Local Government User Guide

Okanagan Water Supply and Demand Project

www.obwb.ca/wsd

Local Government User Guide to the Okanagan Water Supply and Demand Project

Project Manager:
Anna Warwick Sears, Okanagan Basin Water Board

Technical Writer:
Jillian Tamblyn

Editing & Layout:
Webwoman Communications

All correspondence with respect to this User Guide should be directed to:
Anna Warwick Sears
Executive Director
Okanagan Basin Water Board
1450 KLO Road
Kelowna, BC V1W 3Z4

E-mail: anna.warwick.sears@obwb.ca
Phone: 250.469.6251
Fax: 250.762.7011
Web: www.obwb.ca

ACKNOWLEDGEMENTS

The Local Government User Guide to the Okanagan Water Supply & Demand Project is a project of the Okanagan Basin Water Board (OBWB) **with federal funding support through Natural Resources Canada's Regional Adaptation Collaborative (RAC) Program**.

Natural Resources Canada   Ressources naturelles Canada

Canada

The RAC Program enables Canadians to be better prepared to adapt to changes in the climate by providing them with adaptation knowledge, tools, networks and other resources. The RAC Program is a partnership initiative that addresses regional adaptation priorities, constituting a Canada-wide network with the overarching goal of accelerating adaptation at the national scale. Through the collaborative efforts of over 120 partners, including all levels of government, academia, non-governmental organizations and the private sector, the RAC Program is designed to promote and advance integration of adaptation considerations into decision-making to help Canadians reduce the risks and embrace the opportunities resulting from climate change. Some areas of focus include decreases in water supply and changes to timing of water availability, reduced volume and duration of snow cover, and increased droughts and flooding.

Project Manager:

Anna Warwick Sears, Okanagan Basin Water Board

Special Thanks:

- Brian Guy and Drew Lejbak, Summit Environmental Consultants Inc.
- Denise Neilsen, Agriculture and Agri-Food Canada
- Don Dobson, Urban Systems Ltd.
- Ron Fretwell, RHF Systems Ltd.
- Ted van der Gulik, BC Ministry of Agriculture

The Okanagan Water Supply & Demand Project is a partnership of the Okanagan Basin Water Board and the BC Ministry of Environment.

Other partners:

BC Ministry of Community, Sport & Cultural Development
BC Ministry of Agriculture

Environment Canada
Agriculture and Agri-Food Canada
Fisheries and Oceans Canada

Okanagan Nation Alliance

University of British Columbia
Simon Fraser University
University of Lethbridge

BC Agriculture Council
Water Supply Association of BC

Table of Contents

Part I
Introduction

PART I INTRODUCTION

This User Guide outlines how to access current and future water supply and demand information to support effective decision-making in the Okanagan Basin.

How to Use This Guide:

- An **overview** of the Project, data and models is provided in **Part I, Introduction**.
- Discover the Project's **key findings** in **Part II**.
- Find out **what the Project's results mean for local government** in **Part III, Implications**.
- Learn **how to access** Project data, web tools and models in **Part IV, Access Points.**
- See how the Project's climate, land use, water data, and models can be used to **answer local government questions** in **Part V, Mining the Data.**
- Read more about **available tools, models and data** in **Part VI.**

Why Study the Okanagan Basin?

The Okanagan has the lowest per person water supply in Canada and the highest per person water use, with a growing population that is vulnerable to climate change. Our economy, and in particular, major industries such as agriculture and tourism, depend on the health of our water resources.

The last comprehensive water assessment in the Okanagan was completed in 1974. Since then, population growth has outstripped all predictions and our water management technologies have greatly improved.

Adapting to Climate Change

Weather in the Okanagan is known to be arid and variable. Climate change is expected to result in warmer winters, lower snow pack and earlier spring runoff. Longer and drier growing seasons with warmer temperatures and lower rainfall will increase agricultural and landscaping water demand.

Adaptation to these changing conditions, founded on science and best management practices, must occur. Local governments in the Okanagan must build capacity for climate change adaptation, and work together with other local governments, agencies and stakeholders to develop new water conservation and management regimes throughout the basin.

What is the Okanagan Basin?

The Okanagan watershed, or basin, is a narrow strip that spans from Armstrong to the US border and includes five main lakes – Okanagan, Kalamalka-Wood, Skaha, Vaseux and Osoyoos – and surrounding mountains.

A river basin or watershed is high at its edges and low in the centre where the waters flow. The Okanagan Basin includes all the land that feeds water to our big lakes. Kelowna, Vernon, Penticton and Osoyoos all lie within the Okanagan Basin.

The Okanagan Basin is almost 200 km in length and 8,000 km^2 in area.

Where does water from the Okanagan Basin go?

The Okanagan River drains the lakes and flows south across the International Boundary to join the Columbia River, which then flows past the city of Portland to the Pacific Ocean.

State of the Basin:

Supply and demand in the Okanagan Basin was last assessed in 1974.

Many streams are now fully allocated, and users are moving to groundwater.

Increasing water licence requests underscore the need for a valley-wide approach to water management.

The Okanagan has the lowest per person water supply in Canada.

The average Okanagan resident uses 675 litres of water per day, more than double the Canadian average.

What is the Okanagan Water Supply & Demand Project?

The Okanagan Water Supply & Demand Project, or Project, is one of the most advanced water resource assessments ever conducted in Canada, using the latest models and computer technology to estimate Okanagan water availability, taking into account climate change and population growth.

The Project includes studies on groundwater, stream-flows, environmental water needs, and water use – balancing water supplies and water demands through a computer accounting model.

The Project models help us understand patterns of water use and the potential impacts of population growth, climate change, land use and the environment. Updated regularly, these models are essential tools for sustainability planning.

The Project is seeking answers to these questions:

- Is our water over-allocated?
- How do we protect groundwater?
- How will we share during shortages?
- How do we reduce risks to water quality?
- How can we be more water efficient?
- How much water do we have?
- What does the future hold?

Project Timeline and Next Steps

Phase 1 (2005) identified available data and information. Technical studies conducted in Phase 2 (initiated 2007) led to the development of an Okanagan water budget, or model, and future scenarios for use by local governments for planning, and by the Province of BC for water management.

Project results to date indicate a need for more careful management and choices about development, the future of agriculture, and environmental protection.

As these choices require informed input from multiple decision-makers and stakeholders, Phase 3 (2010) focuses on making data and information available, on refining modeling tools, and on consultation and policy development. It paves the way for updates by collecting data on critical elements such as lake evaporation and groundwater. Phase 3 ensures that the work of Phase 2 is put to best use for planning, adaptation, education, and improved management.

Project Tools and Data

Learn more about available tools and data in Part VI. The access point for all tools, reports and data produced by the Project is the Okanagan Water Supply & Demand Project website at **www.obwb.ca/wsd**.

The Okanagan Water Supply & Demand Project is state of the art in Canada, and is a pilot for other water-stressed areas of British Columbia.

A best estimate of current and future water supply and demand in the Okanagan.

The Okanagan Basin water regime - hydrology, actual water use, groundwater, lake evaporation and instream flow requirements - is assessed using **Hydrology** and **Demand Models**, which feed into a **Water Accounting Model** that calculates the water balance for the basin at 81 points in the valley.

Examine supply and demand patterns in specific areas of the watershed, or assess basin-wide trends.

The **Demand Model** developed by this project has been reproduced in the Similkameen, Nicola, and Lower Fraser valleys and received a Premier's Award for Innovation.

Okanagan local governments have already begun using the models and data to inform **regional growth strategies** and **planning**.

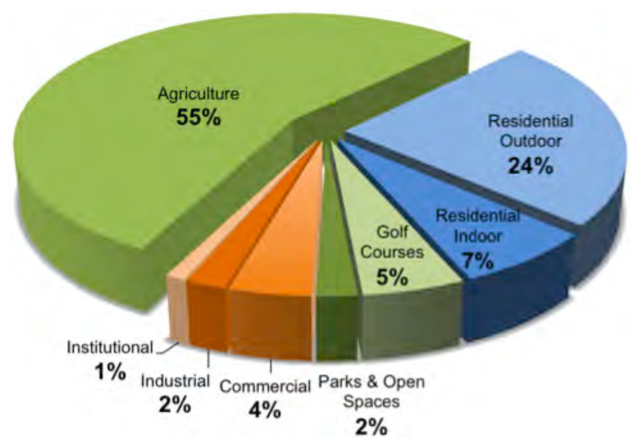
Access all project tools, reports and data at www.obwb.ca/wsd

Part II

Key Findings

PART II KEY FINDINGS

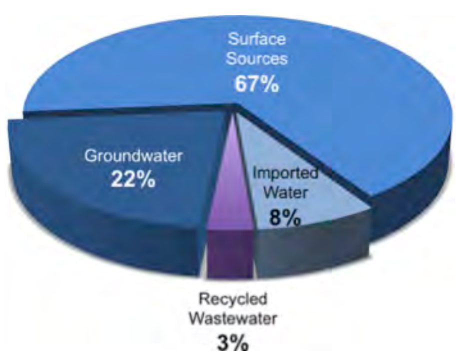
Uses of Water[1]



- **Risks of water shortages for human use and environmental needs are increasing**, and it will only be possible to compensate through thoughtful design and implementation of policies, including local government drought management plans, to address **land-use planning, careful water management including supply, and demand reduction.** Coordinated plans may be required for the basin as a whole.

