Road Map for Sharing & Learning About BC Watershed-Based Solutions & Tools

- MODULE 1: Convening for Action in BC
- MODULE 2: Mimic the Natural Water Balance – Developing Solutions that Build Resilence
- MODULE 3: Regional Team Approach - Implementing Changes in Practice
- MODULE 4: Share Your Ah-Ha Moments

In this Module #2, you will learn….

1. **WHY** provincial direction in BC is to mimic the natural Water Balance
2. **HOW** the new Water Sustainability Act creates a framework for collaboration
3. **HOW** the Water Balance Methodology has evolved over the past decade
4. **HOW** to develop performance targets that mimic the natural Water Balance

In an article published in 2001, Andy Reese asked:

"Do you know where you really are in the shifting paradigms of stormwater management?"

1. Run it in Ditches
2. Run it in Pipes
3. Run it in Stormwater Pipes
4. Keep it from Stormwater Pipes
5. Well, Just Don't Cause Flooding
6. Oh, and Don't Pollute Either
7. It's the Ecology, Stupid
8. Water is Water is Watershed
9. Green and Bear It
10. **Build a Vision, Create a Legacy**

BC's Guidebook

Drainage Planning in BC Has Been Evolving Over the Decades

- 1960s: **Pipe and Remove**
- 1970s: **Detain Peak Flows**
- 1980s: **Reactive Mitigation**
- 1990s: **Stream Stewardship**
- 2000s: **Rainwater Management**

  (Create Livable Communities & Protect Stream Health)

THE ISSUE: An increasing building footprint short-circuits the water balance and has consequences – financial liability and fisheries sustainability

Original 1950s development

After redevelopment

Impervious cover doubled from 28% to 53%

THE SOLUTION: Look at Rainfall Differently

BC was the 1st jurisdiction in North America to adopt the 'Water Balance Methodology'

Released in 2002, the Guidebook is embedded in Liquid Waste Management Plan requirements

A GUIDEBOOK FOR BRITISH COLUMBIA

Stormwater Planning

- Translated Science-Based Understanding
- Introduced the Rainfall Spectrum
- Introduced "Retain, Detain, Convey" Strategy
- Formalized Performance Target Approach
- Established Adaptive Management Precedent
- Initiated Paradigm-Shift to Rainwater Management

BRITISH COLUMBIA Ministry of Water, Land and Air Protection

Guidebook Premise:

Land development and watershed protection can be compatible. Science-based understanding bridges the gap between Policy and Site Design

Policy Level Development Objectives

Science-Based Understanding
of Development Impacts

Site Design Practices that achieve Objectives

Our mind-map for "Build a Vision & Create a Legacy" is….

- **Issue:** How We Manage Population Growth & Adapt to a Changing Climate
- **Impact:** Growth Resulting in Urban Densification (Land Constraints; Smaller Lots)
- **Sustainability:** ***Means Design with Nature***

- **Built Environment:** We Can Improve It
- **Natural Environment:** We Can Protect It
- **Cumulative Benefits:** Accrue Over Time
- **Desired Outcome:** Sustain Community Livability

Process for '*Build a Vision & Create a Legacy*' requires patience, commitment & perseverance…

- Apply a science-based approach to create a shared vision of **achievable goals**
- Facilitate a **sharing & learning process** to build stakeholder consensus over time and agree on expectations
- Obtain **commitment from everyone** to truly integrate RAINwater management with land development practices

Drought, forest fires and floods in 2003 created a 'teachable moment' for change - and galvanized support for development and implementation of the Water Sustainability Action Plan for BC, released in 2004

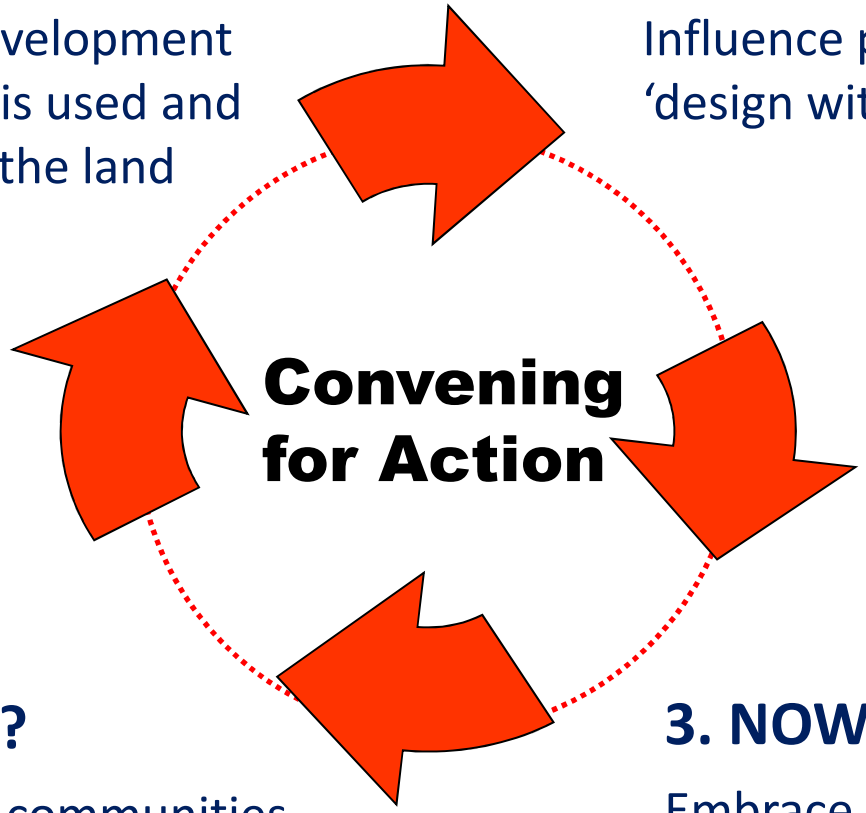
This is the "BC process" for moving from Awareness to Action

1. WHAT is the issue?

The form of land development impacts how water is used and how water runs off the land

2. SO WHAT can be done?

Influence practitioners to 'design with nature'



4. THEN WHAT?

Replicate in other communities

3. NOW WHAT can we do?

Embrace share responsibility, learn by doing and establish precedents

Next, Ted will……

In this Module #2, you will learn….

1. **WHY** provincial direction in BC is to mimic the natural Water Balance
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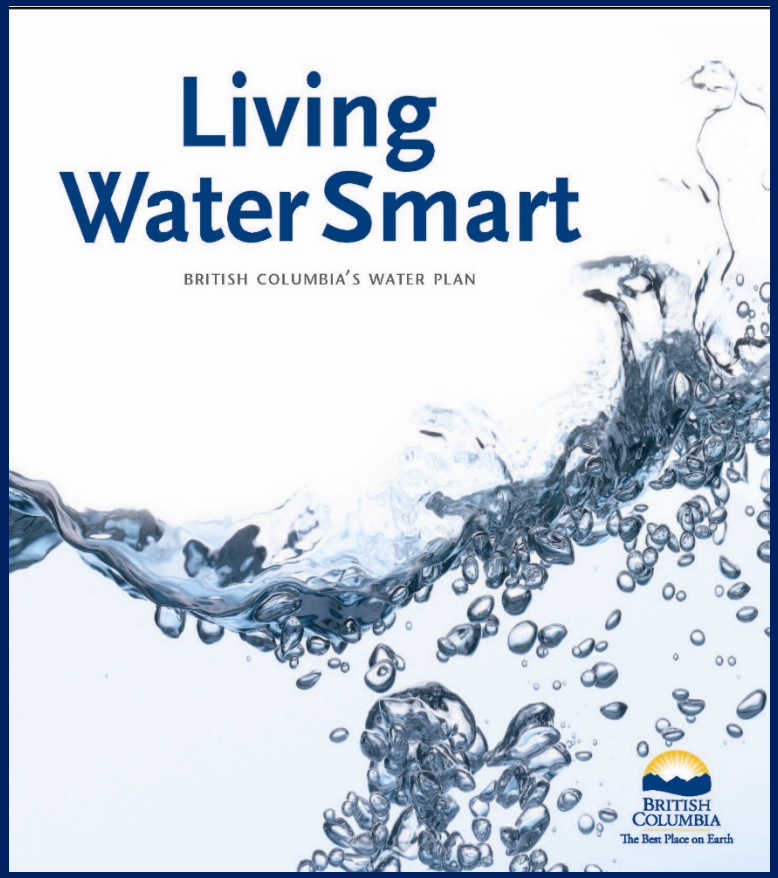
In 2008,
the Province released…….



45 actions & targets established expectations for…..

Doing Business Differently

Preparing Communities for Change

Choosing To Be Water Smart

A Living Water Smart goal is to influence the form and function of the Built Environment:

"While legislative reform is a foundation piece, collaboration takes place outside the legislative framework.....

Embrace shared responsibility. Create a legacy for those who follow in our footsteps."

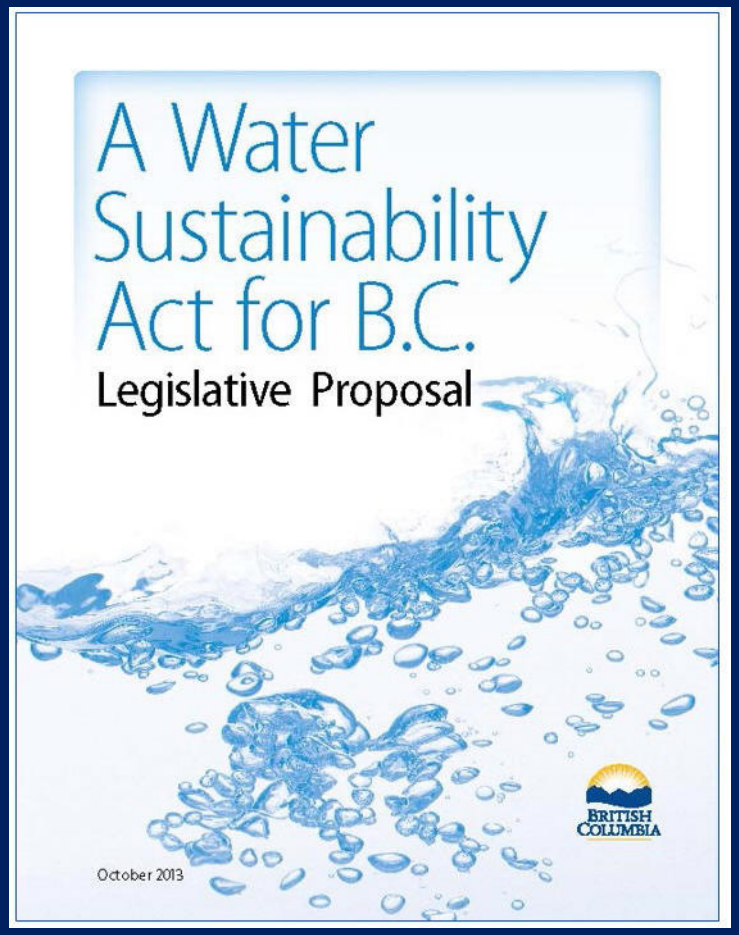
Lynn Kriwoken
Executive Director
BC Ministry of Environment

Since release of Living Water Smart in 2008, the Partnership has assisted the Province with implementation in the local government setting

IMPLEMENTATION THEMES:

- Governance, legislation, regulatory change
- Efficiency, outreach, public awareness
- Science, information & learning
- Watershed planning & restoration
- Community planning & development

Passed in April 2014,
the Water Sustainability Act is…….



….the last piece in a policy framework that establishes expectations for adapting to a changing climate by:

- Striving to build greener communities
- Choosing to live water smart

The new Act has 7 goals:

Within the local government setting, the Partnership is assisting those who have made it a work plan priority to:

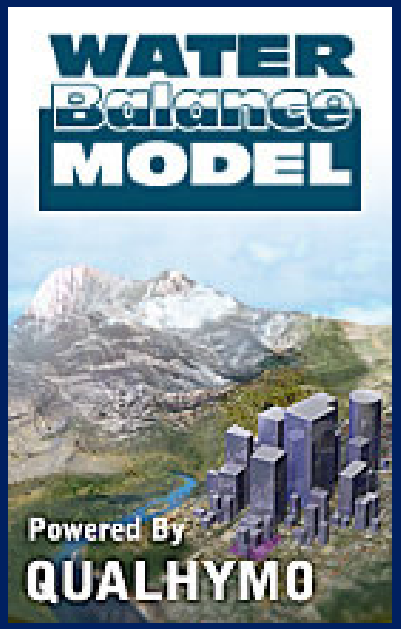
1. Protect stream health & aquatic environments
2. Consider water in land use decisions

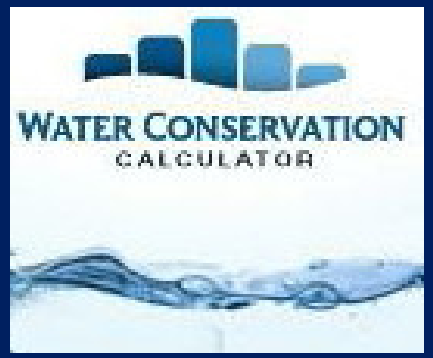
The Act will have widespread impacts on how water and land practitioners conduct their work….

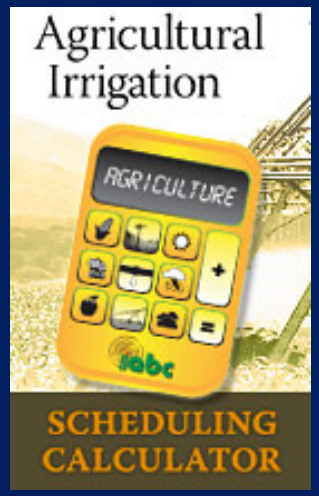
"British Columbia's Water Sustainability Act results in a new opportunity and framework to collaborate."

Ted White
Manager, Water Strategies & Conservation
BC Ministry of Environment

These web-based tools will support implementation of regional Water Sustainability Plans…..

