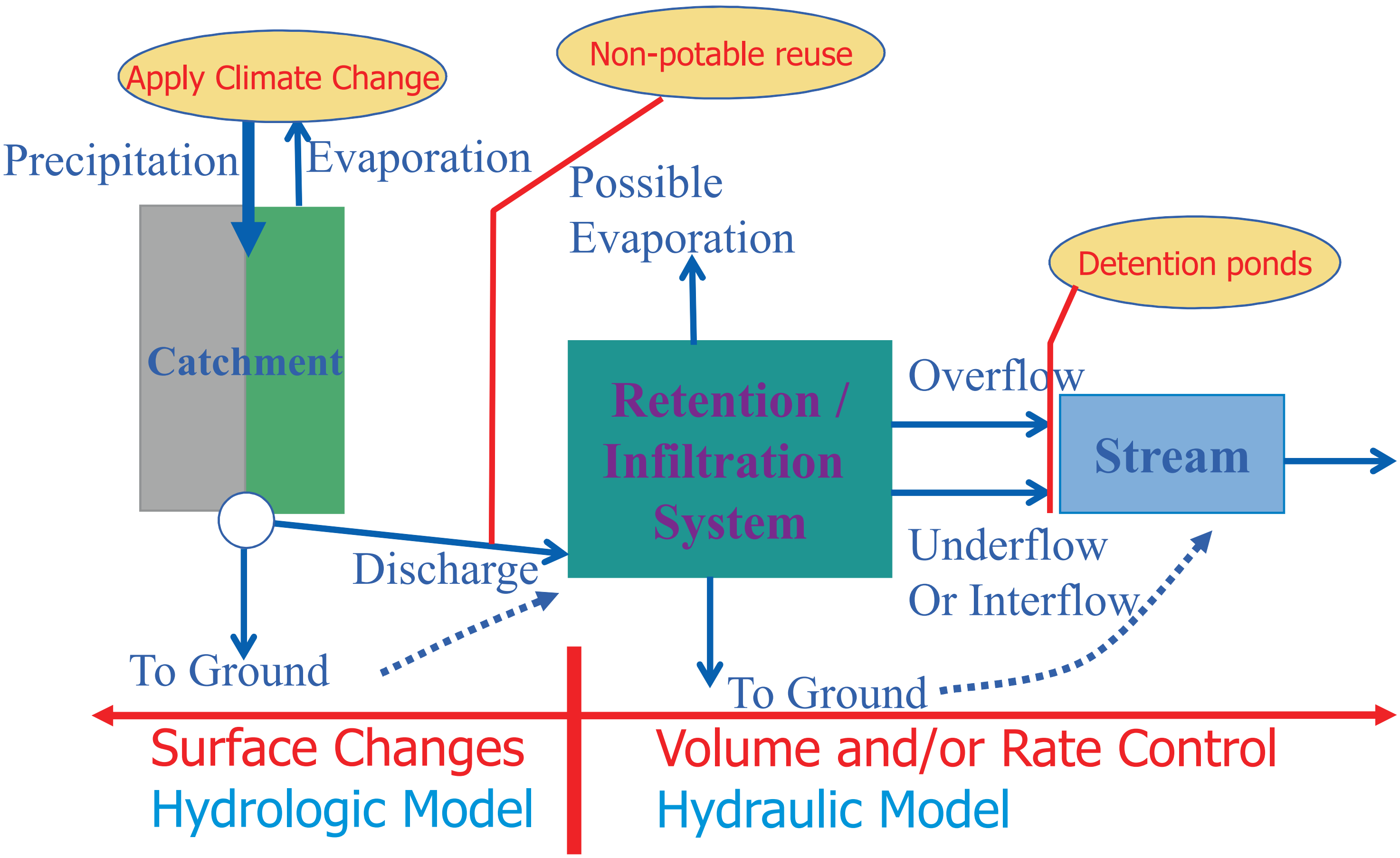
P = wetted perimeter

T = time



Stream Impact Assessment

Water Balance Methodology
Process Diagram



Modelling Surface Changes - Hydrologic Model

Mitigation with Absorbent Landscapes

- Tree cover density
- Increased soil depth
- Porous pavement
- Green roof - typical
- Some infiltration swales
  - without storage

Modelling Runoff Reduction - Hydraulic Model

Capture surface runoff and STORE it for infiltration to reduce discharge volume

- Rain gardens with storage
- Infiltration swales with storage
- Surface and subsurface storage
- Infiltration ponds
- Underground galeries