- **Future shortages are likely to occur in late summer,** when low seasonal water supplies from surface sources are projected to drop by as much as 65% from 2041 to 2070, and demands for water withdrawals and ecosystem needs are high and increasing. Local governments can consider this for water supply and demand planning.

Sources of Water



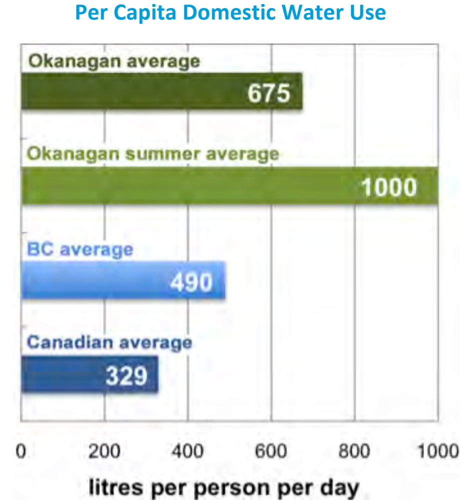
- **High variability in water supply and demand – seasonally, from year-to-year, and in different geographic areas**, should be considered in decision-making.

- **Groundwater is an increasingly important source of water for human needs**, yet is under-regulated. Our knowledge of supply potential, aquifer health, and of the actual amount of groundwater use is poor. Groundwater and surface water are connected and should be managed as the same pool. Groundwater should be permitted or licensed within the same allocation system used for surface water.

- **Per capita domestic water use in the Okanagan is extremely high** compared to national and international use, primarily due to domestic **outdoor water use,** which accounts for 24% of all the water used in the Okanagan. Action is needed to **reduce use through proven conservation measures,** which tend to cost less than measures to increase supply. Local governments can implement measures through bylaws and incentives.

- About **95% of the water licensed for offstream use is managed by 57 large water suppliers** in the basin. Local governments, Bands and purveyors on this list of suppliers can have a large impact on water use.

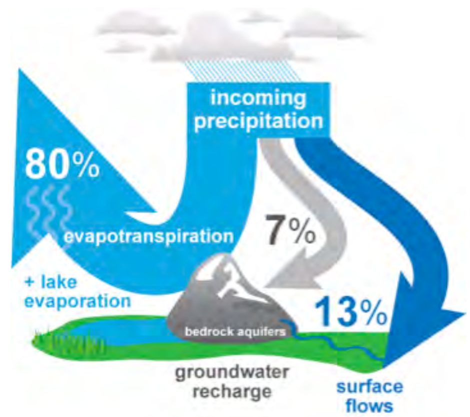
Per Capita Domestic Water Use



1. Agriculture uses 55% of water in the Okanagan. This percentage does not include farms equipped with irrigation systems that are not currently irrigating and therefore does not reflect the total potential amount of water committed to agriculture in the Okanagan.

- **Measurement and record-keeping of bulk water withdrawals** by major water suppliers and large individual licencees has not been standardized and is patchy and **inconsistent**, and coordinated record keeping is needed. Water purveyors can now report use with the Streamlined Water Use Reporting Tool (See **Part IV - Access Points**, Page 16).

Where Incoming Precipitation Goes



- **80% of incoming precipitation is lost** to evapotranspiration from plants and evaporation from lake surfaces. Only 13% contributes to surface flows and 7% to groundwater recharge.

- **Stream flows must be measured for best management**. However, within the last decade, the **network of hydrologic stations has been reduced to about half** of historical levels, and the network must be strategically redesigned and restored.

- As a result of continuing climate change, more winter precipitation will fall as rain and high elevation snowpacks will melt several weeks sooner. This **increases the importance of upland reservoir storage and the difficulty of managing supplies.**

- In a future three-year drought, average annual net inflows to Okanagan Lake are expected to be roughly half of average values today. Assuming such a scenario with current operating procedures, **Okanagan Lake levels would progressively decline to below normal operating ranges, and could affect the ability to keep water flowing in Okanagan River, which can affect water intakes.**

- Due to climate change alone (ignoring population growth or addition of irrigated land), the level of **Okanagan Lake is expected to drop below its historic minimum several times** over the next 30 years. This can impact recreation and infrastructure.

- **Current water licence volumes may not be available or sufficient to satisfy demands** on some streams in future, particularly on those with limited or no storage.

- The models are based on available scientific and water management information; however, the quality of that information is variable, and in some areas **additional data and information should be obtained** on surface water, groundwater, climate, water withdrawals and distribution, aquatic ecosystem needs, lake evaporation, and evapotranspiration.

Visualize project results with the Viewer
at www.okanaganwater.ca

Part III

Implications for Local Government

PART III IMPLICATIONS FOR LOCAL GOVERNMENT

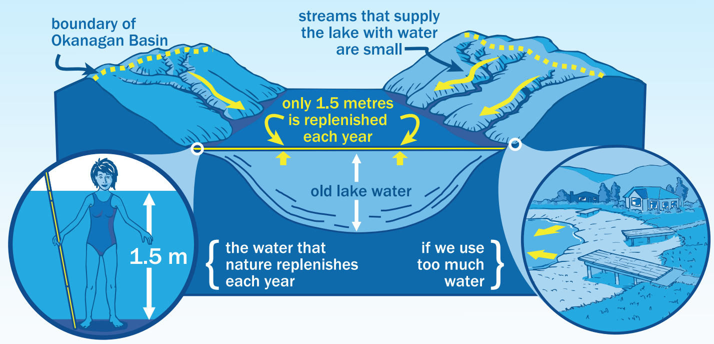
What Do the Results of this Project Mean for Local Governments in the Okanagan?

Local governments make important planning, infrastructure development and operational decisions every day. Many Okanagan local governments manage one or more water utilities.

Changing climatic conditions will challenge our resilience and our ability to adapt. How do we ensure adequate risk management in a time of change and uncertainty? How do we know what the future will bring? What will be the impacts of climate change and population growth, and how will we adapt?

Did You Know?

Only about 1/60th of the volume of Okanagan Lake is refreshed each year. Reduced inflows or increased withdrawals in the watershed could cause drawdown of the lake.



Only the upper 1.5 metres of Okanagan Lake is replenished each year. If more water is withdrawn, lake levels will fall. (Turner et. al, 2006).

Climate change is predicted to strongly impact our water supplies. Paleo-ecological studies show that the 20th century was the wettest of the last 4,000 years. As the Earth warms, the frequency and intensity of extreme weather events is expected to increase. What type of weather abnormalities and unseasonal events will we face in the future?

The results of this Project reinforce the need for:

- **Water conservation programs and bylaws** to reduce demand, with a particular emphasis on reducing outdoor use, including but not limited to water metering, water reduction incentives, drought-tolerant landscaping, and efficient irrigation practices.
- **Drought response plans** to reduce the impacts of shortages on water users, including the environment.
- **Increased reservoir storage** in upland reservoirs, and through management of mainstem lakes.
- **Increased collaboration** with watershed managers and water suppliers throughout the basin.

Modernizing British Columbia's Water Act

The results of this Project are also informing the modernization of BC's *Water Act*. The Okanagan Water Supply and Demand Project Working Group, the multi-agency body overseeing the Project, has submitted a list of recommendations for Water Act Modernization to the Province, including:

- Improved measurement and reporting of surface and groundwater use
- A mechanism for the licensing of groundwater
- Protection of upland reservoirs
- Regulatory incentives for improvements in water use efficiency for all sectors
- Recognition of regional differences – i.e. one size does not fit all.

- Water allocation decisions to consider water availability, including the potential for drought, variability or climate change, a watershed review of existing licences, and environmental needs.

Considerations in Accessing Information

With so much information available from the Okanagan Water Supply & Demand Project, it may be difficult to know where to start.

A local government will benefit from taking the time to scope its needs.

Consider these relevant questions:

- *What do we already know about actual or estimated water supply, demand and delivery in our area?*
- *What are our goals and objectives?*
- *What questions do we need answered about water supply or demand, today and in the future?*
- *Is this an operational or a planning decision?*
- *What can we learn by looking at past, present and future scenarios?*
- *What is our study area and how is it defined in relation to the water sub-units used in this Project (e.g. aquifers, water use areas, sub-basins)?*
- *What is the time period or scale – seasonal or annual, present or future?*
- *What risk factors are we considering, and what level of confidence is needed in the data?*
- *What existing or recent data can our local government provide to calibrate, improve or supplement the results of the Project?*
- *Can we perform additional studies to improve the model in our geographic area to meet the required level of confidence (e.g. by incorporating purveyor actual water use data or current land use)?*

Local governments should keep in mind that:

- **Some models provide more detailed data than others.**
  The **Demand Model** provides estimates at the scale of individual properties. The **Hydrology** and **Water Accounting Models** are more appropriate for examining larger geographic areas, such as the entire area of the basin, sub-basins, stream systems, drainages or water use areas. Data continues to be gathered to improve the Models.
- **Scenarios that examine proposed changes or activities in only one part of the watershed may be too limited in scope.** Other activities occurring upstream or downstream may mitigate or compound these proposed changes. For example, when considering the potential impacts of a specific large housing development in one water use area, the model will not reflect the impact of up- or down-stream developments.
- **Supply scenarios for lake water availability are less complex than those for tributary streams.** Decision-making in tributaries can be more difficult.
- **Phase 2 examined BASIN-WIDE scenarios, but local governments may request SPECIFIC scenarios** based on their geographical area, land use cases, or other assumptions. Submit a **Data Request** online at **db.okanaganwater.ca** or contact the OBWB for more information.