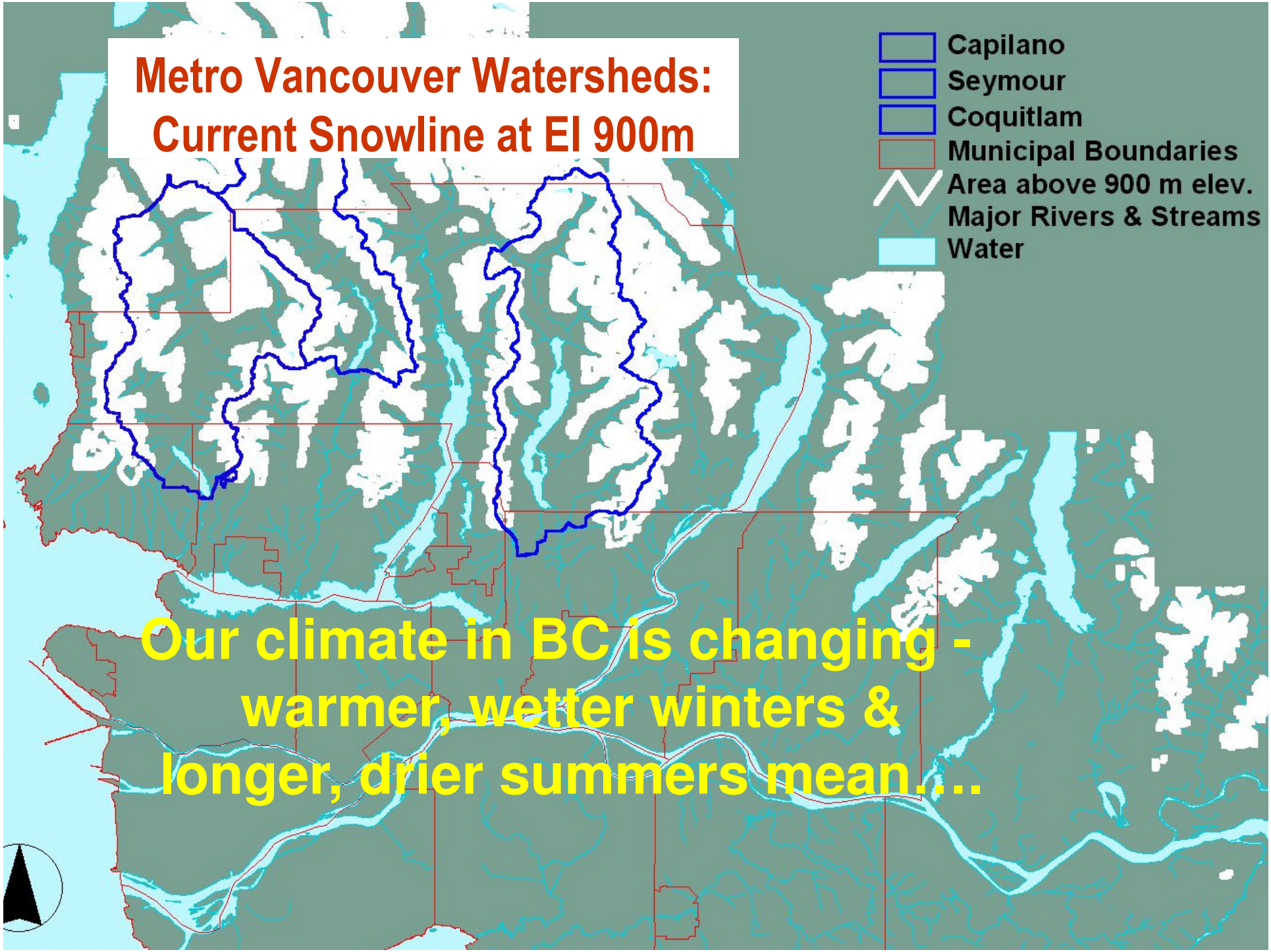


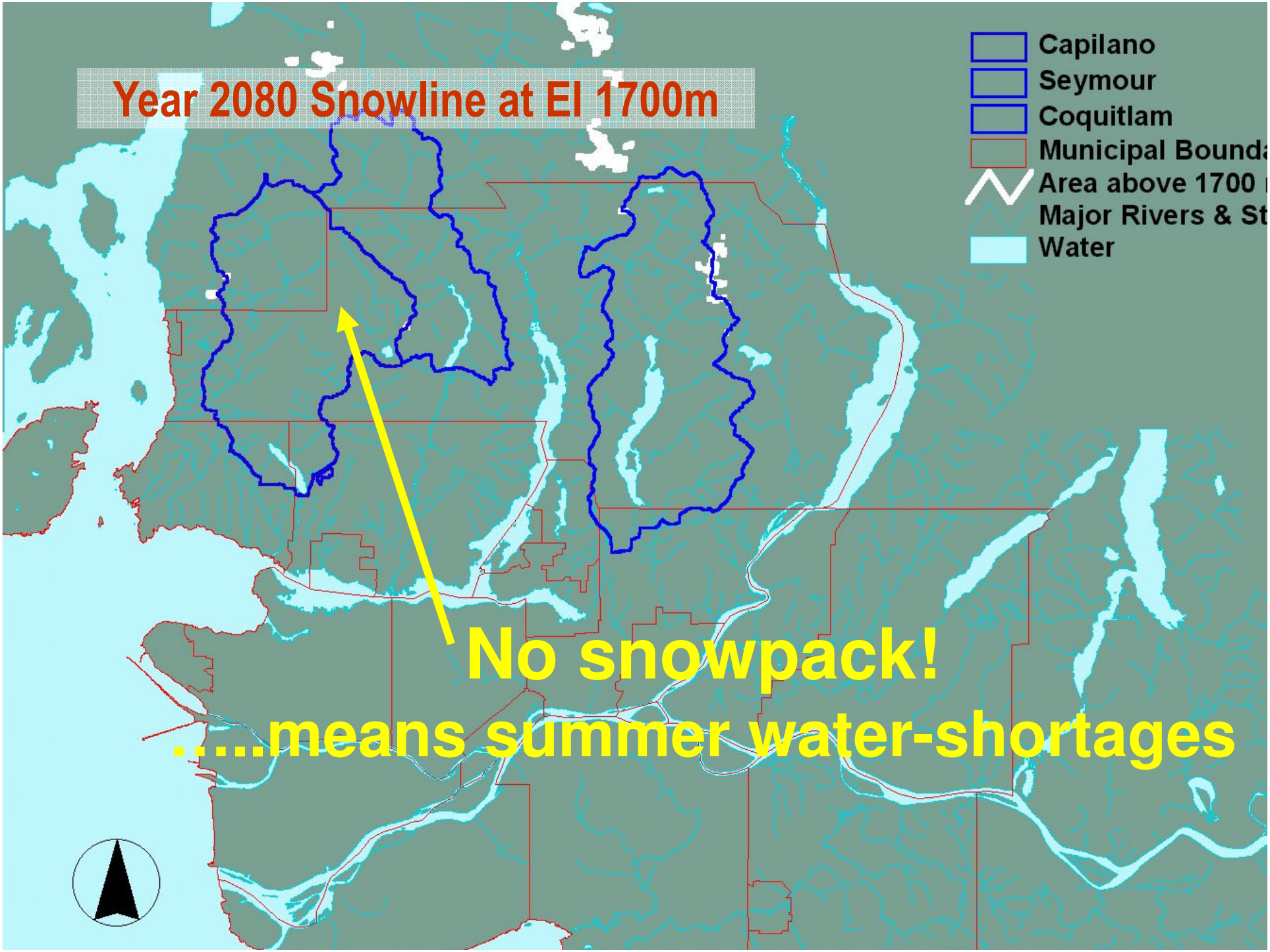




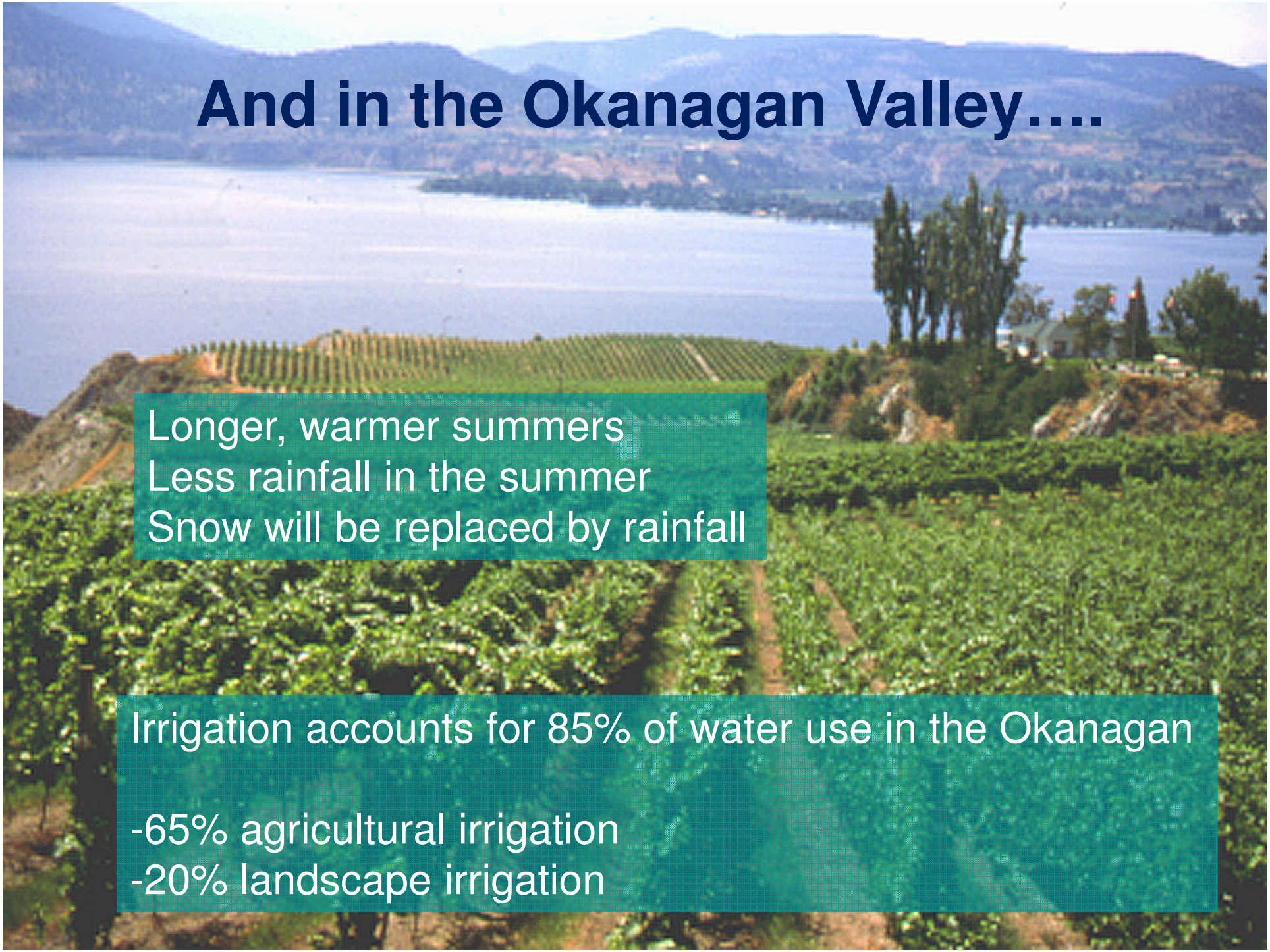
Partnership initiatives are tied to the *Water Sustainability Act* and *Climate Change Adaptation Strategies*

- Rainwater management - mimic the natural environment – Water Balance Model
- Competition between urban, fisheries, recreation and agriculture for water will increase - Water Sustainability Plans will allow watershed residents to collaborate, discuss issues and formulate solutions by developing and implementing plans - Agriculture Water Demand Model
- Agriculture irrigation is the largest consumptive user of water – efficiency improvements are required to accommodate climate change – Irrigation Scheduling Calculator
- Municipalities will need to implement water conservation - Water Conservation Calculator
- Measuring and reporting water use will be required to improve water management – Water Use Reporting Tool


Metro Vancouver Watersheds:
Current Snowline at El 900m
Capilano
Seymour
Coquitlam
Municipal Boundaries
Area above 900 m elev.
Major Rivers & Streams
Water
Our climate in BC is changing -
warmer, wetter winters &
longer, drier summers mean….


Year 2080 Snowline at El 1700m
Capilano
Seymour
Coquitlam
Municipal Bounda
Area above 1700
Major Rivers & St
Water
No snowpack!
.....means summer water-shortages

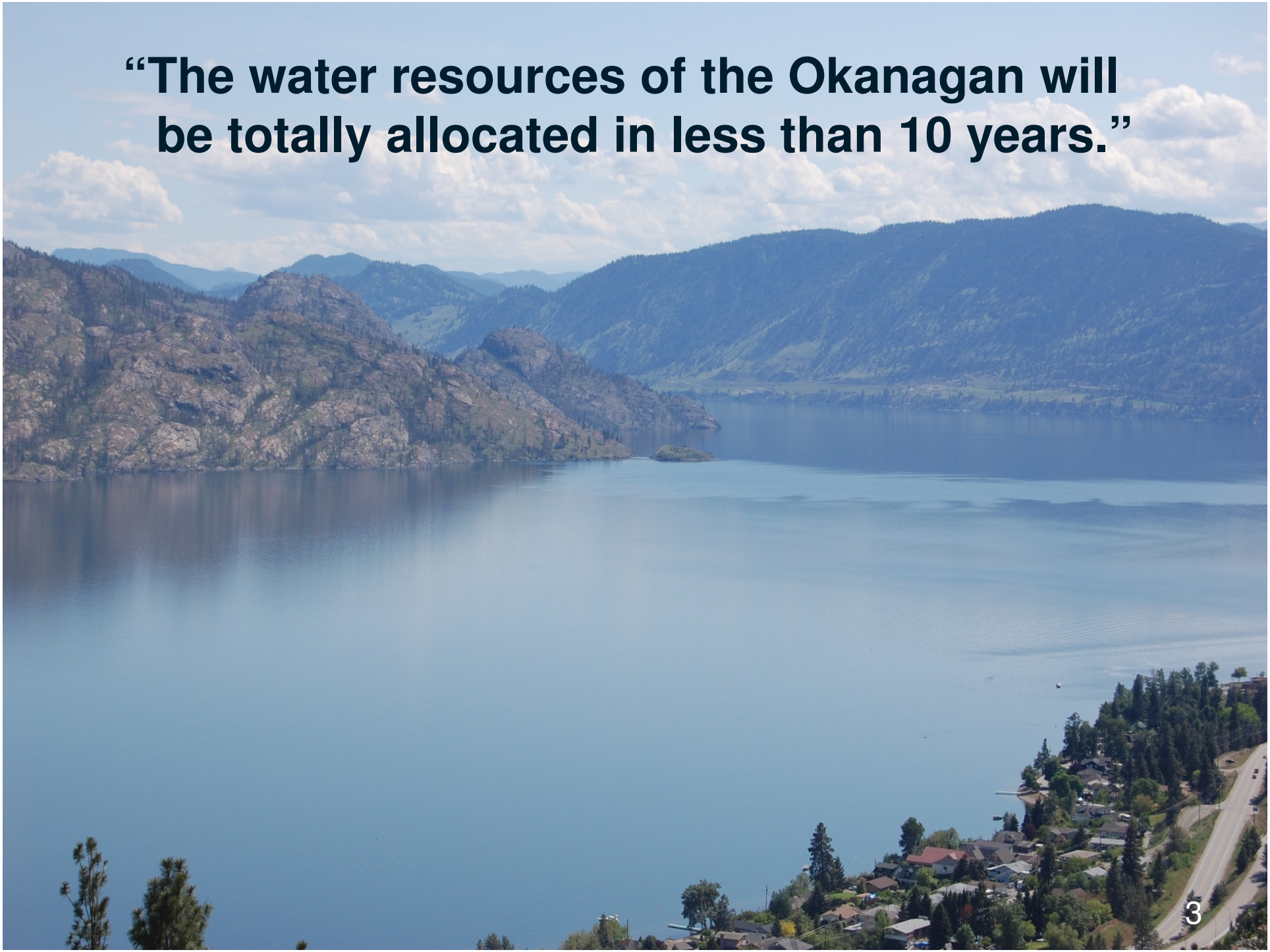
And in the Okanagan Valley….



Longer, warmer summers
Less rainfall in the summer
Snow will be replaced by rainfall

Irrigation accounts for 85% of water use in the Okanagan

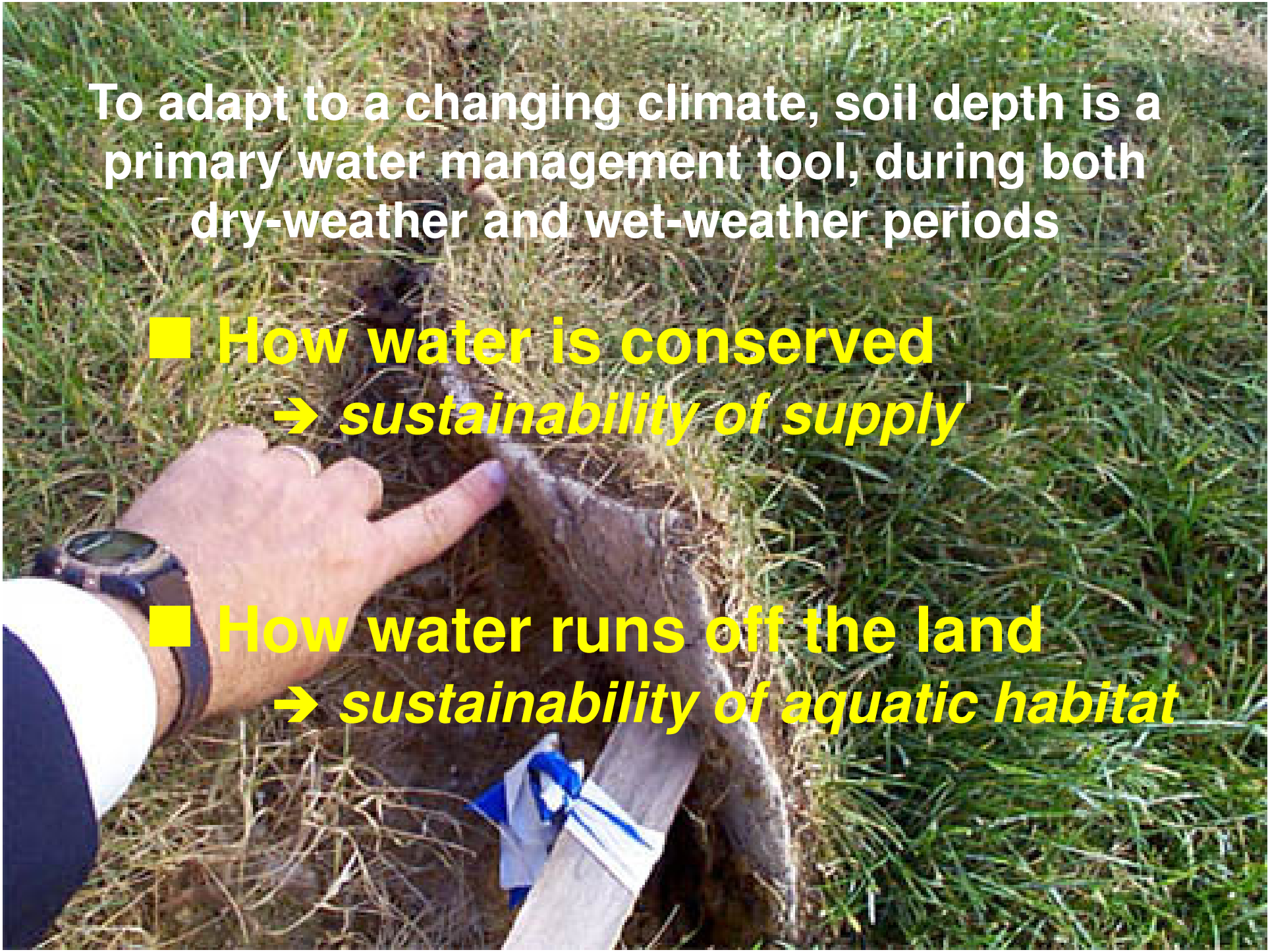
-65% agricultural irrigation
-20% landscape irrigation


“The water resources of the Okanagan will be totally allocated in less than 10 years.”