To address this information gap, the Hydrological Connectivity Project will examine licence priorities, i.e. who has rights to the water, and how water use in one area affects another.

Part IV

Access Points

PART IV ACCESS POINTS

Okanagan Water Supply & Demand Project Website - www.obwb.ca/wsd

The Okanagan Water Supply & Demand Project website is the main access point for all tools, reports and data produced by the Project.

Visit the **Okanagan Water Supply & Demand (WSD)** website to find out more about the Project, and to access:

- **Project Updates**
- **Phase 2 Project Summary Report, Maps & Appendices**
- **Okanagan Water Supply & Demand Viewer**
- **Okanagan Water Science Library**
- **Okanagan WaterWise**
- **Okanagan Water Database**

Access the WSD website at **www.obwb.ca/wsd**

www.obwb.ca/wsd

Okanagan Water Supply & Demand Viewer – www.obwb.ca/wsd

The Okanagan Water Supply & Demand Viewer is a web-based tool that displays interactive maps of water sources, water use, and other results of the Okanagan Water Supply & Demand Project in a user-friendly format.

The Viewer provides graphical and statistical information about the **current state** of water supply and demand at various locations in the Okanagan valley, and examines the likely **future influences** of population growth, climate change, land use, and other factors.

Available comparative scenarios include:

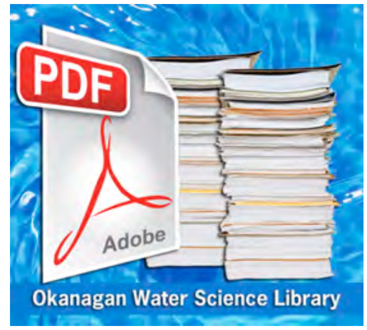
- **Population Growth:**
  The expected rate versus a higher rate.
- **Agricultural Conditions:**
  The current amount of land under cultivation versus a larger area that includes all reasonably irrigable land.
- **Water Use Efficiency:**
  Current trends versus the Provincial guideline of achieving 33% efficiency improvements by 2020.

Additionally, one of the scenarios simulates the effects of a **three-year drought**, similar to the historically significant Okanagan drought of 1929-1931.

Okanagan
Water Supply & Demand
Viewer

The Viewer is available from every page of the WSD website at **www.obwb.ca/wsd** or access the Viewer directly at **www.okanaganwater.ca.**

Okanagan Water Science Library – www.obwb.ca/wsd



The **Okanagan Basin Water Resource Information Database (OBWRID)** is a fully searchable digital document database, or **Okanagan Water Science Library,** of water-related information compiled, studied and acquired about the Okanagan Basin.

Try a simple Keyword Search, Browse by Topic, or perform an Advanced Search by specifying parameters such as date, author, subject, keyword, watershed, surface or groundwater.

The **Okanagan Water Science Library** is the largest electronic repository of current and historical information about the Okanagan Basin, and is the only digital source for many Okanagan water documents and reports. Links to downloadable PDFs are provided for most entries.

The **Okanagan Water Science Library** is searchable from every page of the WSD website at **www.obwb.ca/wsd** or access the Advanced Search page directly at **www.obwb.ca/obwrid**.

Okanagan WaterWise - www.okwaterwise.ca

Okanagan WaterWise is an Okanagan Basin Water Board outreach initiative that encourages conserving & protecting the Okanagan's most valuable natural resource - water. This educational web site features water conservation tips and information for homes, businesses and schools, and addresses both indoor and outdoor water use.

The **Okanagan WaterWise** website is accessible from every page of the WSD website at **www.obwb.ca/wsd** or access the site directly at **www.okwaterwise.ca**.

Streamlined Water Use Reporting Tool – www.obwb.ca/swurt

The Streamlined Water Use Reporting Tool (**SWURT**) is targeted to water purveyors and other large water users. This graphical tool summarizes current and future water availability in the valley – taking into account population, climate, and land use.

Water purveyors can use this tool to track surface and groundwater use and storage, and to access current and historical information, including snowpack depths, reservoir levels, stream-flows, and weather. **SWURT** is accessible only to registered users – please contact the OBWB for more information.

For more information about **SWURT**, visit **www.obwb.ca/swurt**.

"The SWURT tool will allow utilities to provide current water use data and access historic data for trending. And just as importantly, we'll be able to see what other water utilities in the valley are extracting, helping us work together and manage our common water resource."

– Bob Hrasko, Vice-Chair, Water Supply Association of BC and Administrator, Black Mountain Irrigation District

Okanagan Water Database - db.okanaganwater.ca

The **Okanagan Water Database** is the repository and management tool for all technical Project data and acts as the data bridge between the Project models.

Okanagan
Water Database

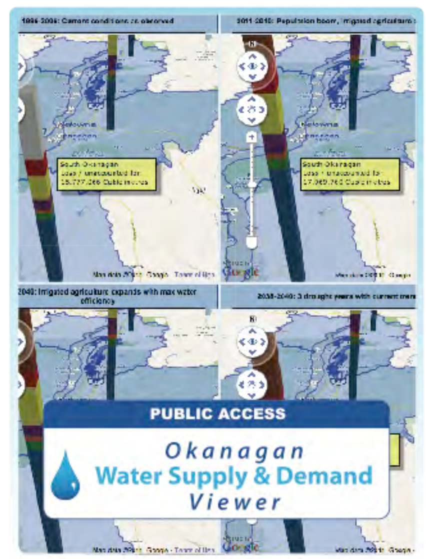
The primary function of the database is to host time series and other data produced by the Project's technical studies, which include estimates of water use throughout the basin from the **Demand Model**, supply information derived from the **Hydrology Model**, and the effects of water management on natural flows and lake levels as calculated by the **Water Accounting Model**.

Information from the Okanagan Water Database is freely available through the tools produced by the Project, most notably the user-friendly and interactive Okanagan Water Supply & Demand Viewer.

Data Requests & Uploads

The **Okanagan Water Database** is managed by the Okanagan Basin Water Board (OBWB). Specific or 'protected' data sets and models may be accessed through a **Data Sharing Agreement**. After a local government has determined its project scope and parameters, OBWB staff and contractors will assist in refining the information request and identifying the opportunities and limitations of the data and models.

Visit db.okanaganwater.ca to **Submit a Data Request**, or contact the OBWB for more information.



Visualize data from the Okanagan Water Database with the Viewer at www.okanaganwater.ca

Data Sharing Agreement & Costs

The OBWB will cover all or a portion of data retrieval costs for Okanagan local governments, with the cost-sharing formula to be determined by the scale of the request and availability of funding. Parties other than local governments, or not contributing to the Project, will be charged on a cost-recovery basis.

For more information on the **Okanagan Water Database:**

- **Submit a Data Request** online at db.okanaganwater.ca
- **Contact the OBWB:**
  Okanagan Basin Water Board
  1450 KLO Road, Kelowna BC V1W 3Z4
  Phone: 250-469-6323
  Fax: 250-762-7011
  info@obwb.ca

Part V

Mining the Data

PART V MINING THE DATA

The Okanagan Water Supply & Demand Project signifies a major step forward in our understanding of the Okanagan Basin, making it one of the most water information-rich areas in British Columbia.

A number of user-friendly web-based tools have been developed to assist local governments and other users in understanding, accessing and applying the Project's results and data.

The main access point for all tools, data and models developed for the Project is the Okanagan Water Supply & Demand Project website at **www.obwb.ca/wsd**.

Visit the Project website at **www.obwb.ca/wsd** to access tools such as the Okanagan Water Supply & Demand Viewer and the Okanagan Water Science Library, and learn more about each tool in **Part VI** of this Guide.

How Should Local Governments Use This Data?

Questions about water supply and demand are important to many of the services that local governments provide. Generally, the Project's results indicate what is happening with water in the Okanagan Basin, and what is expected to happen in the future.

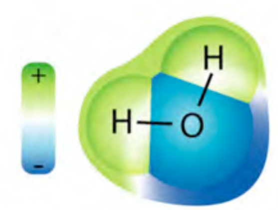
Each local government must determine how best to address these results. The models and data used in this Project can be used in a variety of ways by local governments.

Local governments may also request specific datasets or scenarios for their particular geographical area, land use cases, or other assumptions, from the Okanagan Basin Water Board (OBWB). Staff and consultants of the Okanagan Basin Water Board are available to assist with accessing and processing limited public access data.

Keep in mind that many of the Project's components can be used to answer questions about current and future scenarios at a variety of scales - however, some datasets may not be available at the level of accuracy or detail required for your project, and may only provide a starting point for further investigation.