In 2012, the Okanagan Basin Water Board and the Partnership jointly released…

"A well-designed landscape with healthy topsoil helps communities through both wet and dry times."

Anna Warwick Sears, PhD
Executive Director
Okanagan Basin Water Board

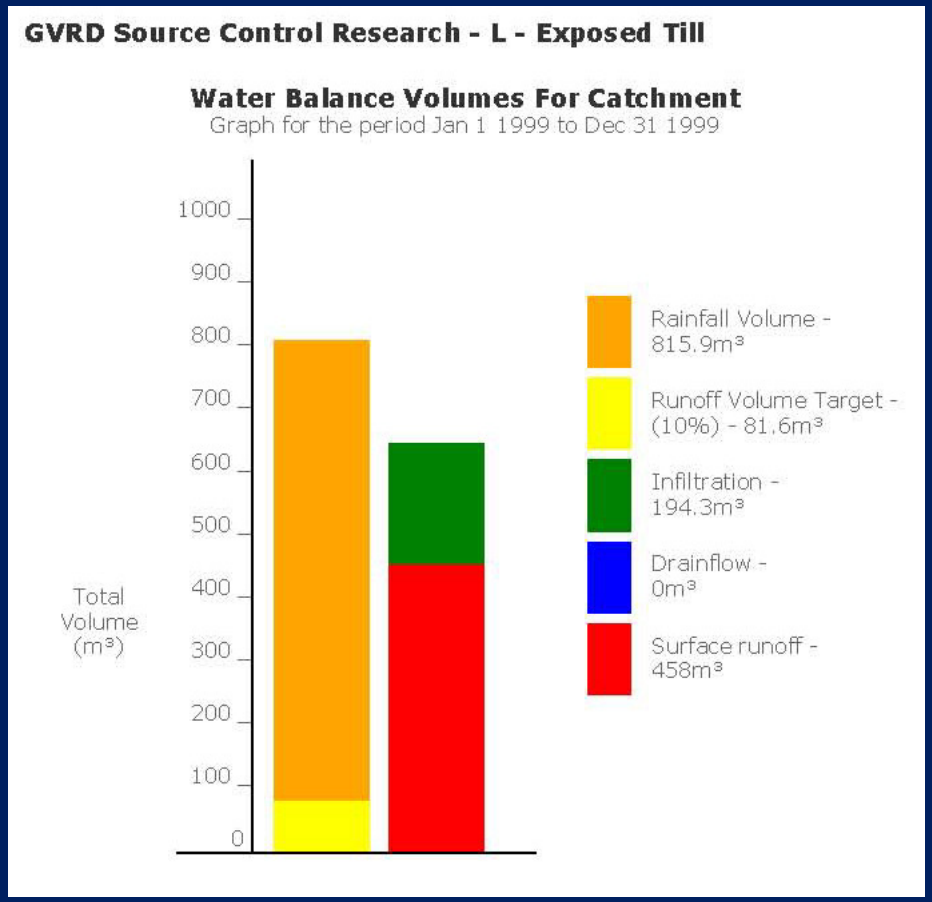


To adapt to a changing climate, soil depth is a primary water management tool, during both dry-weather and wet-weather periods

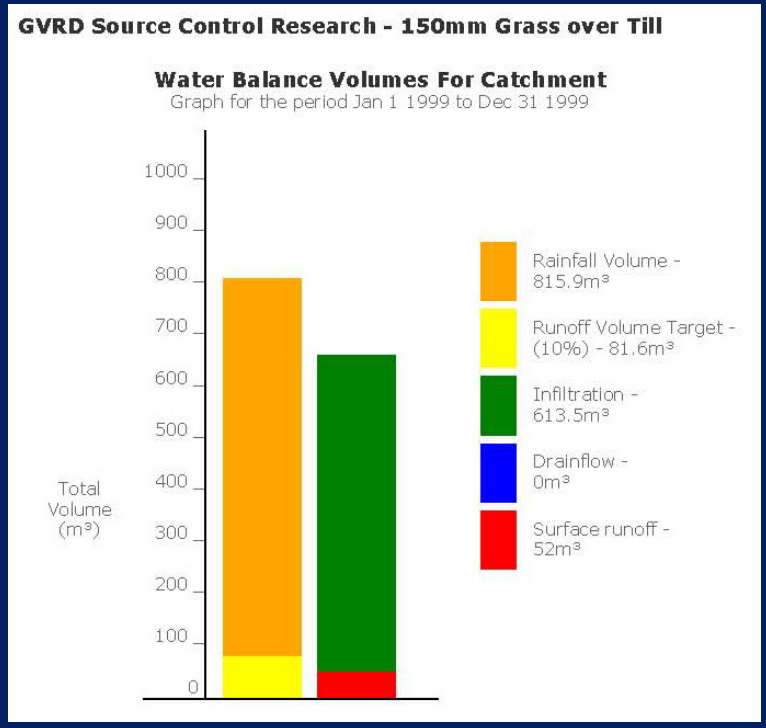
- **How water is conserved**
  → ***sustainability of supply***

- **How water runs off the land**
  → ***sustainability of aquatic habitat***

KEY MESSAGE #1 - Poor landscape design results in excessive rainwater surface runoff



KEY MESSAGE #1 - An absorbent landscape captures and infiltrates rainwater, where it falls



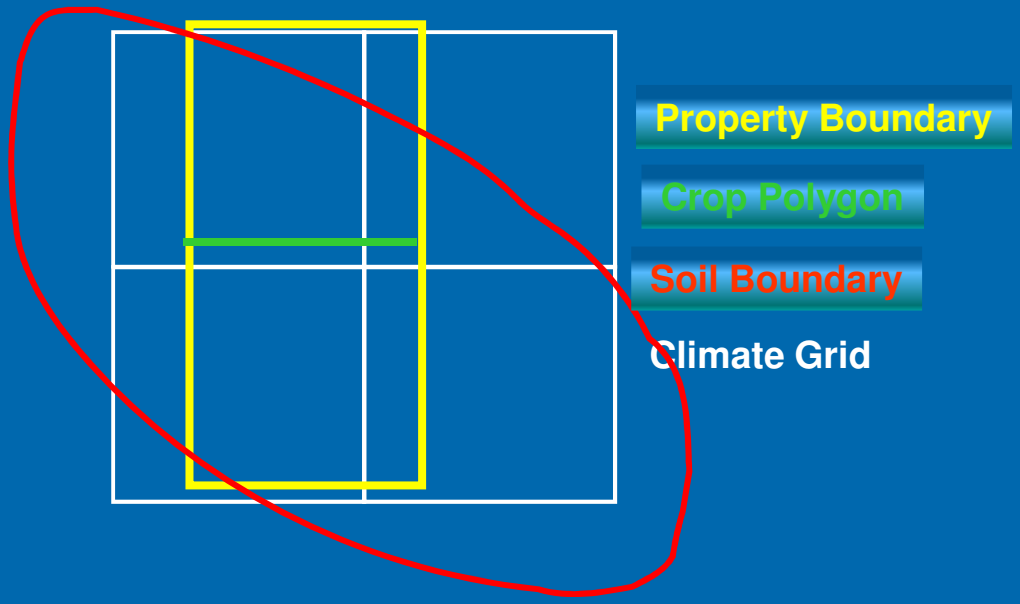
Water Sustainability Act reserves water for agriculture…..

- Establishes a process for securing water for food production
- Water Sustainability Plans are key
- Agricultural Water Demand Model provides critical information to the planning process
- Agricultural build-out and climate change are taken into account

Ag Water Demand Model

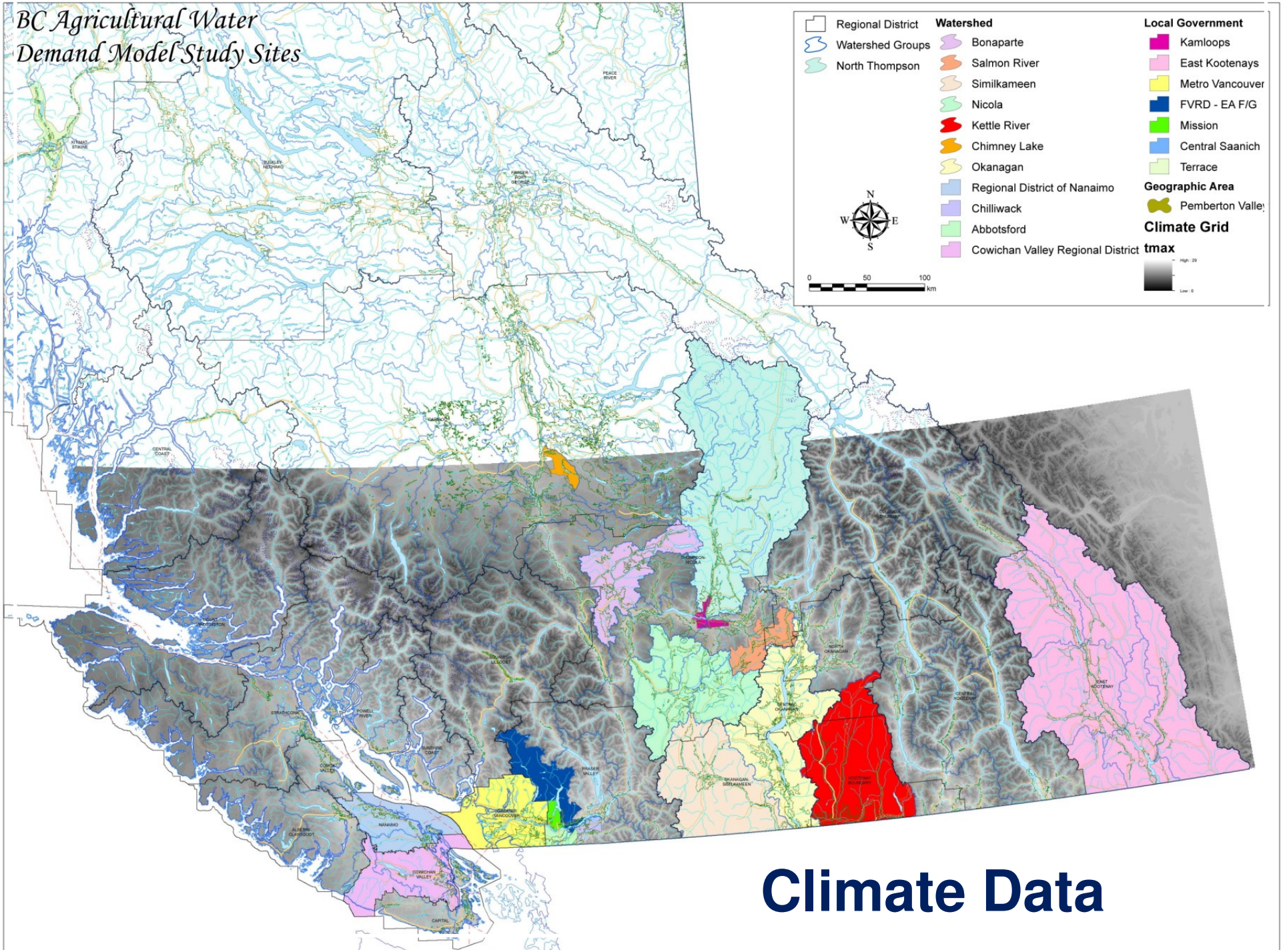
- Determines theoretical requirements on a property by property basis including climate change
- Current and future water demand
- Water demand for ALR lands currently irrigated and not irrigated
- Can assess groundwater demand

Agriculture Water Model



Objective: Make Informed Decisions on water management

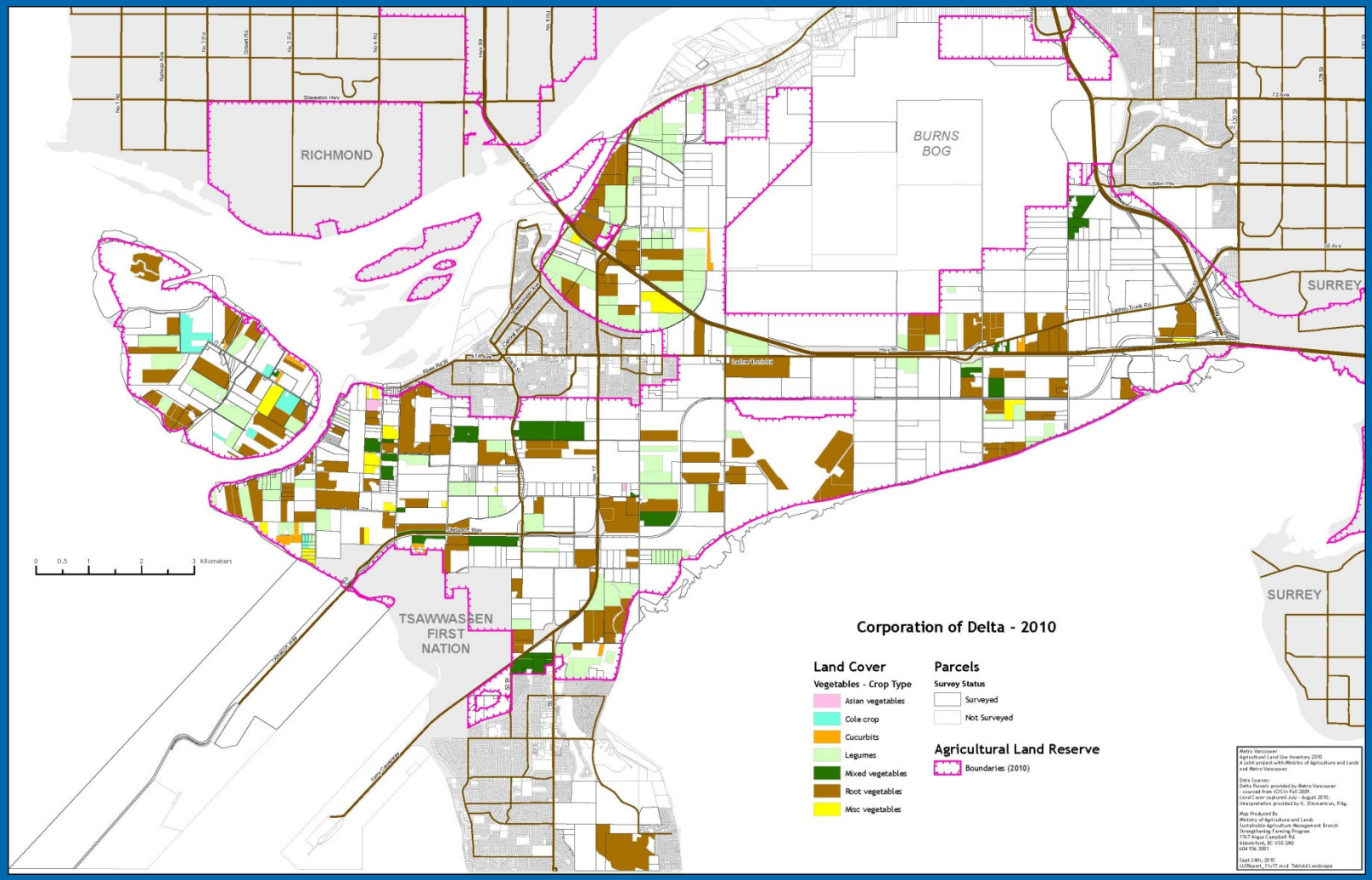
Result: Planning Tools that Secure Water for current and future Agricultural needs



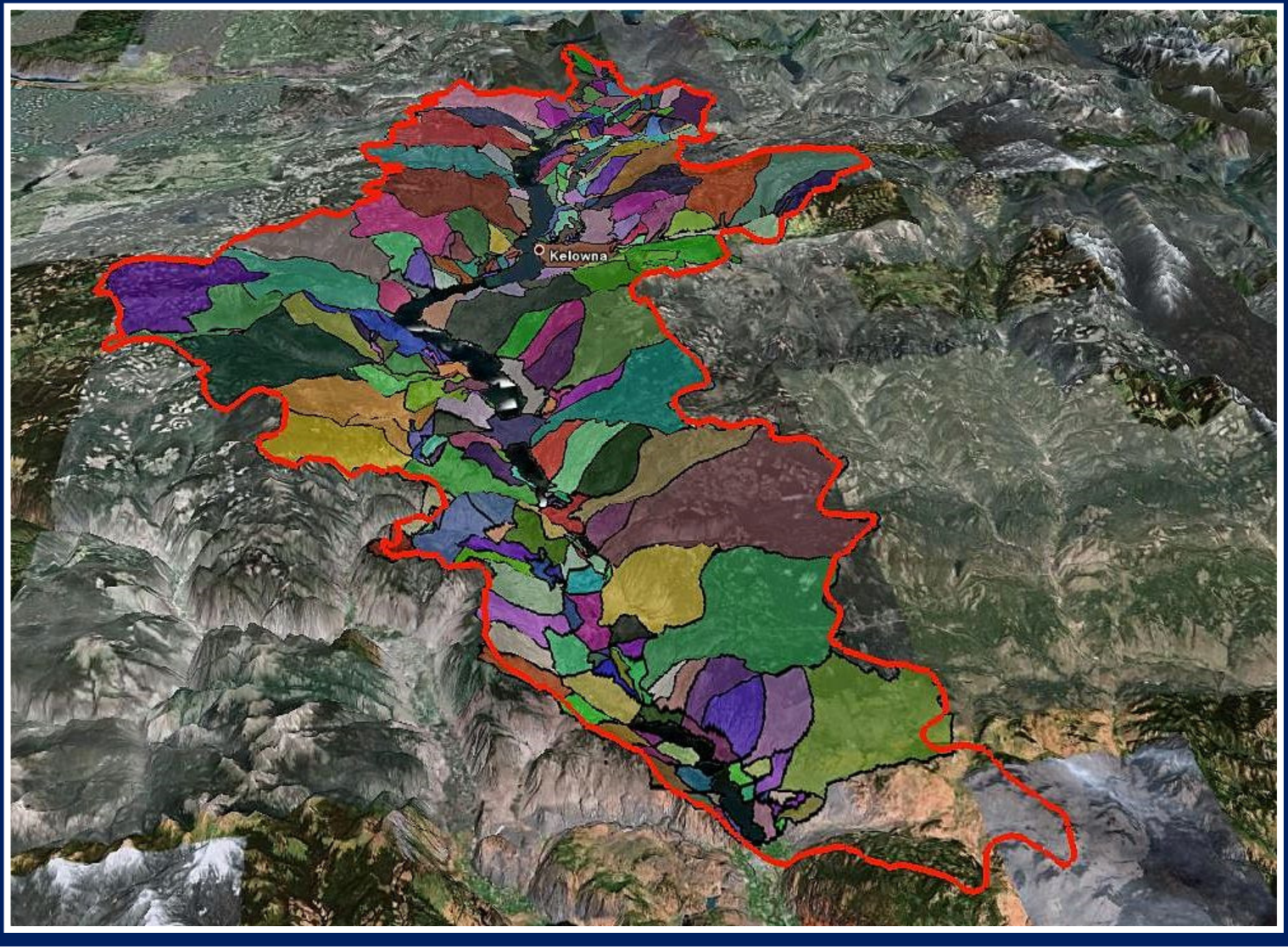
Climate Data

Land Use Inventories:

Land Cover Results for Delta Municipality in Metro Vancouver Region



Groundwater Layer



How much agricultural land do British Columbians depend on?

Each person in BC has a food footprint of 6 city lots, or 0.5 ha

Collectively, we need 2.15 million hectares of land to feed us, including both intensive and extensive agriculture production zones

We need 215,000 ha of irrigated land

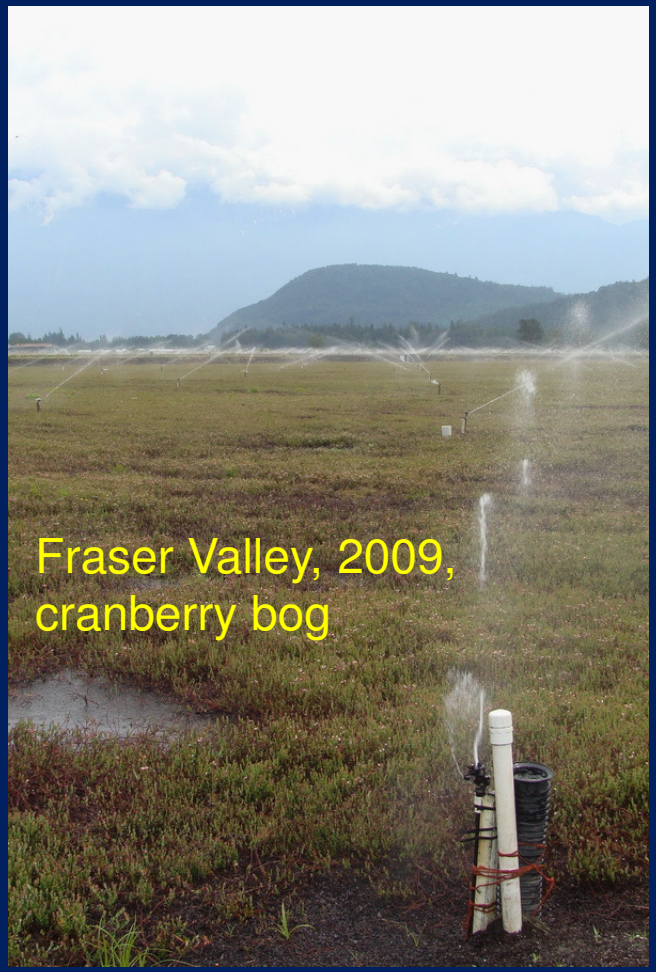
Cranberry harvest in Pitt Meadows, 2007

The access to water for irrigation is key attribute of Fraser Valley agriculture land

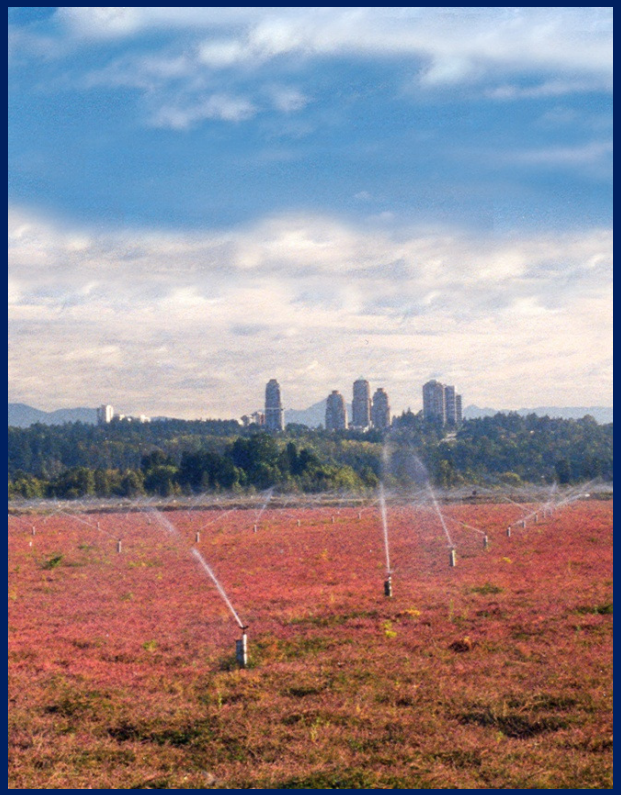
215,000 ha of irrigated land are currently needed to meet all our food needs

189,000 ha of land in BC had access to irrigation (2005)—not all this land is going to remain productive under climate change

115,000 ha Agricultural Land Reserve in Fraser Valley available for agriculture-almost all can be irrigated

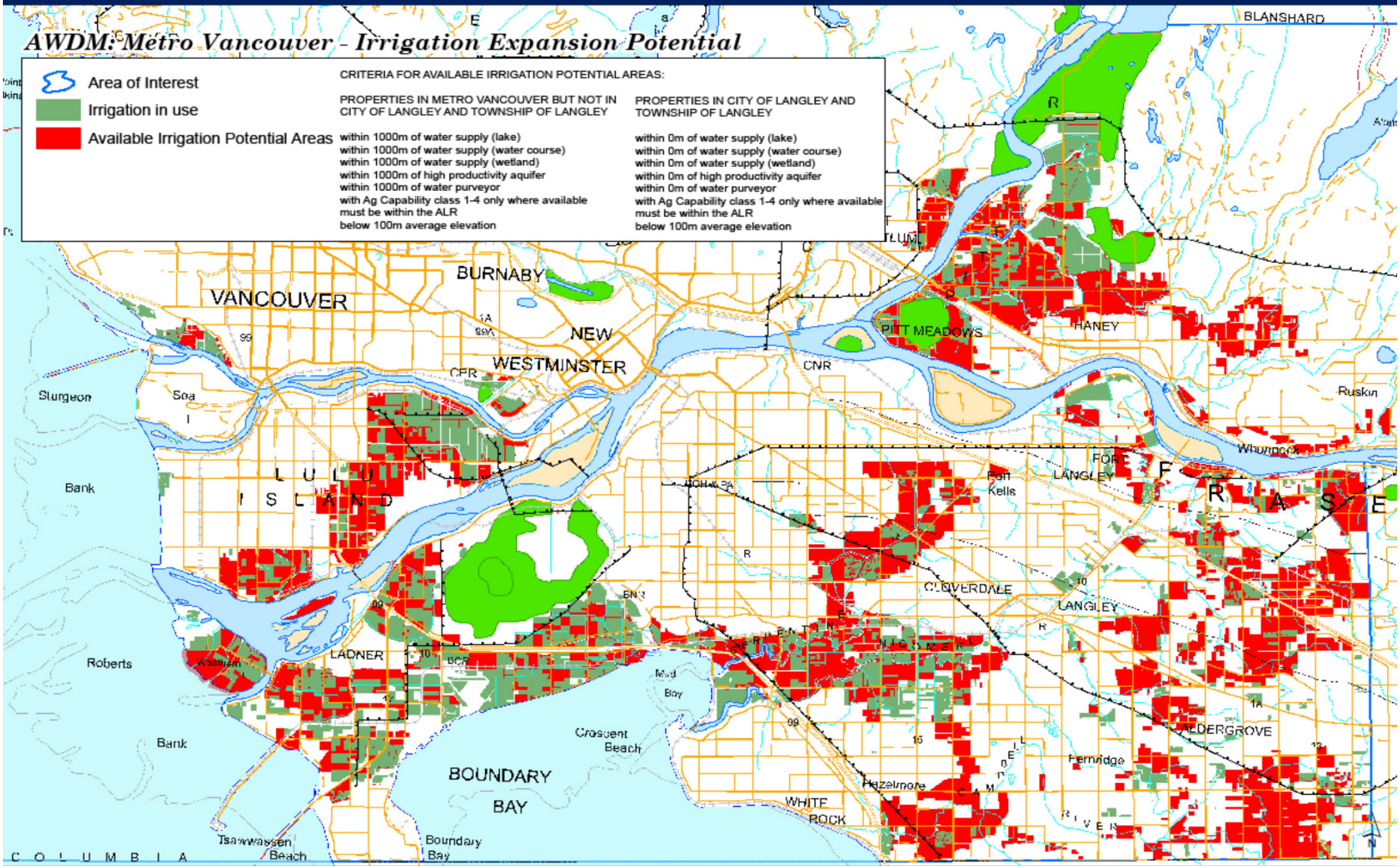


Model Results for Metro Vancouver

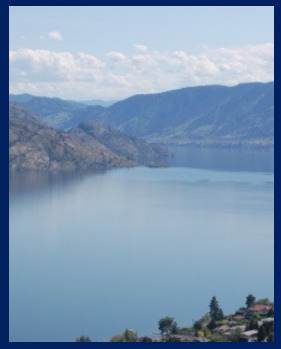


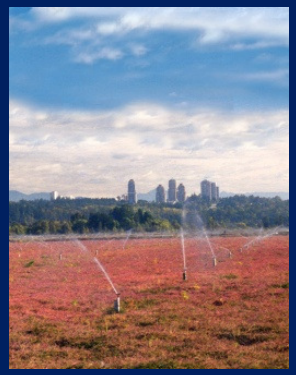
Crop Group	Total Area (ha)	Irrigation Area (ha)	Irrigation Demand (mm) 2003
Blueberries	5504	4106	332
Cranberries	2591	2570	567
Forage	8776	1561	561
Golf	1170	1170	613
Nursery	715	125	370
Raspberries	177	119	374
Strawberry	180	82	321
Turf Farm	105	105	545
Vegetables	4515	2365	351
Greenhouse	466.6	466.6	1060
Total =	**28,222**	**13,070**	**441**

Potential for Irrigation Expansion in Metro Vancouver

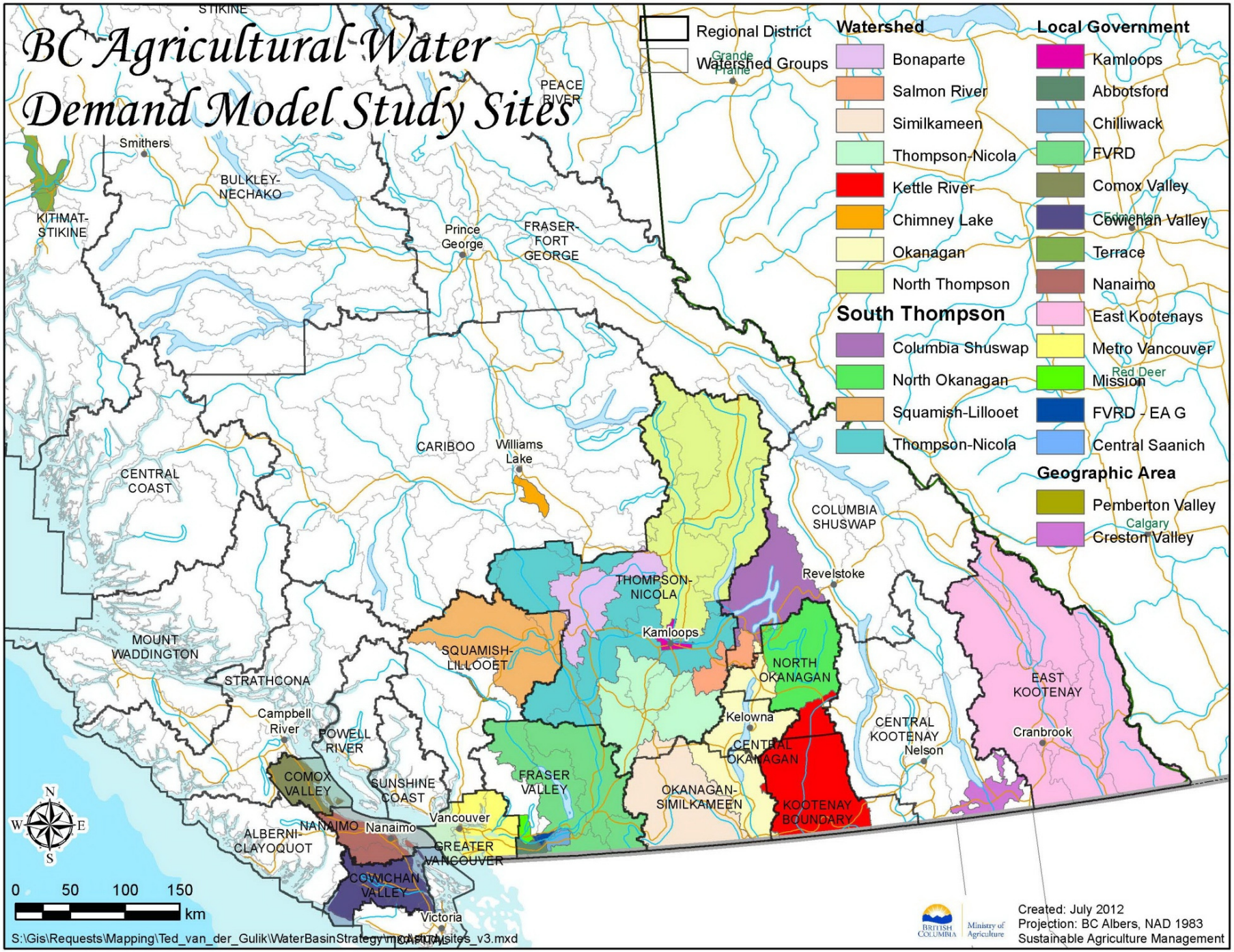


Comparison of Agriculture Water Demand in the Okanagan versus that in Metro Vancouver