For example, a local government may identify an aquifer that is sensitive to further development or an expansion of agriculture – and then determine how to respond to that information through bylaws, decision-making or additional detailed studies.

How Researchers Are Using the Results of the Okanagan Water Supply & Demand Project



Virtual Water Use in the Okanagan

Dr. Hans Schreier at the University of British Columbia used the maps and water requirements of agricultural areas, parks, and other large turf areas to determine **the amount of water used** to produce wine and other local agricultural products. This water use can then be compared to the "**virtual water**" that is imported into the basin by the import of agricultural products that are grown elsewhere.

Pollinator Studies in Okanagan Agricultural Areas

Using the maps of agricultural areas developed by this project, Dr. Jason Pither and his research team at UBC-Okanagan are studying the **distribution of different crops** and how they may affect the **presence and abundance of different pollinators**.

Local Government Questions and Considerations

Sample questions and considerations for local governments are listed below. Examples of how Okanagan local governments are using the results of the Project are contained in the sidebars.

Water Management and Land Use Planning

In a water-scarce region such as the Okanagan, local governments must carefully consider water management and land-use planning to meet risks of future water shortages.

Land-use decisions can have long-lasting impacts on a community. Once established, development patterns, travel corridors, infrastructure, and services usually remain on the landscape.

Planning tools and legislative plans used by local governments must consider and take into account local, as well as basin-wide water management, which may be the key to the success of any overall initiative.

Although some Project data may not currently be available at the level of detail required for a local or site-specific plan, the Project's results may be used to flag areas of interest. In addition, local governments may request data for specific land-use cases, geographical areas or scenarios from the Okanagan Basin Water Board.

For more information about available Project data and tools, refer to Part IV, Access Points and Part VI, More About Data and Tools.

EXAMPLE:
A growth area's surface water is **fully** or **close to fully licensed** and the aquifer has **limited recharge**.

RECOMMENDATION:
Prioritize this area for further study to determine the **availability of water**.

IMPLEMENTATION:
Water availability information is used to establish **Development Permit Areas** or **Development Information Areas** for consideration of future development applications.

Agricultural Area Plans

Agricultural planning is most likely to make use of the **Climate Data** and the **Water Demand Model**. Current and future supply data should also be considered, especially if the supply of surface or groundwater is limited in a particular agricultural area.

The BC Ministry of Agriculture uses Land Use Inventories to develop Agricultural Area Plans, and a number of Okanagan local governments are currently working with this information. Input data available include **crop types**, **soil textures**, **irrigation systems**, and **climate**. Outputs include **irrigation water demand** (optimal), **climate moisture deficits**, **crop evapotranspiration**, and **crop water requirements**.

Data is available in some cases for **backcasting**. Whereas forecasting predicts the future based on current trends, backcasting imagines a future successful outcome and then poses the question "What do we need to do today to reach that outcome?". Backcasting is increasingly used in urban planning and resource management of water and energy. In 2006, the Capital Regional District committed to backcasting to the year 2050 as a formal element of all future strategic water planning initiatives.

The **Water Demand Model** will supply the science behind establishing Agricultural Water Reserves, whose purpose is to secure access to water for lands within the Agricultural Land Reserve (ALR). Visit Living Water Smart at www.livingwatersmart.ca/business/agriculture.html for more information.

AGRICULTURAL WATER SUPPLY

Questions:

- *If 50 more acres of alfalfa were to be irrigated in a water use area through a groundwater source such as a well, how much additional water would be drawn from the aquifer?*
- *Does the aquifer have low or high recharge rate?*

Considerations:

- What further studies will be required to understand the capacity of this aquifer?
- If there is high uncertainty in water availability, what recommendations should be considered for this aquifer?

AGRICULTURAL WATER DEMAND

Questions:

- *How will total agricultural water demand change, between now and mid-century, under different climate models?*
- *How is total agricultural water demand impacted by land-use or efficiency?*
- *How much water would we use if we irrigated all irrigable lands?*
- *How much water would we use if we implemented 33% efficiency?*
- *How will agricultural demand increase if all farms that currently have irrigation systems and access to water but are not currently irrigating, were to irrigate?*

Considerations:

- Do we have sufficient capacity within our current infrastructure to address these scenarios?
- If not, how can we reduce demand, and/or increase capacity, to meet future needs?

AGRICULTURAL DEVELOPMENT

Questions:

- *Where do we have sufficient water capacity to sustain agricultural development?*
- *Which areas will require major infrastructure upgrades to enable irrigation?*
- *Which areas have low availability for irrigation?*

Considerations:

- Where do we allocate resources to agricultural development?

RECLAIMED WATER IRRIGATION

Question:

- *What volume of reclaimed water could effectively be used for irrigating a particular land base and crop type scenario?*

Consideration:

- How do we plan for this water re-use in our Liquid Waste Management Plan?

How Local Governments Are Using the Results of the Okanagan Water Supply & Demand Project:

City of Penticton

DATA UTILIZED:

- Monthly breakdown of historical outdoor water use by property
- Projection of water use during a future drought scenario

TO ANALYZE:

- Irrigation planning, including changing crop-types and irrigation systems
- Potential agricultural build-out

Twin Lakes Aquifer

DATA UTILIZED:

- Precipitation
- Deep percolation (water going in)
- Aquifer extraction
- Data provided for the years 2010 - 2040 using two different (dry and wet) climate model variations

TO ANALYZE:

- Current and potential future health of the Twin Lakes aquifer

Kelowna Joint Water Committee

DATA UTILIZED:

- Water requirements for indoor and outdoor domestic needs, by distribution areas
- Agricultural water use, by distribution areas

TO INFORM:

- Planning process

Official Community Plans

As one of the main documents used for long-range planning and policy setting for current and future land use, Official Community Plans (OCPs) in the Okanagan should set a strong foundation for water management. The **Accounting Model** provides information on the current and future status of water in an area. Appropriate interpretation and application of these results is key to the success of any OCP.

GROUNDWATER SUPPLY

Questions:

- *What is the recharge for this aquifer? Minimal, limited or significant?*
- *Are surface water sources available?*

Considerations:

- What does this mean for future development / land use designation of this area?

SUPPLY AND DEMAND

Question:

- *What are the supply and demand characteristics in this OCP area?*

Consideration:

- Based on this information, where is development feasible?

WATER MANAGEMENT

Questions:

- *Where should we designate development permit areas to help with water management?*
- *Are surface or groundwater sources susceptible to contamination or low water?*

Considerations:

- Which combination or types of development permits, information areas, and protection zones will address our water management needs:
    - protecting the natural environment, its ecosystems and biological diversity
    - protecting farming
    - establishing objectives for the form and character of:
        - intensive residential development
        - commercial, industrial or multi-family residential development
        - development in the resort region
    - establishing objectives to promote water conservation.

How Local Governments Are Using the Results of the Okanagan Water Supply & Demand Project:

City of Vernon

DATA UTILIZED:

- Current water demand in existing spray irrigation areas
- Irrigation capacity of the land
- Identification of other agricultural lands for potential expansion of the spray irrigation program

TO ANALYZE:

- Future capacity for spray irrigation of wastewater effluent as part of the Liquid Waste Management Plan.

District of Lake Country

DATA UTILIZED:

- Proportion of indoor, outdoor, and agricultural water use.
- Separating areas on surface water from areas on groundwater.

TO INFORM:

- Master Water Plan

International Joint Commission (IJC) Operating Orders for Zosel Dam on Osoyoos Lake

DATA UTILIZED:

- Agricultural water demand data
- Climate models and scenarios

TO INFORM:

- The renewal of the international agreement that controls water levels on Osoyoos Lake, including a report on Osoyoos Lake level management, and studies on the potential impacts of climate change on Osoyoos Lake water supplies.

Amendments to Official Community Plans or Zoning Bylaws

An Official Community Plan is a living, guiding document. Often, individuals or developers approach a local government to propose a different development scenario that may require an OCP or zoning bylaw amendment. Many factors are considered when reviewing these applications.

A local government may wish to obtain detailed water supply information, particularly for:

- Large developments
- Land use that requires infrastructure upgrades
- Land use that leads to significant changes in water use, and
- Areas where groundwater recharge remains challenging.

Upland development impacts could also be considered, although this analysis may be more complex and costly.

WATER MANAGEMENT IMPACT OR BENEFIT?

Question:

- *What is the water management impact or benefit of this proposed bylaw amendment?*

CHANGES IN LAND USE

Questions:

- *This land is currently undeveloped forest or grassland, how might this development type impact the water supply in the area?*
- *How might the water use increase?*
- *The land is currently in agriculture, how might single family or multifamily development or other land uses increase or decrease the water demand?*

ADDITIONAL DEVELOPMENT CAPACITY

Questions:

- *Is there capacity for additional development in an area?*
- *What is the estimate of current use?*
- *What build out is possible based on current zoning?*
- *What is the estimated water use with a higher population or a different commercial/industrial mix?*
- *What happens if you factor in the build out based on current zoning, plus the specific zoning change?*

Considerations:

- Based on the amount of build out possible, combined with the proposed zoning, are there any risks to water supply in approving this development?