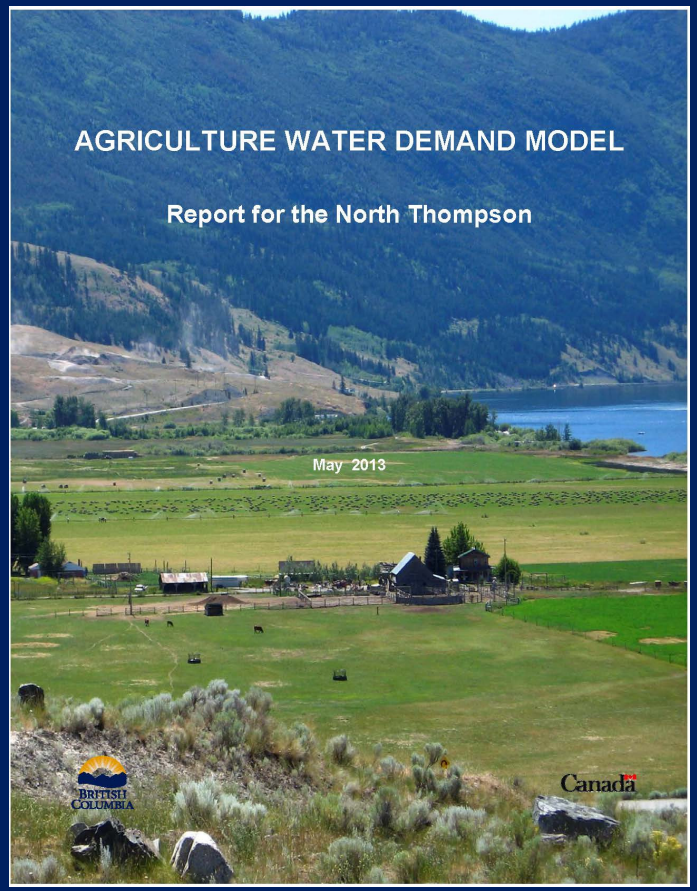


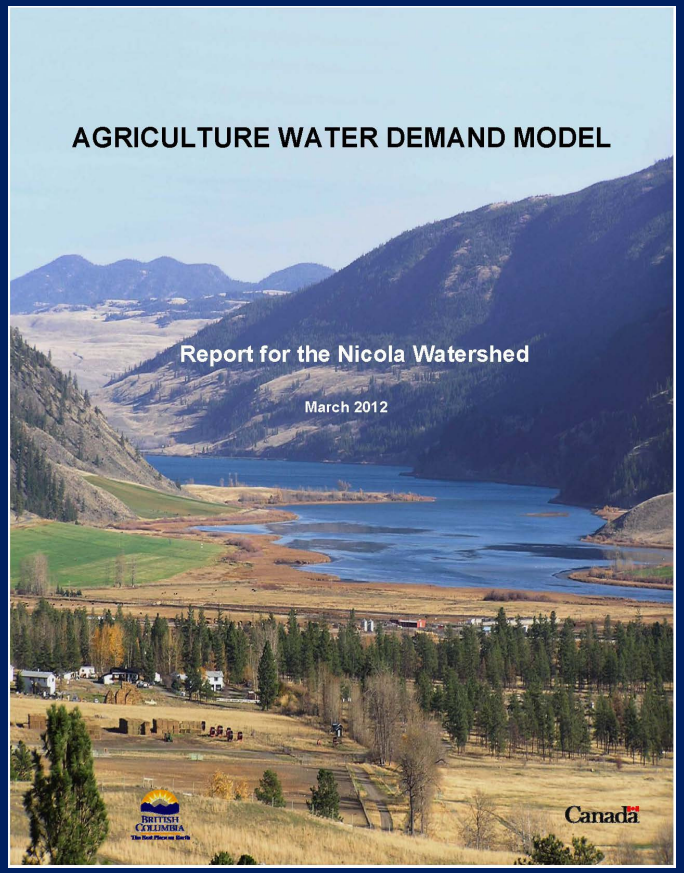


Year	Irrigation Area (ha)	Irrigation Demand (m3)
Okanagan	**20,083**	
1997		**110 million**
2003		**148 million**
Metro Vancouver	**13,070**	
1997		**36 million**
2003		**60 million**


BC Agricultural Water Demand Model Study Sites
Regional District
Watershed Groups
Watershed
Bonaparte
Salmon River
Similkameen
Thompson-Nicola
Kettle River
Chimney Lake
Okanagan
North Thompson
South Thompson
Columbia Shuswap
North Okanagan
Squamish-Lillooet
Thompson-Nicola
Local Government
Kamloops
Abbotsford
Chilliwack
FVRD
Comox Valley
Cowichan Valley
Terrace
Nanaimo
East Kootenays
Metro Vancouver
Mission
FVRD - EA G
Central Saanich
Geographic Area
Pemberton Valley
Creston Valley
STIKINE
PEACE RIVER
Grande Prairie
Smithers
BULKLEY-NECHAKO
KITIMAT-STIKINE
Prince George
FRASER-FORT GEORGE
CARIBOO
Williams Lake
CENTRAL COAST
COLUMBIA SHUSWAP
Calgary
Edmonton
Red Deer
Revelstoke
THOMPSON-NICOLA
Kamloops
MOUNT WADDINGTON
SQUAMISH-LILLOOET
NORTH OKANAGAN
STRATHCONA
Campbell River
POWELL RIVER
Kelowna
CENTRAL OKANAGAN
CENTRAL KOOTENAY
Nelson
EAST KOOTENAY
Cranbrook
COMOX VALLEY
SUNSHINE COAST
FRASER VALLEY
OKANAGAN-SIMILKAMEEN
KOOTENAY BOUNDARY
Vancouver
NANAIMO
Nanaimo
ALBERNI-CLAYOQUOT
GREATER VANCOUVER
COWICHAN VALLEY
Victoria
N
W
E
S
0 50 100 150
km
S:\Gis\Requests\Mapping\Ted_van_der_Gulik\WaterBasinStrategy\mcAllsites_v3.mxd
BRITISH COLUMBIA
Ministry of Agriculture
Created: July 2012
Projection: BC Albers, NAD 1983
Sustainable Agriculture Management

Agricultural Water Demand Reports in the Thompson-Nicola Regional District





Available at www.waterbucket.ca

Significance of 33% Water Reduction in the Okanagan

60 million m^3

300,000 People or 9000 hectares

It is an exciting new era in water & watershed management because…

The Water Sustainability Act provides a framework to collaborate and implement watershed-based solutions!

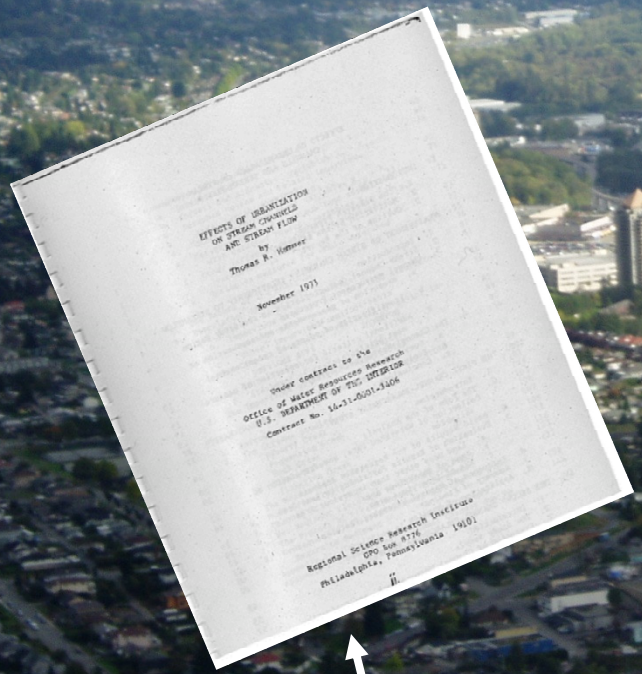
Next,
Kim and Jim will……

In this Module #2, you will learn….

1. **WHY** provincial direction in BC is to mimic the natural Water Balance
2. **HOW** the new Water Sustainability Act creates a framework for collaboration
3. **HOW** the Water Balance Methodology has evolved over the past decade
4. **HOW** to develop performance targets that mimic the natural Water Balance

By 1969, we had put a man on the moon…

…. but we did not truly understand how urban land use changes degrade streams



EFFECTS OF URBANIZATION
ON STREAM CHANNELS
AND STREAM FLOW

by

Thomas R. Hammer

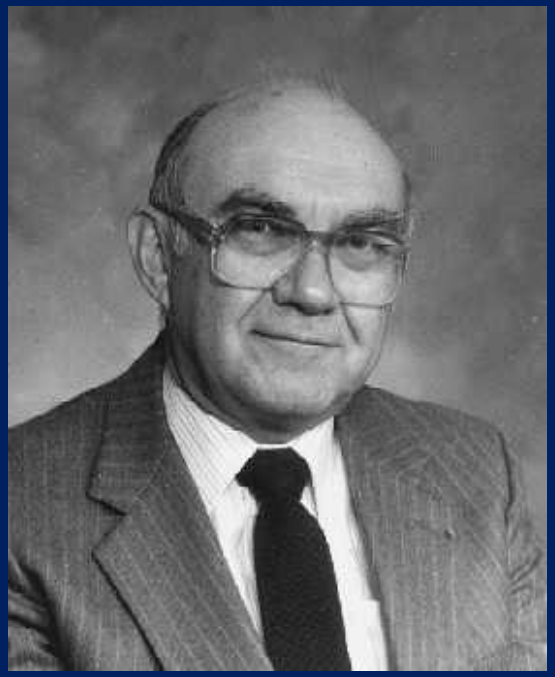
November 1971

Under contract to the
Office of Water Resources Research
U.S. DEPARTMENT OF THE INTERIOR
Contract No. 14-31-0001-3404

Regional Science Research Institute
GPO Box 8776
Philadelphia, Pennsylvania 19101

We have picked up where
Thomas Hammer left off in1973

“Hydrology remains a hybrid between the art and the science,” wrote Robert L Smith in 1990



“Hydrology remains one of the few opportunities in technology where one's diagnostic capability is put to the test of both theory and experience."

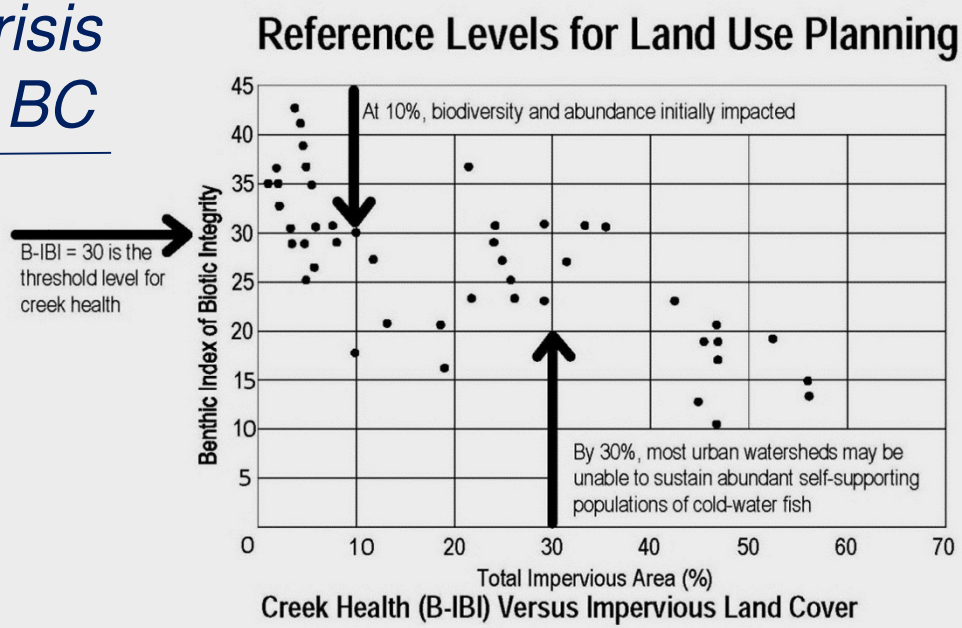
Robert L Smith (1923 – 1995)
Professor, University of Kansas
Presidential Science Advisor for Water Resources
1990 Ray Linsley Award

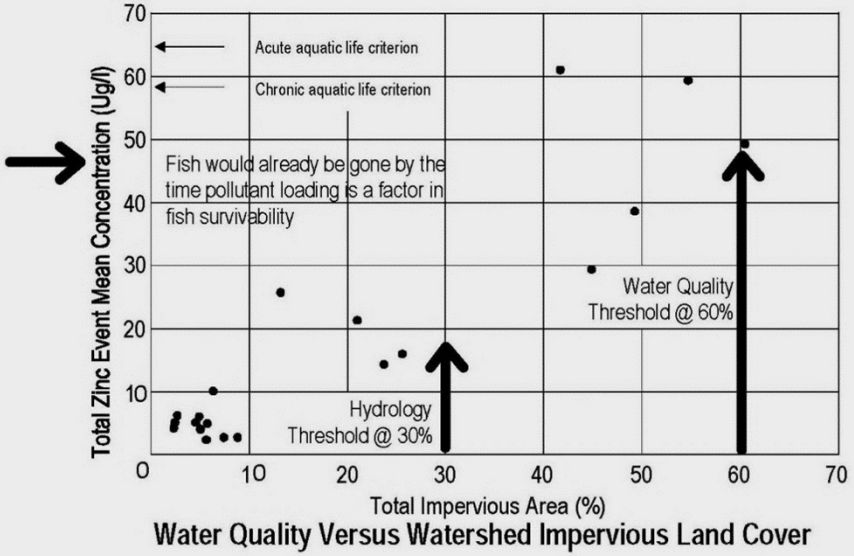
In the 1990s, the salmon crisis was a catalyst for action in BC

An "Ah-Ha Moment" in our understanding

In 1996, Richard Horner and Chris May provided us with this road map for "Integrated Watershed Management":

1. **Changes in Hydrology**
2. Disturbance to Riparian Corridor
3. Degradation of In-Stream Habitat
4. Deterioration of Water Quality





The work of Rich Horner and Chris May is standing the test of time because…

"So many studies manipulate a single variable out of context with the whole and its many additional variables.

We, on the other hand, investigated whole systems in place with attention to a wide range of physical, chemical, and biological variables."

Richard Horner, PhD
Professor (retired)
University of Washington
Seattle

September 2014

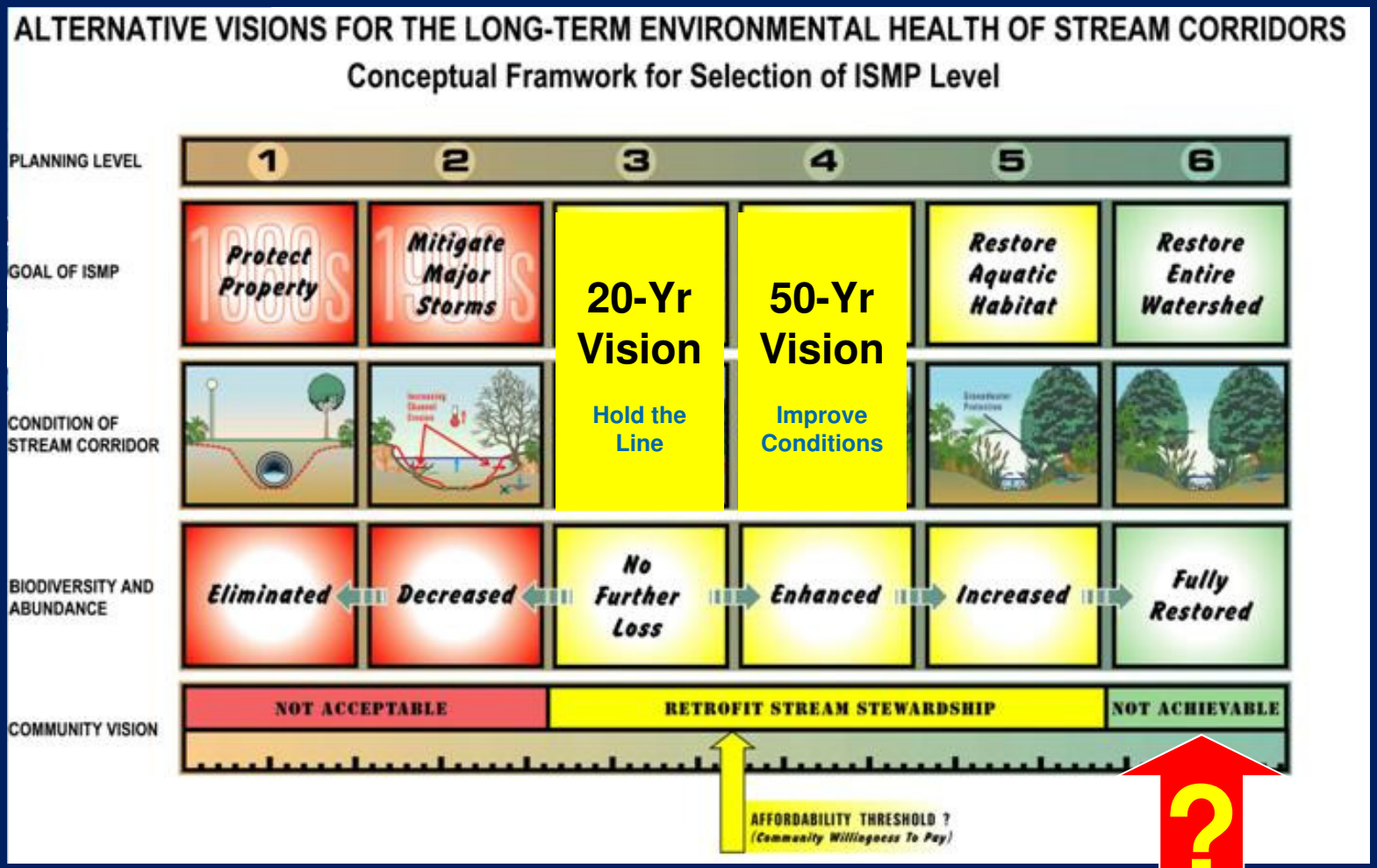
The challenge we faced at the turn of the century was to "Overcome Fear and Doubt" that green infrastructure practices would protect watershed and stream health…

"If we fail, it will be a generation before anyone will even have the opportunity to try again; so we must not fail."

Circa 2000

Patrick Condon
James Taylor Chair
University of British Columbia

Watershed Restoration - what we believed to be unachievable in 1998 is now within our grasp!



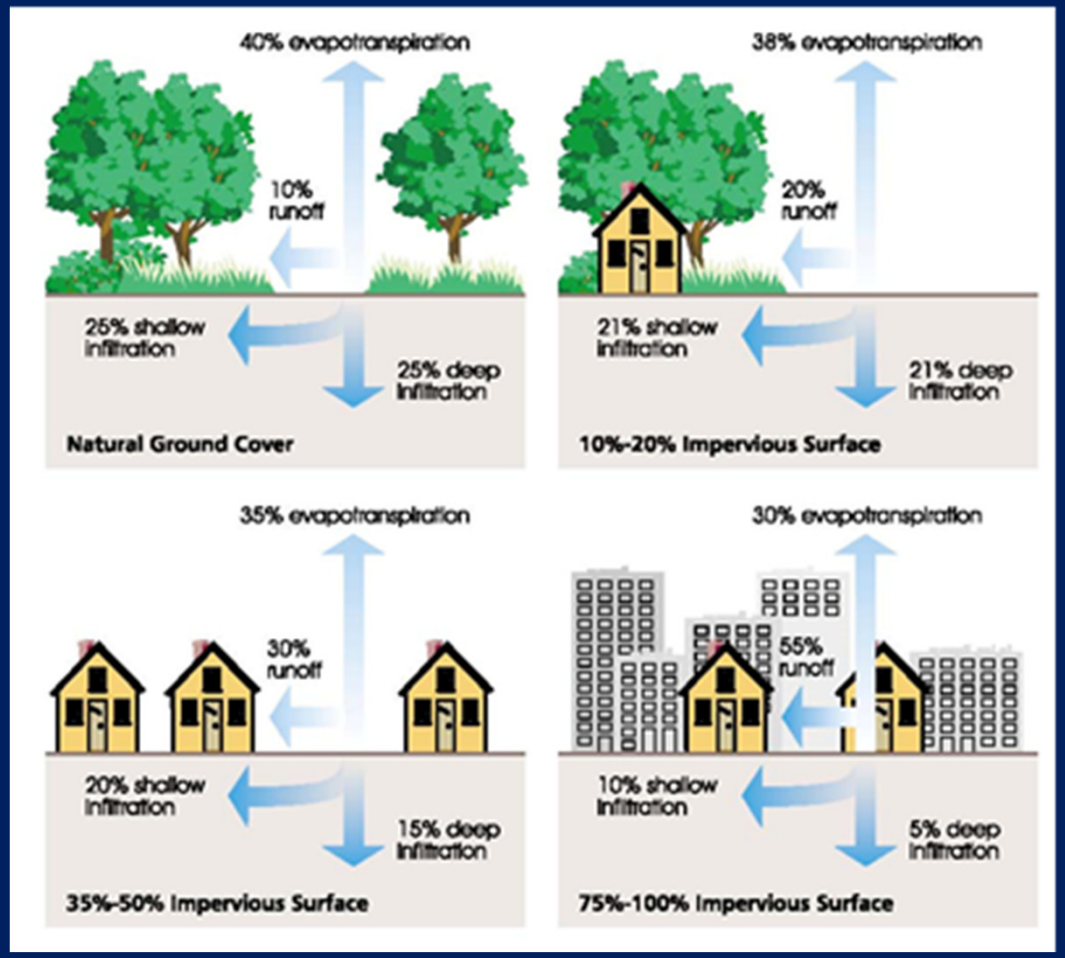
Now achievable?

Where does the groundwater go, how does it get there, and are there any impacts along the way?

This is our storyline:

- Knowledge expands and becomes clearer over time
- The headwater streams in BC have forced us to expand our view from the site to the watershed and stream
- Shifting the focus away from the site to the watershed and the stream brings a new perspective
- Including the knowledge of soil science allows us to create a new understanding of the physical processes
- Unintended consequences can be costly

Knowledge Advances Over Time

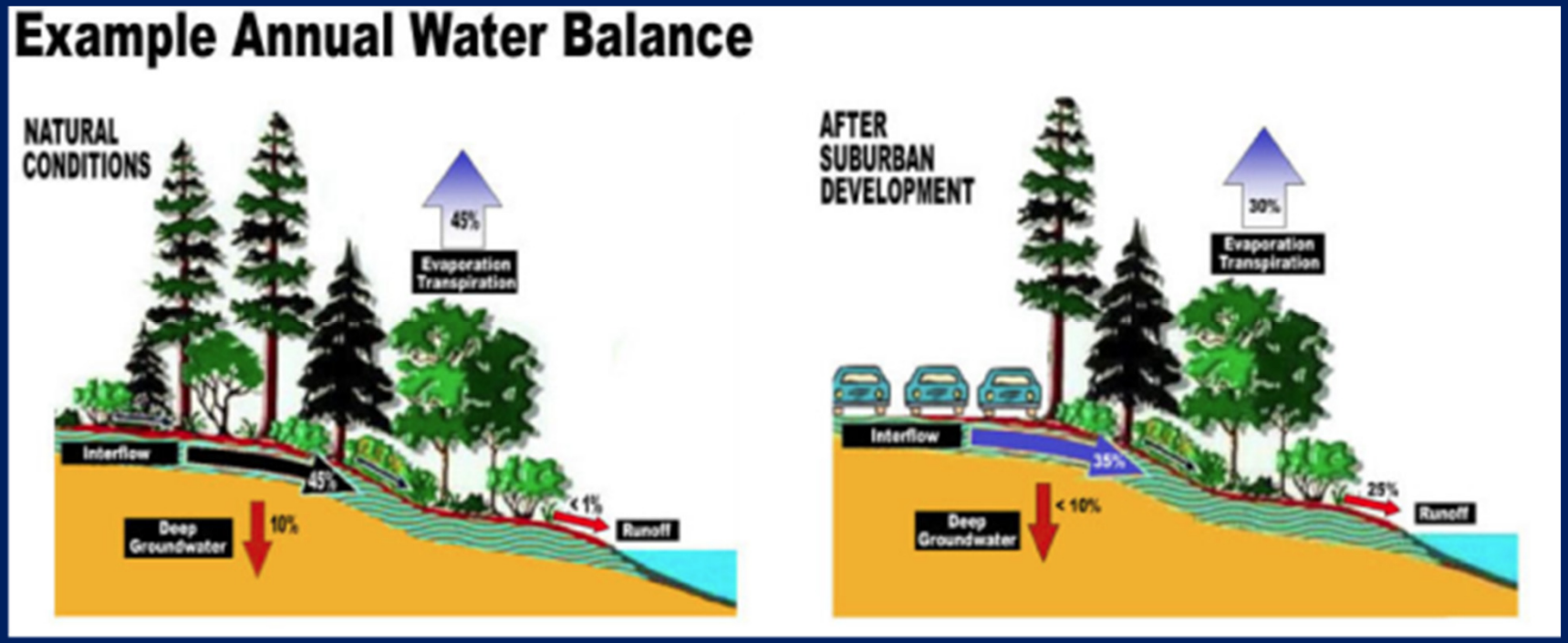


Source:
Low-Impact Development Hydrologic Analysis,
Prince George's County, Maryland July 1999

The experience of one Vancouver Island city illustrates why it is important to avoid unintended consequences

This experience reinforces the need for balance…

The headwater streams in BC have forced us to expand our view from the site to the watershed and stream…..



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

KEY MESSAGE: Guidebook identified the importance of ***interflow*** within the shallow vadose zone

Including the knowledge of soil science allows us to create a new understanding of the physical processes….

Typical forest soil

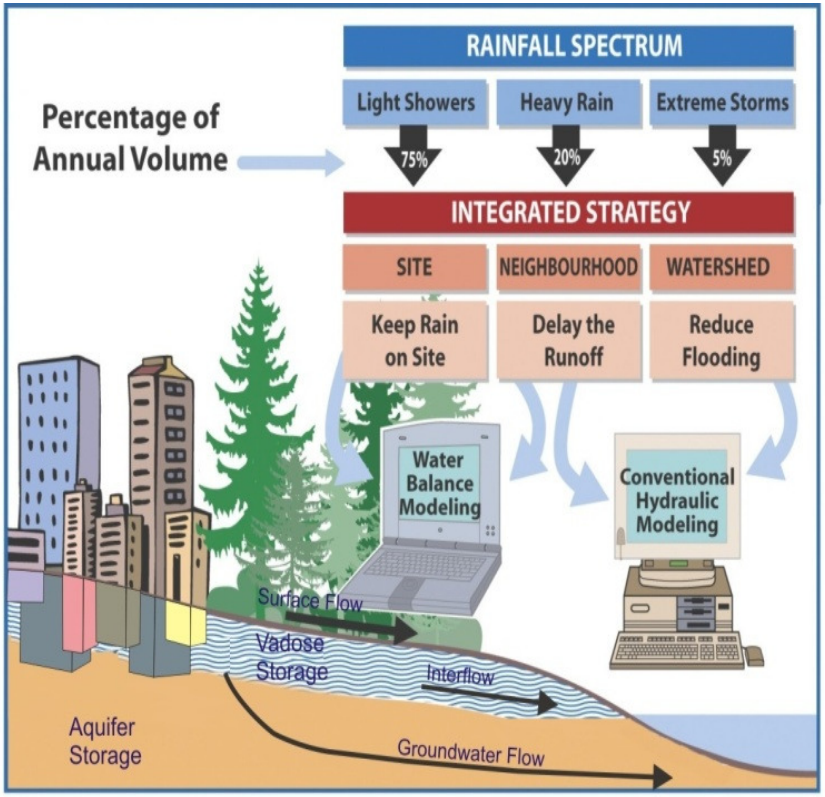
Water content and flow direction

Less typical soil

Iron leached into B Horizon
C Horizon typically dry even after big storms

Grey (gleyed) B and C Horizons
typically saturated for extended periods

Watershed protection starts with an understanding of how water gets to a stream, and how long it takes…



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!

Replicating interflow is incredibly important because….

These are typical West Coast annual water balance flow proportions:

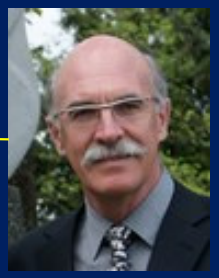
- Rainfall → 100%
- Stream Discharge → 70% to 80% of Rainfall
  - Surface Runoff 10%
  - Aquifer recharge 10% up to 25%
  - Interflow 25% **up to 60%**

Linking Rainfall, the Landscape, Streamflow and Groundwater has been a Building Block Process

- 2002 – How to reduce runoff volume
  (Province - Stormwater Guidebook)

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

- 2012 – How to sustain deep infiltration
  (Parksville – Englishman River Research

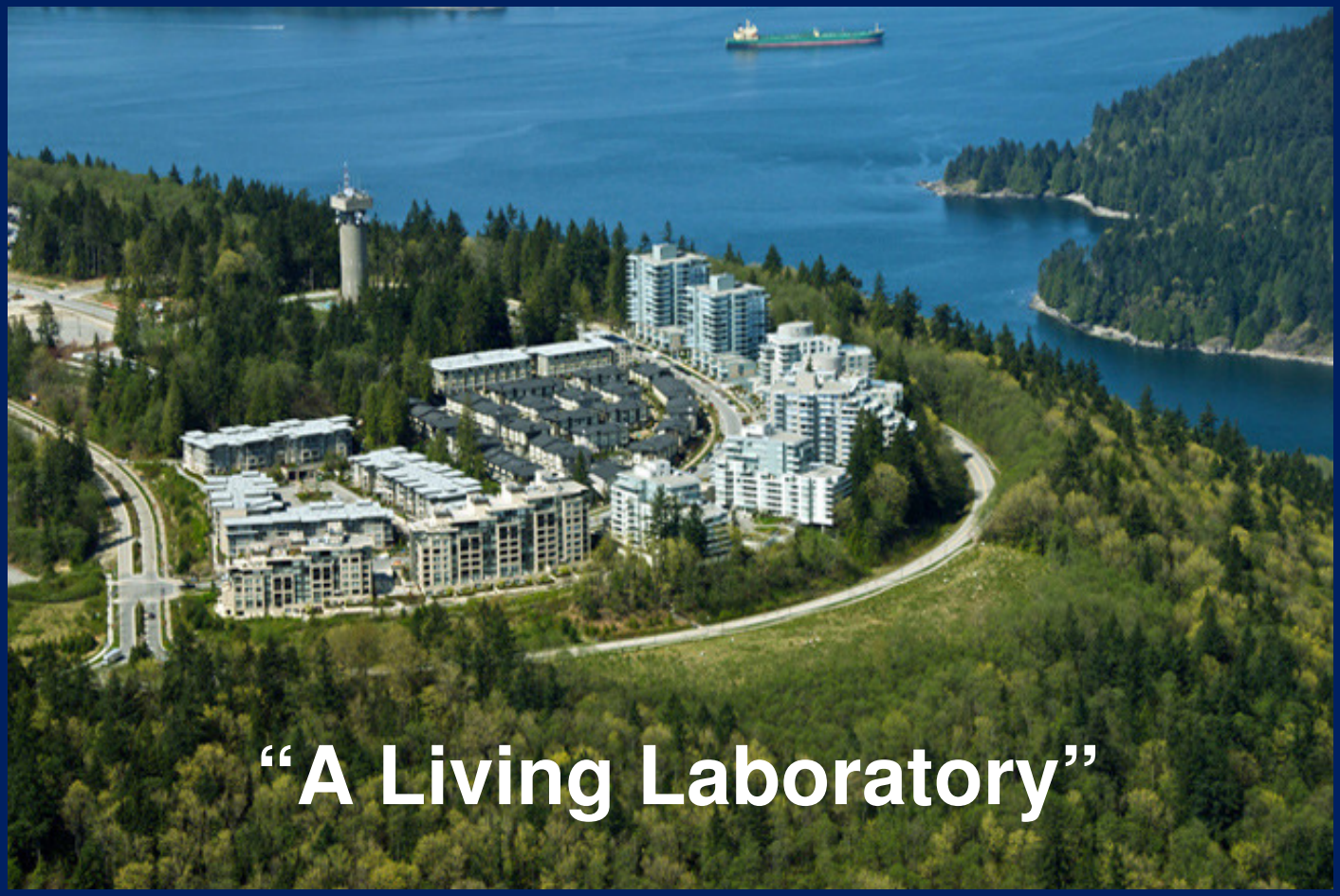


- 2013 – How to integrate performance targets
  (Cowichan Valley & North Vancouver - case studies)

Dr. Gilles Wendling

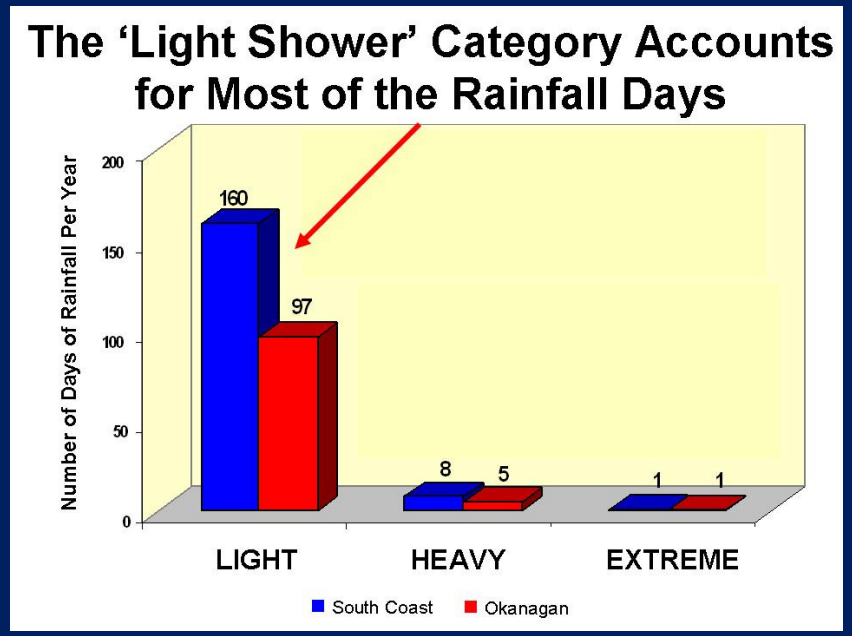
Genesis for Water Balance Methodology:

Looking at rainfall differently started with the UniverCity Sustainable Community on Burnaby Mountain (2000)

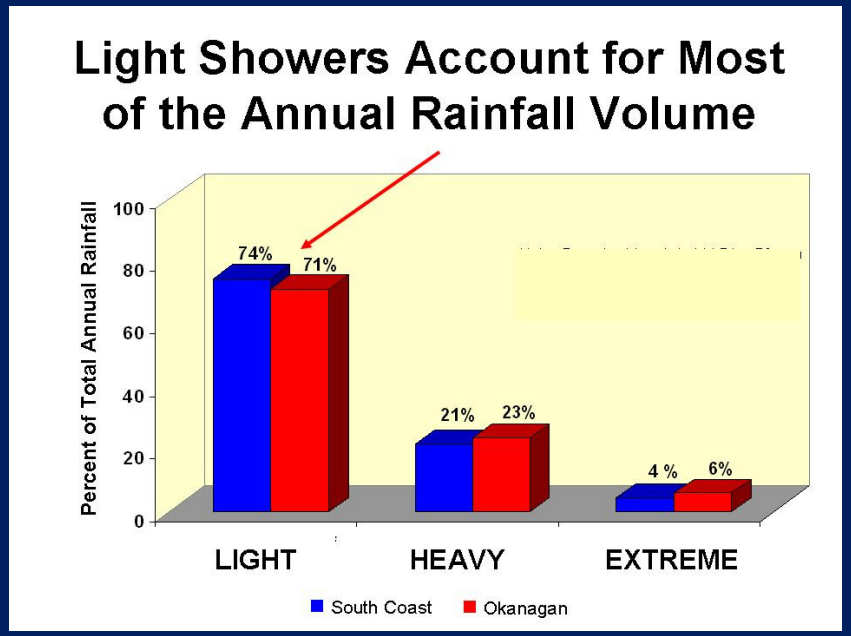


In 2000, we went back to basics and developed the concept of a Rainfall Spectrum.