Regional Growth Strategies

A regional growth strategy (RGS) is a plan for regional districts and member municipalities to coordinate action on social, economic and environmental issues. An RGS covers a minimum 20-year time frame and provides long-range planning direction for regional district and municipal Official Community Plans.

Water is a critical component for many aspects of regional growth strategies. The *Local Government Act* specifies that an RGS should work toward the goals of protecting environmentally sensitive areas, reducing water pollution, and protecting the quality and quantity of groundwater and surface water.

Results from the **Accounting Model** may be used to inform the development of an RGS, including the formation of a baseline for monitoring, and long-term predictions that may be addressed by the RGS.

SUPPLY

Questions:

- *Does this area have sufficient water for growth as a primary or secondary growth area?*
- *How do different types of development impact water use in an area?*

DEMAND

Questions:

- *What is the current water supply and demand in this area?*
- *What watersheds or aquifers have potential supply or demand challenges?*
- *How much water could be saved through conversion to drip or other lower water use options on the landscape?*

Considerations:

- What targets should we set in the RGS for water use?
- Have we reduced our demand?
- Are we meeting the water demand targets in the RGS?
- Should we mandate further management planning in areas that have challenges?

Subdivision and Servicing Bylaws

Subdivision bylaws specify the level and standard of construction for works and services such as the provision of water, sewer and other services in a subdivision, and are often based on engineering standards. Although the Project's models may not provide outputs at the scale required for very small subdivisions, the results may be used to inform larger subdivisions. In addition, Project information may be used to identify areas of concern, or to pinpoint future development sites for rigorous study. For example, an area of concern could include a large development on well water that is proposed for an area with minimal aquifer recharge.

Subdivision bylaws can be site-specific and may include specifications for site grading, erosion control, and roof drainage. The Project may not be able to address site-specific subdivision requirements, but larger scale planning processes may incorporate background and baseline information from the Project and its models to inform storm water management plans, water supply and demand planning, and other activities.

SUBDIVISION WATER SUPPLY

Question

- *Is this subdivision proposed in an area with minimal aquifer recharge or a sub-basin with low storage capacity?*

Consideration:

- What do we need to know about this development's potential impact on water supplies, infiltration, or runoff?

Water Services

It is already a challenge to meet water needs throughout the year. How can we use historical information and climate change knowledge to make better operational and infrastructure planning decisions over the short and long term?

One way to better inform individual water supplier decision-making, while acquiring more data to improve the Project's models, is for water suppliers to measure and report their water extractions, and measure the water delivered to end-users.

The Streamlined Water Use Reporting Tool (**SWURT** - see Page 17) allows water purveyors to track surface and groundwater use and storage, and to access current and historical information, including snowpack depths, reservoir levels, stream-flows, and weather.

SUPPLY AND DEMAND

Questions:

- *How much water is available to us?*
- *How much water do we currently use?*
- *How much water should we maintain in streams to protect aquatic life?*
- *What are the future projections for supply and demand?*

Considerations:

- How can we increase our reservoir capacity to address these scenarios?
- How can we reduce demand in the watershed to reduce the current and future demand?

Project data, tools and studies can be used to contribute to provincially enabled or mandated water management plans, including:

- **Water Allocation Plan**
  A technical plan developed by the provincial government to assist with water licensing decisions.

- **Supply and Demand Planning** – *current availability, use, time of year*

- **Water Source and System Assessments** - *drinking water source assessments*
  A structured and consistent approach to identifying, evaluating, and managing risks to drinking water. Initiated by a Drinking Water Officer under Part 3 of the *Drinking Water Protection Act.*

- **Drought Response Plan** - *threats to drinking water – upland land*
  A strategy that outlines the actions to be taken before, during, and immediately after a drought to reduce its impacts.

- **Source Protection Plan** – *quality, quantity, timing*
  A plan to ensure better protection of our drinking water sources, reducing drinking water treatment costs and protecting aquatic ecosystems.

- **Drought Management Plan** - *users and instream flows for fish, under drought conditions*
  A community specific plan that designates trigger conditions for different drought stages and regulatory responses that may be imposed at each stage.

- **Water Use Plan** – *human and environmental needs including fish flows, under drought conditions*
  A formal agreement for how water will be shared between licensees while ensuring adequate flows for fish and wildlife.

- **Groundwater Protection Plan**
  A plan to safeguard groundwater for community drinking water, the environment and the economy.

- **Well Protection Plan**
  Practical protective measures to manage activities in the well capture zone to reduce the risk of contaminating the well.

- **Water Management Plan** – *quality, quantity, instream flows, under all conditions*
  A comprehensive and integrated watershed plan intended to be a basis for provincial regulation on water quality, instream flow requirements, and water supply, among other issues. This planning tool was introduced in 2004 under Part 4 of the *Water Act*.

- **Water Conservation Planning**
  A comprehensive approach to reduce water use, waste or loss, and extend the life of current water supplies.

Infrastructure

Infrastructure is usually a long-term, high value investment. This Project can assist local governments that are contemplating important infrastructure decisions with a supply and demand analysis, both from a current and future perspective.

INFRASTRUCTURE PLANNING

Questions:

- *Does our water delivery, stormwater drainage, water intake, reservoir, etc., meet current and future capacity needs within the lifetime of the current infrastructure?*
- *How will future climate and population conditions influence our water supply infrastructure?*
- *What are the estimated annual and weekly rates of flow through the supply and distribution lines?*
- *What supply or demand scenarios will new infrastructure have to meet?*
- *What lake levels can be expected in the future?*

Considerations:

- How will this affect the design of water intakes, docks, boat launches, etc.?

Parks / Facility Management

For most parks and facilities, **water demand management** will be the main focus of analysis.

The **Demand Model** calculates theoretical water use based on information about the soil, crop, irrigation system, and rainfall. Your local government may have access to more accurate information for your particular area, which may be used to improve the Project models.

WATER USE IN PARKS / FACILITIES

Questions:

- *How will our water use change if we implement a different type of irrigation or crop cover in our parks?*
- *How much demand in our system comes from our parks / facilities?*
- *Is it cost-effective to construct landscape elements in our parks to control surface runoff or collect water for irrigation?*

Considerations:

- Is it cost-effective to change irrigation systems or irrigation management in our parks?

Landscape Elements

Detention ponds and conveyance systems such as **bioswales** are designed to **remove silt and pollution from surface runoff water**, and also provide opportunities for **passive recreational opportunities** such as habitat and nature discovery.

Stream Health Restoration Initiatives

Many local governments are involved in the restoration of surface waterbodies and riparian habitats. The benefits of stream health restoration initiatives include reducing sediment loads upstream of water intakes, increasing flood protection, and improving water quality.

Some considerations include instream needs for fish, instream flow volumes for engineered capacity of works, and habitat design for different flow levels.

Much like infrastructure planning, restoration projects associated with watercourses must address long-term variation in a watershed.

STREAM HEALTH RESTORATION

Questions:

- *How might changes in the upper watershed affect the stability of this erosion control structure?*
    - *For example, could mountain pine beetle kill result in the need to build for higher flows, or will climate change counteract this?*
- *What are the instream needs for fish?*

Considerations:

- What further field studies do we need to complete to understand the instream needs for fish?
- What are the costs and benefits to the organization?

Part VI

More About Data & Models

PART VI MORE ABOUT DATA AND MODELS

As shown in **Figure 1**, many components work together to form the overall water balance for the basin.

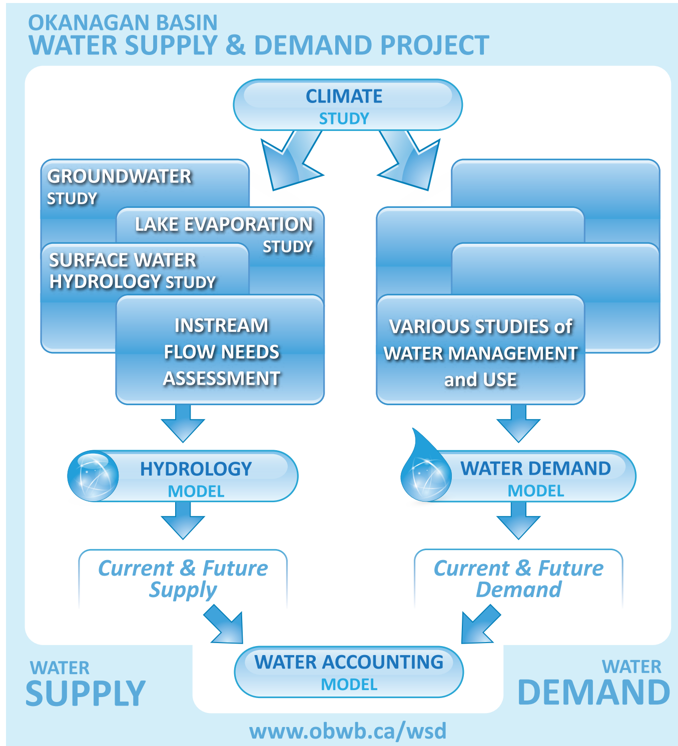
On the supply side, studies of groundwater, lake evaporation, instream flow needs and surface water hydrology inform the **Hydrology Model**. On the demand side, various studies of water use and management inform the **Demand Model**. Both models utilize local climate data.

The outputs of the **Hydrology** and **Demand** Models are combined into the **Water Accounting Model**, which estimates the effects of water storage and extractions on streamflow, groundwater and lake levels.

This section:
Here you can find detailed information about the **types of data** compiled by the Project, and the **limitations and applications** of the Project's models, including**:**

- Climate
- Water Supply
  - Hydrology Model
  - Groundwater Study
  - Lake Evaporation Study
  - Surface Water Hydrology Study
  - Instream Flow Needs Study
- Water Demand
  - Demand Model
  - Water Management and Use Studies
- Water Accounting Model
- Scenarios

Figure 1 – Project Overview (Phase 2)



Learn more:

- Discover quick facts in **Part II, Key Findings**.
- Learn about **considerations for accessing Project data** in **Part III, Implications for Local Government.**
- Find out **how to access Project data, tools and models** in **Part IV, Access Points.**
- See how the Project's climate, land use, water data and models may be used to **answer local government questions** in **Part V, Mining the Data.**
- Visit the Project website at **www.obwb.ca/wsd**.

CLIMATE

Climate is a key factor for calculating water supply and demand in the Okanagan Basin. Climate data was developed by the University of Lethbridge, Environment Canada and Agriculture & Agri-Food Canada. Climate modeling is based on a 500 m by 500 m grid covering the entire basin. Climate change information was generated based on comparison of future periods with the period 1996-2006, which includes a mix of average, wet and dry years.

Available Data

Observed data from 154 climate stations over the period 1961-2006 was used to derive daily maximum and minimum temperatures and daily precipitation estimates for each 500m x 500m grid cell, going back to 1961 and ahead to 2100. Elevation, slope and aspect values are attributed to each cell.

Annual Indices Available for Each 500 m x 500 m Grid Cell

- Last, first and killing frost, and number of frost free days
- Various measures of heat accumulation used as indicators for crop suitability such as Growing Degree Days, Temperature Sums, and Corn Heat Units
- Total annual precipitation and potential evapotranspiration
- Average annual minimum and maximum temperatures
- Absolute annual minimum and maximum temperatures and days they occur
- Other indices can be added

www.obwb.ca/wsd

For more information on Climate Datasets:
Okanagan Water Supply & Demand Project
Phase 2 Summary Report

Appendix N (715Kb PDF)
Development of Climate Datasets

For access to the raw climate data, contact Dr. Denise Neilsen of Agriculture & Agri-Food Canada (denise.neilsen@agr.gc.ca) at the Summerland Research Centre.

The Okanagan Basin Water Supply & Demand Project assesses potential impacts of climate change in the Okanagan valley, and supplies essential information for current and future water decisions.

Which Climate Model is Best?
The initial analysis was completed in 2010 using one of six possible global climate models – the CGCM2 Model, using the A2 emissions scenario - considered most likely by the International Panel on Climate Change. This is not necessarily the "best" climate dataset, but one of several potentially realistic climate datasets.

Selecting a different global climate model will produce different results, which will be examined in the next phase of the project.

More Data to Come
This project makes the Okanagan one of the most water information-rich areas in British Columbia. Information gaps have been identified, and a baseline of current conditions has been established.

Data collection efforts are now on-going to address the information gaps identified by the project.

WATER SUPPLY

- ***Hydrology Model***
- ***Groundwater Study***
- ***Lake Evaporation Study***
- ***Surface Water Hydrology Study***
- ***Instream Flow Needs Study***

Hydrology Model

The Hydrology Model covers both surface and groundwater, including precipitation, lake evaporation, stream-flow, and groundwater. The model estimates natural stream-flows in each tributary in the Basin.

Available Data

Similar to the climate data, the hydrology data is based on a 500m x 500m grid, including overland flow, unsaturated flow, and evapotranspiration. Stream-flows are calculated at nodes – please refer to the **Surface Water Hydrology Study** (Page 36) for more information.

The topography of the basin was defined by a digital elevation model that was re-sampled to a 500m x 500m grid to match the Project's data sets. Bathymetry (contour maps of the lake beds) was also included.

For more information on the Okanagan Basin Hydrology Model:
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 3.15 - Okanagan Basin Hydrology Model (468Kb PDF)

Appendix B (155Kb PDF)
Spatial Layers, Water Balance Terms, and Water Balance Equations Report

Appendix J (18.3Mb PDF)
Okanagan Basin Water Accounting Model

Groundwater Study

The Groundwater Study summarizes aquifer locations, types, and water yields to provide a conceptual model of groundwater storage and flow in the Okanagan Basin. The model assumes that upland areas recharge valley-bottom aquifers. Due to minimal regulation of groundwater use, there is relatively little information available about groundwater resources and use.

A total of 324 aquifers were identified by this study: 245 bedrock aquifers in the upper elevations, and 79 alluvial aquifers in the main valley and large tributary valleys, where the majority of human activity takes place. A spreadsheet-based Groundwater Balance Analysis Tool (GWBAT) model was used to estimate monthly water balances and annual groundwater flow in each aquifer.

Many of the bedrock aquifers are potentially recharge-limited and may not support intensive groundwater development - **see Figure 2.**

If your jurisdiction contains a high-risk aquifer, groundwater extraction should proceed only after further study indicates sustainable yields.

Regional studies are currently underway to improve the groundwater conceptual model for Deep, Vernon, Shorts, Vaseux, Upper Penticton, Fortune and BX Creeks, and other regions of the North Okanagan, Kelowna and Oliver.

Groundwater supply information is currently available only on a sub-basin or regional scale - local supplies are not calculated.

Available Data

Available data includes **estimated groundwater use** and **irrigation return flow**. The study team also developed estimates of **stream-flow loss to groundwater**, **aquifer recharge rates**, and **physical aquifer properties**. Characterized aquifer properties include **hydraulic conductivity**, **aquifer saturated thickness**, **hydraulic gradient**, **porosity**, and **water table elevation**. Refer to the "Groundwater State of the Basin Report" for a summary of **aquifer dimensions**, **materials**, **hydraulic properties**, and other data collected as part of the Groundwater Study.

Although the Project's groundwater information has some limitations, it may be used as a starting point and prioritization tool for further studies.

For more information on the Groundwater Study:

Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 2.7 Groundwater Resources (921Kb PDF)

Appendix D (index)
Groundwater State of the Basin Report

Appendix E (ZIP archive)
Okanagan Conceptual Groundwater Model Report

Groundwater Licencing
Although BC's Water Act provides for the licensing of surface water for beneficial uses, it does not provide for the licensing of groundwater. As a result, there is a lack of information about the groundwater resource, its use, and the impacts of that use on both surface and groundwater resources.

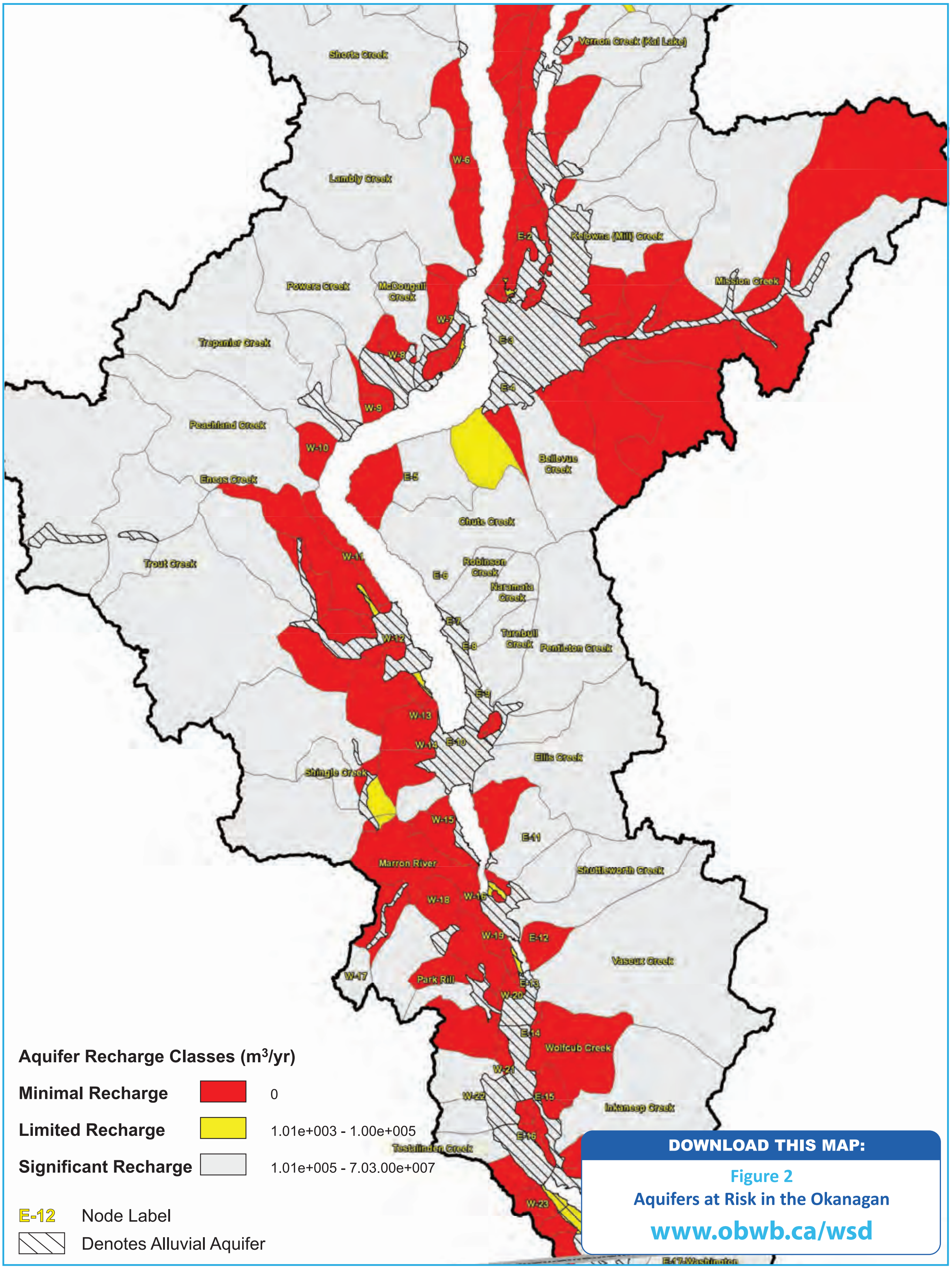
Surface-Groundwater Interaction
In many locations in the Okanagan, surface water and groundwater are so interconnected that a withdrawal from groundwater can affect a nearby surface watercourse, and vice versa. In these cases, a groundwater well can be used to withdraw surface water without the need for a surface water licence.