We demonstrated the achievability of "rainfall capture". This helped overcome fear and doubt.

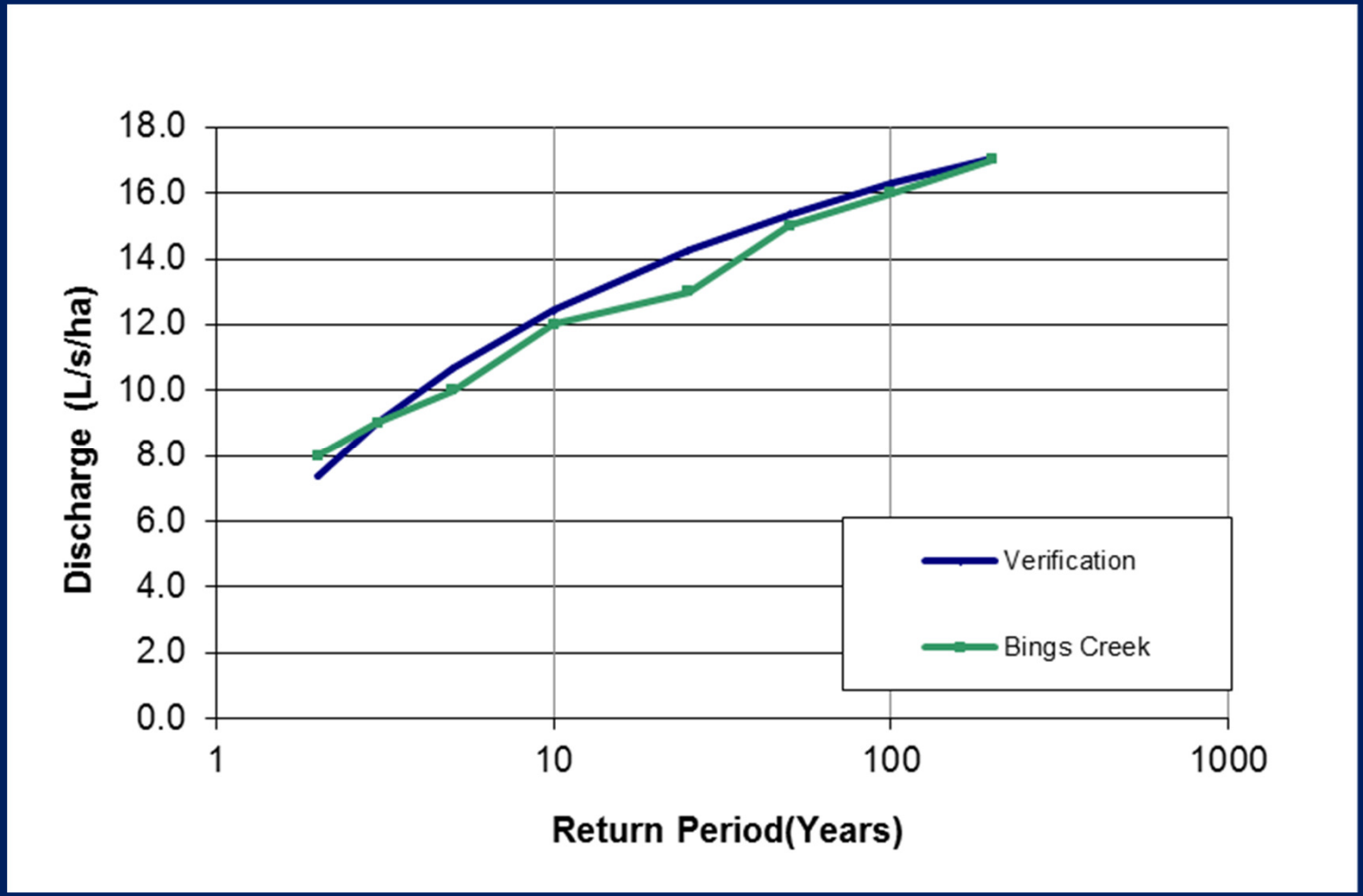


Days

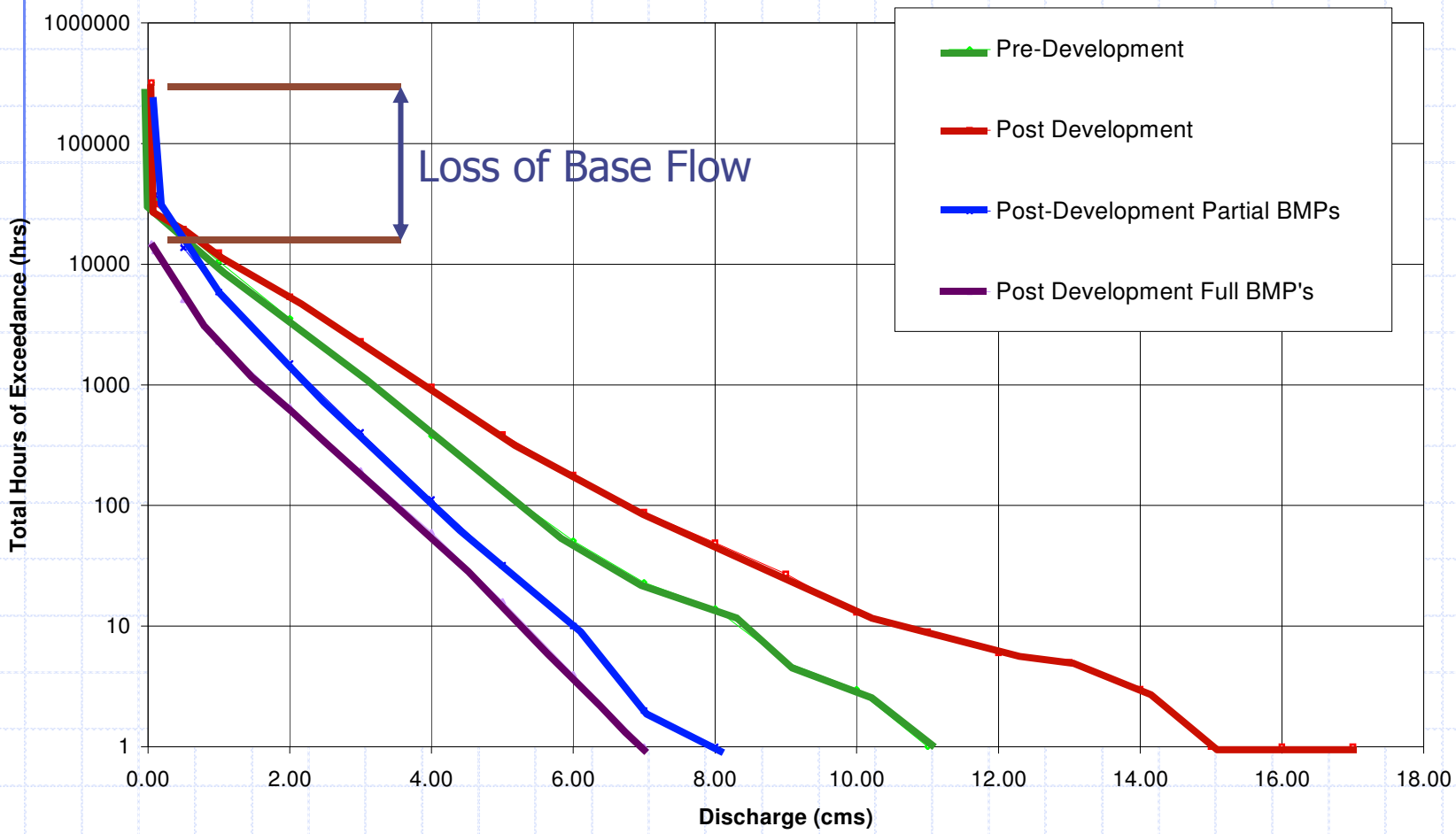


Volume

Model Calibration



Ultimately, the goal is to replicate INTERFLOW and mimic flow discharge-duration in the stream

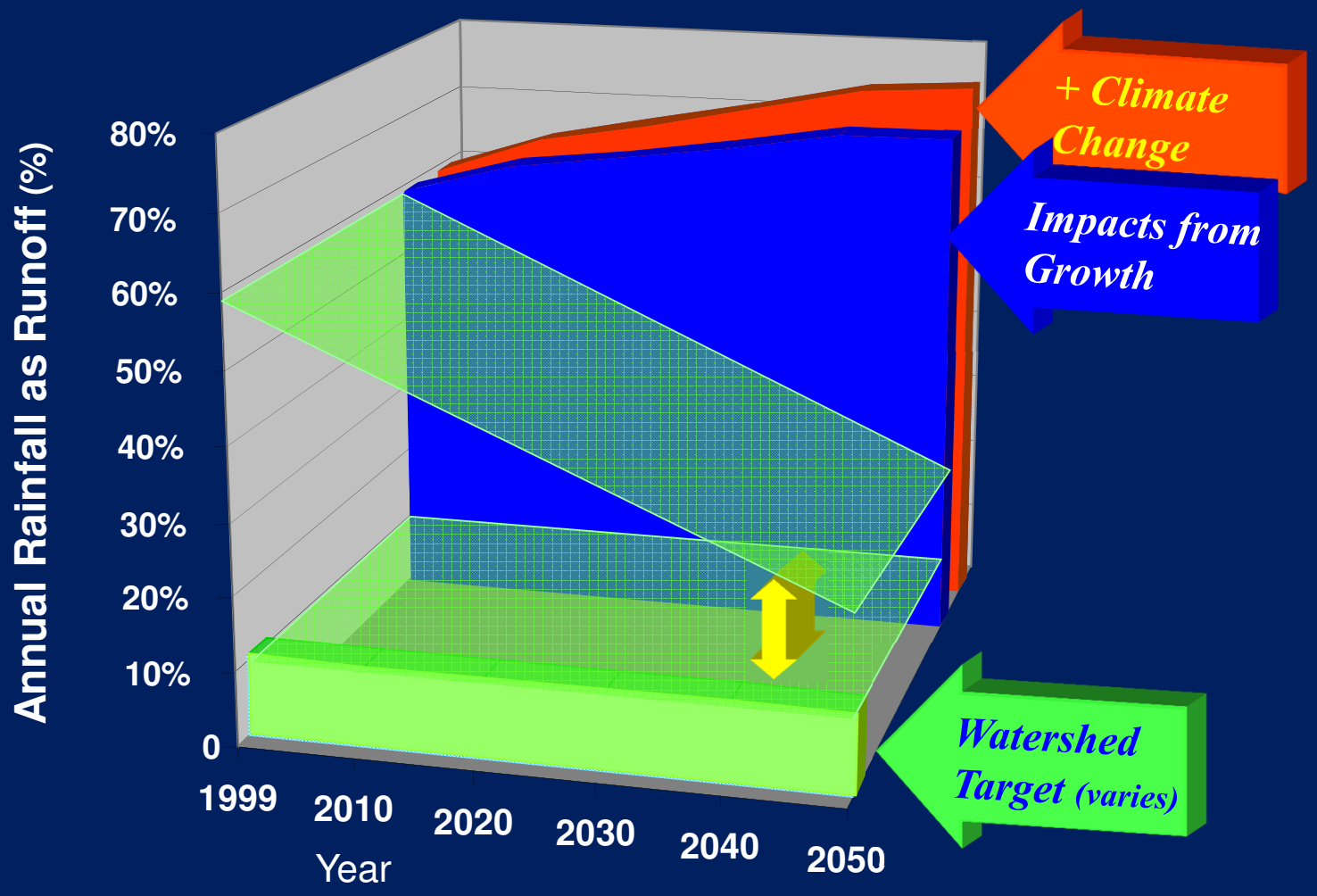


In a nutshell, the Water Balance Methodology…..

- Facilitates comparison of scenarios
- Applies science-based understanding to simplify complexity
- Synthesizes fundamentals of hydrology, flood protection aquatic ecology, geomorphology and hydrogeology
- Evolving to incorporate insights learned from case studies
- Builds on the 'runoff-based approach' to modelling because:
  - Rainfall and runoff have different return periods
  - Objective is to mimic stream flow and duration to limit stream erosion, prevent flooding, and improve water quality
- Keyed to continuous simulation of watershed response to rainfall over the period of record

Genesis for Water Balance Model in 2001:

Demonstrate that we could make a difference at a watershed scale, over time, one property at a time



So, what is the Water Balance Model?

Launched by an inter-governmental partnership in 2003, the WBM is a web-based, scenario comparison tool. Users can quantify the impacts of land use changes on the Water Footprint and hence Stream Health

THREE SCALES

- watershed
- development
- site

Now, three

USER LEVELS:

- planning
- engineering
- **landowner**

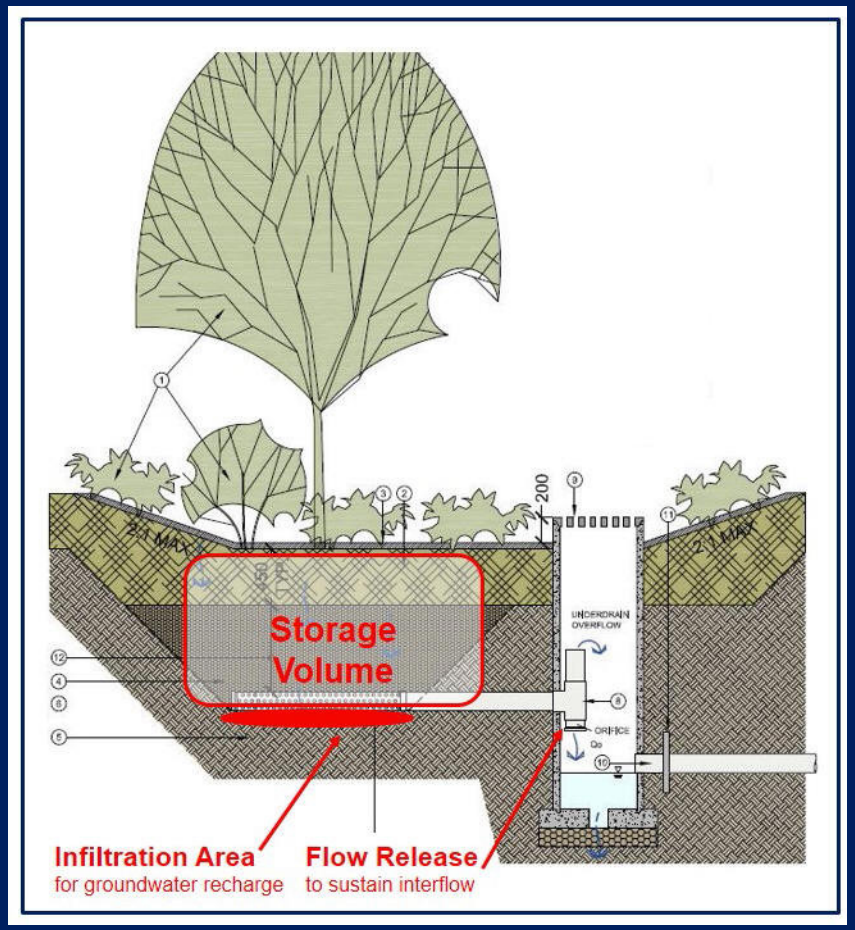
Applying the "Water Balance Methodology" is a Three-Step Process because…..