In the Okanagan, it is estimated that 22% of water use is derived from groundwater wells.

Installing 15 New Groundwater Monitoring Wells
The Groundwater study targeted priority sites for new monitoring wells in at-risk aquifers. Using this information, the OBWB coordinated a three-year plan to install 15 new wells and 3 new weather stations. The project has received cash and in-kind support from Agriculture Canada, Environment Canada, the BC Ministry of Environment, and the local jurisdictions where the wells are located.

Okanagan Groundwater, the Book
The OBWB provided data for a book on Okanagan groundwater by Murray A. Roed, author of Okanagan Geology, a Canadian bestseller.

Figure 2 – Aquifers at Risk in the Okanagan



Lake Evaporation Study

Our knowledge of the amount of water that evaporates from lakes in the Okanagan is limited. After testing 17 different evaporation models, Environment Canada researchers resolved that the only way to accurately determine lake evaporation was to obtain direct measurements by conducting on-lake and shoreline meteorological studies.

An intensive effort is now underway for 2011-2012 using researchers, equipment and techniques from the Great Lakes area.

Available Data

The Penman-Monteith model was chosen for estimating evaporation from Okanagan lakes. Due to the lack of direct measurements, evaporation estimates are provided within a fairly broad range.

For more information on the Lake Evaporation Study:

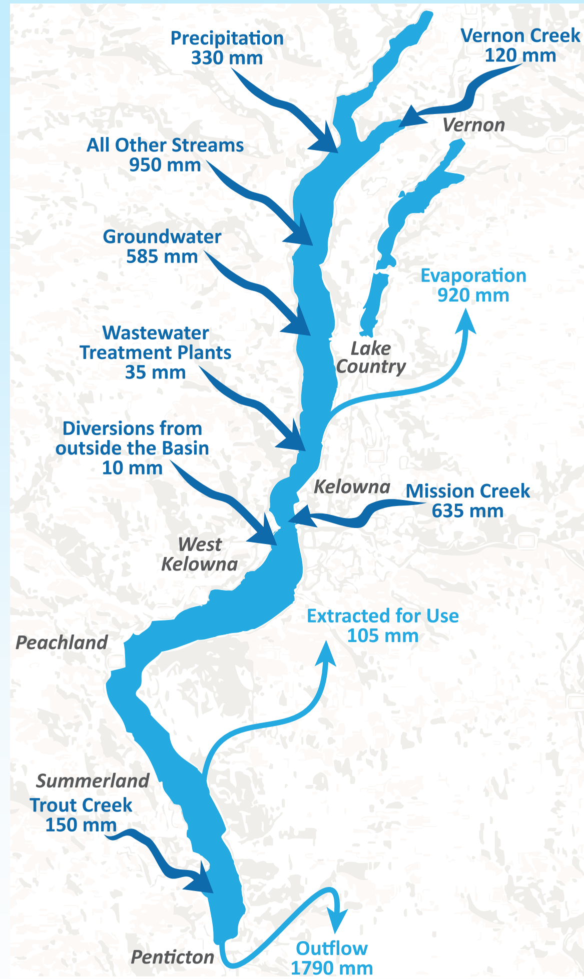
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 2.8 (13Kb PDF)
Lake Evaporation

Appendix F1 (254Kb PDF)
Lake Evaporation Summary Report

- *Mainstem Lake Evaporation Report (Environment Canada 2009)*

Okanagan Lake Average Annual Water Balance



Adapted from Figure 2, Phase 2 Summary Report (Summit Environmental Inc. 2010)

Surface Water Hydrology Study

The Surface Water Hydrology Study estimated natural stream-flows in tributary streams to calibrate the Hydrology Model. Information was compiled and summarized for each of 81 specific locations, or "nodes" in the basin (**Figure 3**), including 32 sub-basins, the five mainstem lakes (Kalamalka-Wood, Okanagan, Skaha, Vaseux, and Osoyoos), 4 Okanagan River locations, and 40 residual areas that account for less than 5% of the total runoff in the basin.

The three largest tributaries, Mission Creek, accounting for 28% of the flow in the basin, and Trout and Vernon Creeks, each producing about 7% of basin flow, were investigated in detail.

About 83% of stream-flow in the basin originates north of Penticton. Runoff, or the stream-flow generated per unit of land surface area, increases from south to north, from west to east, and with elevation. Stream-flow is highly seasonal, with the freshet (spring thaw) from March to July accounting for 86% of total annual flows.

Available Data

Hydrometric records throughout the basin were compiled and summarized for 81 nodes in the basin, including annual discharge (m^3/s), annual runoff (ML) and annual unit area runoff (mm). Estimates of annual, monthly and weekly naturalized stream-flows (m^3/s) were developed for 73 nodes over the 11-year period from 1996 to 2006.

Actual stream-flow data is available for many streams. For regulated streams (those affected by human management, i.e. the storage and diversion of water) or streams without monitoring stations, natural stream-flows were estimated using nearby unregulated, monitored streams and other available data. Natural flows for the mainstem lakes and the nodes on the Okanagan River were not estimated because dams and other control structures have regulated these flows for many decades.

Mainstem lake water balances were calculated using estimates of natural surface inflow, groundwater inflow and outflow, precipitation, wastewater return flows to surface waters, water imports from other basins, evaporation, and water extraction by licence holders.

For more information on the Surface Water Hydrology Study:

Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 2.9 - Surface Water Resources (20Kb PDF)

Appendix G (ZIP archive)
Okanagan Hydrology State of the Basin Report

Appendix J (18.3Mb PDF)
Okanagan Basin Water Accounting Model

Streamlined Water Use Reporting Tool (SWURT)

Motivated by the giant information gap in data for water extraction and use, the provincial and federal governments recently funded the development of a web-based reporting tool for all large water users.

The Streamlined Water Use Reporting Tool, or SWURT, allows large water utilities to report their water use, reservoir levels, snowpack, and other data. This pilot project is currently under consideration for implementation across BC.