STEP ONE: Complete watershed-scale analysis to establish watershed-based target values for the three Water Balance parameters: *storage volume, infiltration area* and *flow release rate*

STEP TWO: Customize WBM Express interface so that it is Partner-specific; and populate with target values

STEP THREE: Align roles and responsibilities within the Land Development Process and implement

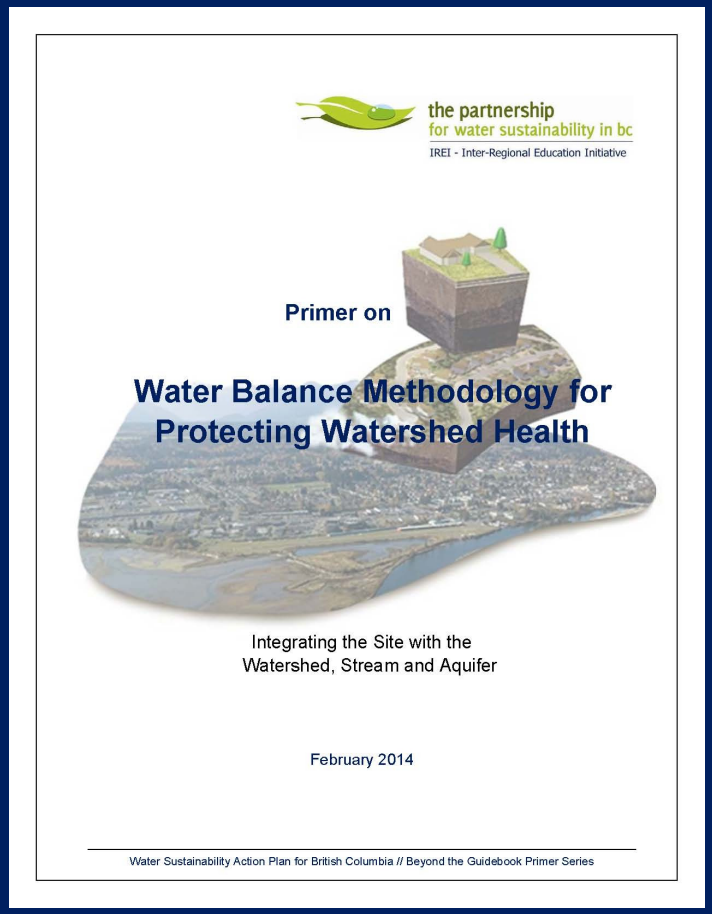
How Volume, Release Rate and Area Targets are implemented at the site scale….



The WBM Express integrates and balances three targets:

- **Volume for Interflow Storage**
- **Release to Sustain Duration of Interflow (to Mimic Shallow Groundwater flow)**
- **Area to Allow for Groundwater Recharge at limited rates**

Released in February 2014……



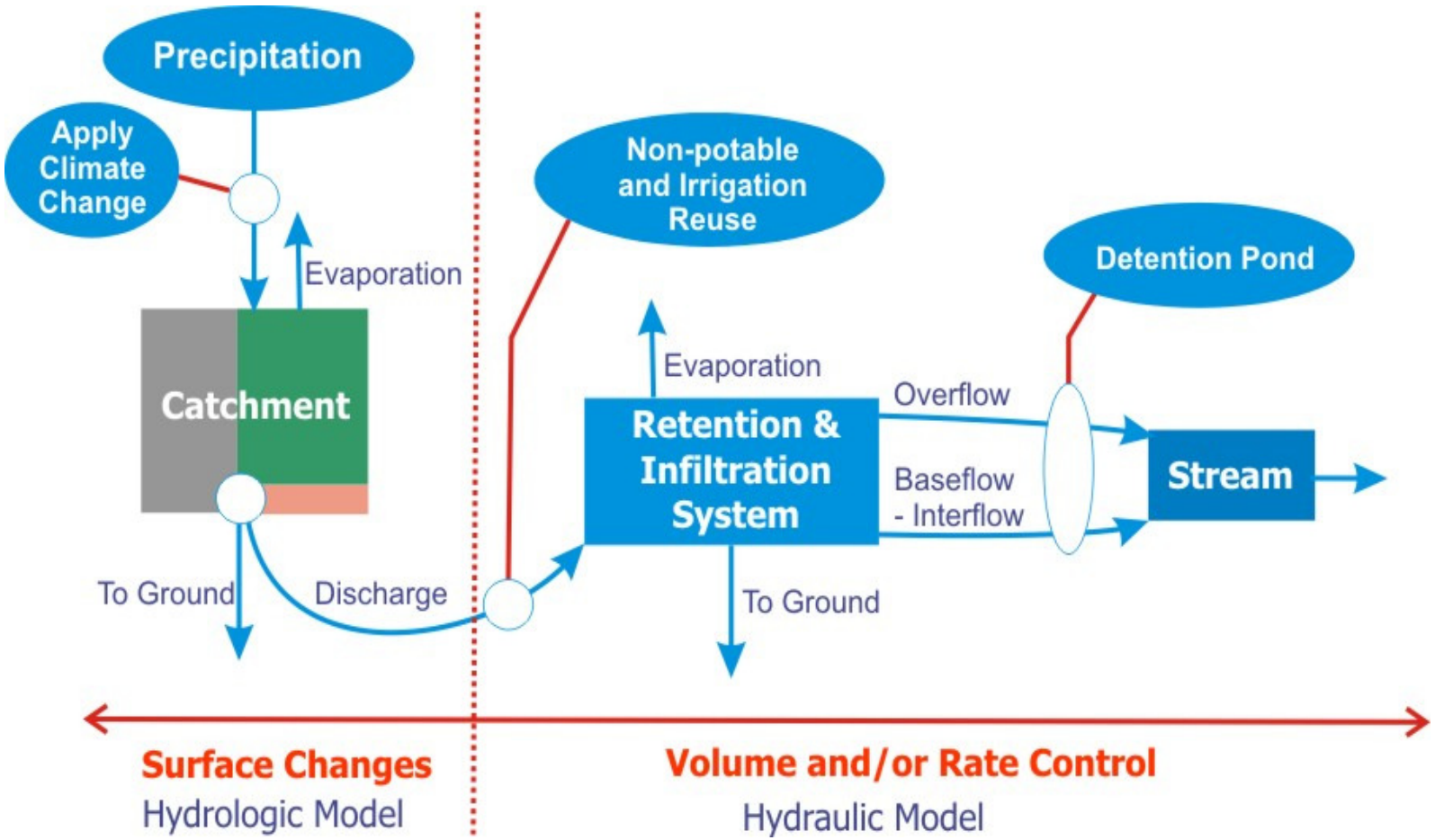
The Primer provides guidance on how to apply the Water Balance Methodology and quantify three performance targets:

- Storage Volume
- Infiltration Area
- Flow Release Rate

An Over-Arching Message

The Water Balance 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.*

Processes for simulation of a watershed plus retention and infiltration discharge control systems….



Because there are three pathways to streams……

- KEY MESSAGE #1 -

  The Water Balance Methodology examines the flow paths of water in the watershed, and the flow in streams.

- KEY MESSAGE #2 -

  At the heart of the Water Balance Methodology is recognition of the integrated significance of the three flow paths …. the period of time required for rainwater to reach the stream via each flow path …..and the need to protect and maintain the natural distribution of rainwater via each flow path.

Because there are three pathways to streams……

- KEY MESSAGE #3 -

  Mitigation means replicate the shallow soil storage and interflow conveyance system in order to mimic the natural watershed.

- KEY MESSAGE #4 -

  The analysis embodied in the Water Balance Methodology seeks to minimize the volume of retention and the infiltration system area while sustaining the selected base flow release rate.

An illustration of how the Water Balance Methodology can be applied to establish targets for design of rainwater capture and flow release systems…..

Watershed-Specific Performance Targets			
Target Parameter	**Water Balance Function**	**Units of Measurement**	**Example Target Values***
Base Flow Release Rate	Interflow Replicator Rate	litres per second per hectare of drainage area	0.5
Storage Volume	Interflow Storage Replicator	cubic metres per hectare of hardened land surface	300
Infiltration Area	Groundwater Storage Recharge	percentage of project site area in contact with native ground	3%

**represents expected order-of-magnitude of target value*

What is the "Baseflow Target" & How is it Established?

- Baseflow Target = Natural Stream Flow
  = Mean Annual Discharge
  (based on streamflow records)

- A KEY MESSAGE: "Green infrastructure" is necessary to replace lost interflow storage and lost flow pathways below ground

  Therefore, Discharge Rate = Interflow to Stream

What is the "Volume Target" & How is it Established?

Water Balance Methodology addresses this question:

How much rainwater enters the stream, and

How does it enter the stream?

This is important because:

- Rain infiltrates and is **stored** in shallow soils.
  It flows to stream through interflow
- Infrastructure is required to replace lost interflow storage and lost flow pathways below ground
- Streams need this flow and volume

What is the Volume Target & How is it Established?

Volume estimation is a balance because need:

1. Volume for Interflow Storage
2. Volume to Sustain Duration of Interflow
3. Volume to Allow Infiltration to Groundwater

Release from Storage to Sustain Base Flow

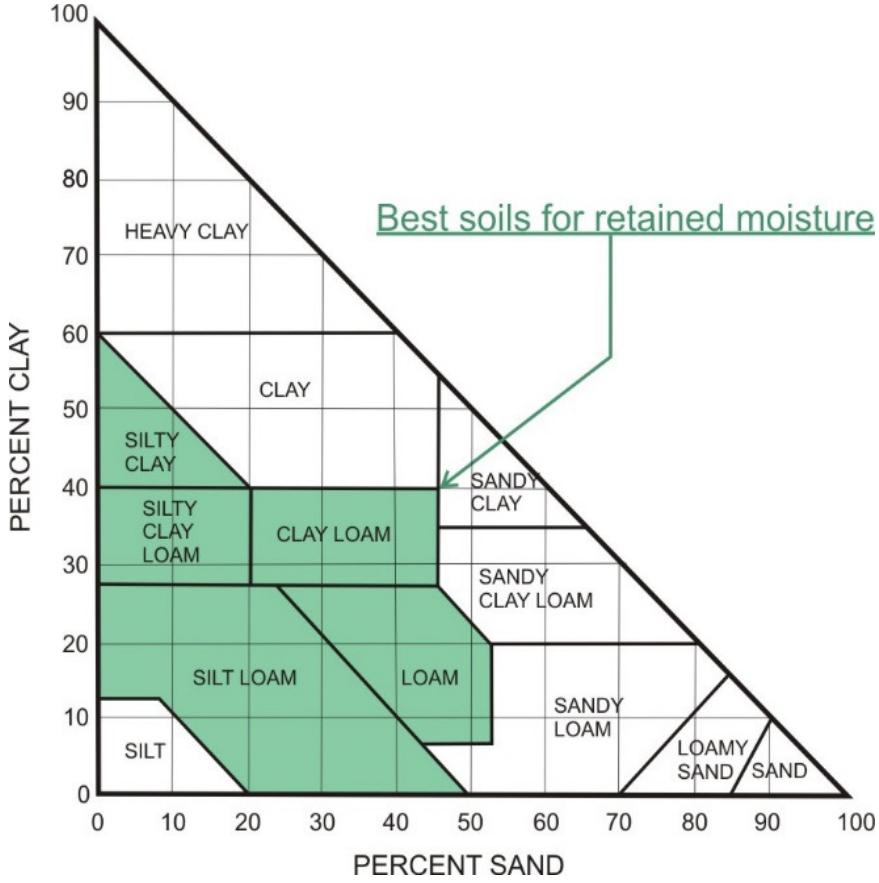
Infiltration Area to Support Deep Groundwater

What is the "Area Target" & How is it Established?

A guiding objective is to find the right percentage of surface area to promote deep infiltration because:

- Not all infiltrated water finds its way to deep groundwater
- Only a small portion of the land surface is directly connected to deep groundwater
- It is easy to either eliminate, or to amplify, flow to deep groundwater and thereby upset the natural Water Balance

Soils Science 101 – An Introduction to the Link Between Rainfall and Underground Aquifers

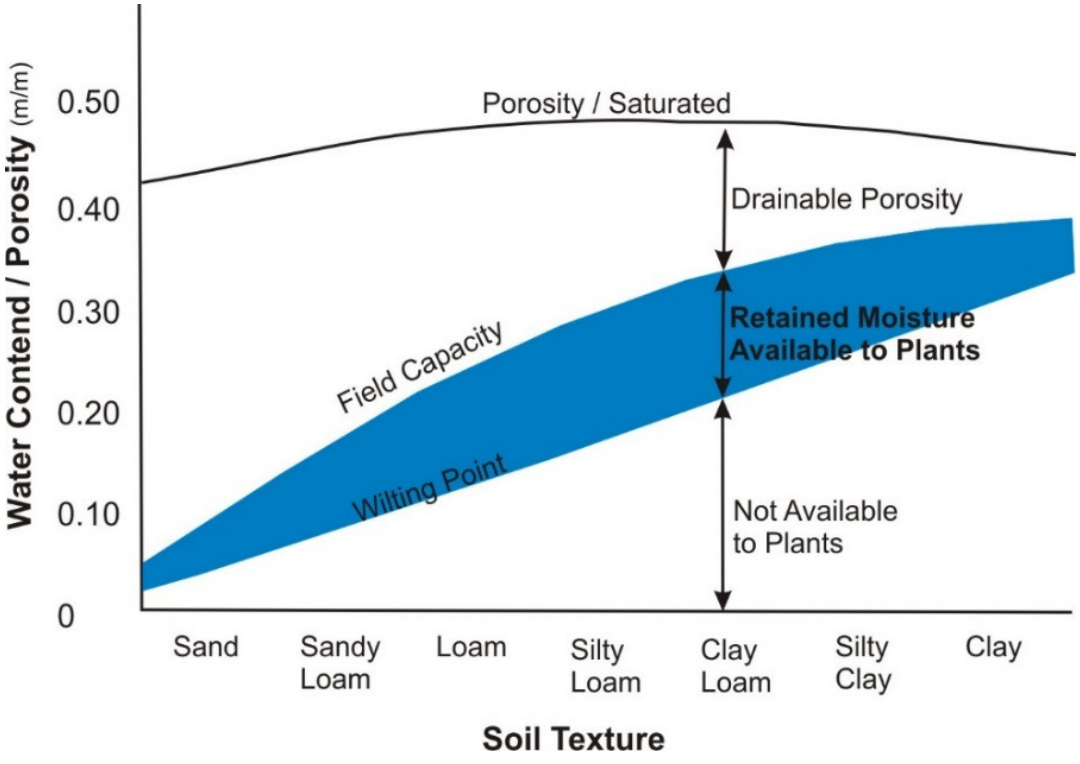


It is critical to know the fate of rainwater when water balance volumes are critical.

A major aspect of the shallow surface soil is its ability to act as a reservoir.

The soil texture determines how much of the retained water is available to plants.

Soils Science 101 – An Introduction to the Link Between Rainfall and Underground Aquifers



Where does the water go?

The soil reservoir will drain both downwards and sideways.

Our vision is that the WBM Express will drive practices that "Mimic the Natural Water Balance"

From natural….

..to initial development …….. and then densification

THE GOAL: After development, the site will function as it did before, or better!

Beyond the Guidebook Primer Series

Integrating the Site with the Watershed, Stream and Aquifer

Primer on Rainwater Management in an Urban Watershed Context (2011)

Primer on Urban Watershed Modelling to Inform Local Government Decision Processes (2011)

Primer on Integrated Rainwater and Groundwater Management for Lands on Vancouver Island and Beyond (2012)

Primer on Land Development Process in BC: Industry Standards of Practice in Implementing Rainwater Management (2013)

Primer on Water Balance Methodology for Protecting Watershed Health *(2014)*

Primer on Underground Rainwater Discharge – Facility Siting and Design Practices for Protection of Groundwater Resources
(*to be released later in 2014*)

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

A decade ago at their 2003 annual conference, BC local government politicians embraced Water Balance thinking and "design with nature"

"In 2002, the Province provided clear direction for land development:

- *"Mimic the natural Water Balance"*

"It's taken a decade long sojourn to really demonstrate how 'designing with nature' has achieved this goal".

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

Moderator, SmartStorm Forums
(1999- 2001)