For more information about SWURT, visit www.obwb.ca/swurt

Hydrometric Monitoring Database

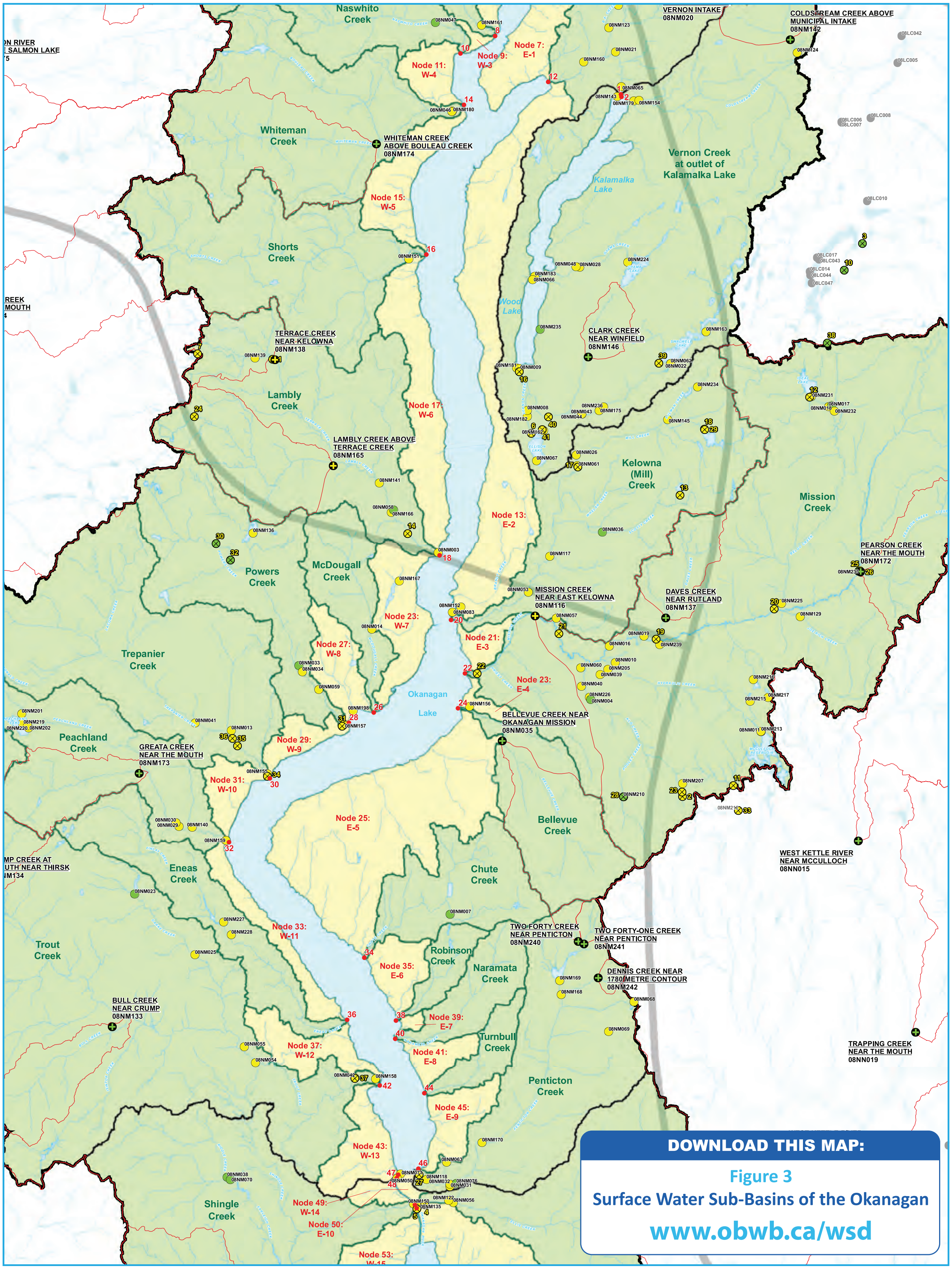
The first step to re-establishing an adequate hydrometric network is to organize and make best use of existing information.

The Water Survey of Canada has a network to gather and store information, but there is no mechanism for compiling non-Water Survey hydrometric data.

This information gap was highlighted by the hydrology modelling conducted for the Project.

Hydrometric data can now be entered through SWURT, the Streamlined Water Use Reporting Tool.

Figure 3 – Surface Water Sub-Basins of the Okanagan



DOWNLOAD THIS MAP:

Figure 3
Surface Water Sub-Basins of the Okanagan
www.obwb.ca/wsd

Instream Flow Needs Study

The Okanagan River and its tributary streams are important spawning and rearing habitat for salmon and trout (salmonids) and other aquatic life. Fish and wildlife habitat in many sub-basins has been degraded or eliminated over the last century by water extraction, flood control structures, and by development of land next to watercourses. Protecting instream flows preserves environmental health and services (such as the ability of systems to naturally clean polluted water) for future generations, and also protects aboriginal rights to hunt and fish. Okanagan salmonids support important recreational and food fisheries in both Canada and the United States.

Instream flows are especially important because salmon and trout are sensitive to water quality and quantity. Compared to streams on the Pacific coast, many Okanagan streams do not naturally provide optimal habitat for fish like kokanee that thrive in cold water. This desk-based (not field) study estimated the minimum risk and optimal instream flow needs for fish and the ecosystems they rely on. The study gathered data on where sensitive species occur, and how their life-cycle water needs (for example, spawning conditions) are affected by seasonal variations in water availability in different tributaries, lakes and rivers.

The study found that the greatest challenges for fish spawning and rearing occur during low flow periods of the late summer to mid-winter. Other sensitive plants and animals were also identified as potentially impacted by variable instream flow or lake levels. However, it was noted that flow alone does not ensure the maintenance of water quality or required water temperatures.

While site-specific studies will yield the best estimates of instream flow needs for specific aquatic species, the pace of water allocation decisions requires a method of rapid assessment while site-specific field studies are conducted. Field assessments can verify instream flow needs to maintain important features like pools and riffles that provide essential fish habitat. Field studies can also develop more accurate estimates of the environmental flow regimes needed to sustain aquatic life and ecosystem function in any particular location (for example, scouring flows to clean gravel spawning beds).

As site-specific studies are expensive and time-consuming (and must be performed over multiple years to determine environmental flow regime needs) fisheries biologists and planners can use this study as a ***starting point*** to establish **preliminary instream flow needs** and priority areas to target for **future site-specific research**.

Additional new desk-based methods for instream flows are under development, based on some of the hydrology modeling completed as part of the Okanagan Water Supply and Demand Project.

The choice of which method used to determine instream flows depends on: (i) legal requirements in both federal and provincial laws, (ii)

Three types of science-based instream flow guidelines were calculated for the project:

Conservative *minimum risk* flows specify the levels that are expected to result in low risk and stress to fish, fish habitat, and overall productive capacity of a stream; and that help to maintain important features of the natural hydrograph. Some natural and regulated streams in the Okanagan already have flow regimes that are stressful to fish. Minimum risk guidelines place the burden on water extraction proponents to prove there are no unacceptable consequences of such activities. The methods used to derive minimum risk flows were also used to define *watershed conservation flows* to sustain the geomorphic and riparian habitat conditions in and around streams.

Optimal spawning and rearing flows were identified for kokanee, sockeye, rainbow trout, steelhead, chinook and coho in 36 Okanagan tributaries. These flows do not address all the needs of other fish or animals, or the quality of the habitat. While these three references identify some key instream flow needs, more detailed biological studies are required to protect additional species and their habitats. Some analysis of what is an acceptable level of risk is also needed.

Flow guidelines from *site-specific studies / water use agreement negotiations*. These flows are available for the Okanagan River mainstem, Trout Creek and Mission Creek. The flows for Trout Creek and Mission Creek address goals for rainbow trout, kokanee or sockeye salmon, and were part of Water Use Planning negotiations convened by the Province.

ecological objectives such as maintaining species diversity; (iii) personal and community values placed on healthy streams, and (iv) the larger environmental management strategy for fish protection in the Okanagan. For example, choosing to protect a number of healthy sub-basins as ecological reserves where water extraction is highly constrained, while allowing more intensive development elsewhere.

Available Data

Minimum risk flows, watershed conservation flows, optimal spawning and rearing flows, and 25th percentile flows are available for each relevant node considered to be fish-bearing. Probabilities were developed to show what percentage of time the weekly flows would be met.

Another instream flow analysis method, the Uniform Continuous Under Threshold (UCUT) approach, is under investigation for the Okanagan, and may provide more accurate data in the future.

For more information on the Instream Flow Needs Study:

Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 2.10 - Instream Flow Needs for the Okanagan (20Kb PDF)

Appendix H (9.4Mb PDF)
Okanagan Instream Flow Needs Assessment Report

WATER DEMAND

- ***Demand Model***
- ***Water Management and Use Studies***

Okanagan Water Demand Model

The **Okanagan Water Demand Model** was originally built to estimate current and future agricultural water demands for the Okanagan Basin, and was expanded to include golf courses and residential water demands. The Demand Model calculates water use on a property-by-property basis, and sums each property's water use to obtain a total for the entire basin or sub-basins. Crop, irrigation system type, soils, and climate data are used to calculate water demands.

The Demand Model calculates, for historic and future conditions, **all indoor and outdoor water uses** for different **time periods** and **water use areas**, and links each water use area with one or more **sources** of surface or groundwater. The Demand Model also calculates the **required withdrawals** from each water source to meet the demands in a water use area.

The original Agricultural Water Demand Model received the Premier's Award for Innovation. The Demand Model is best used for comparative trend analysis using different land bases, crop types, irrigation systems, and climatic conditions.

A total of 259 water use areas were defined for the Okanagan Basin – see Figure 4. Each water use area was linked with one or more sources of surface or groundwater.

In areas serviced by water purveyors, water use areas generally correspond to the boundaries of water distribution systems. In areas not serviced by water purveyors, water use areas were derived based on available water licences, well, and/or aquifer information to tie the source of water to the use.

Water Management and Use Studies

Background studies were used to compile a variety of information about water use in the Okanagan.

Available Data

Demand Model inputs include **crop types**, **soil textures**, **irrigation system**, and **climate data**. Available outputs include **soil moisture deficits**, **crop evapotranspiration**, **crop water requirements**, and **irrigation water demand**.

Geographic scales range from the area of crops and irrigation on a specific property, through to sub-basin and basin-wide information.

There is seasonal, annual, and geographical variation around the basin for water use, extraction and availability.

There are over 100 known water suppliers in the basin and nearly 4,000 active water licences.

About 95% of the water licensed for offstream use is managed by the 57 largest water suppliers.

Water supplies in the Okanagan are derived mainly from surface (67%) and ground water (22%), imported water from adjoining basins (8%), and the reuse of treated wastewater (3%).

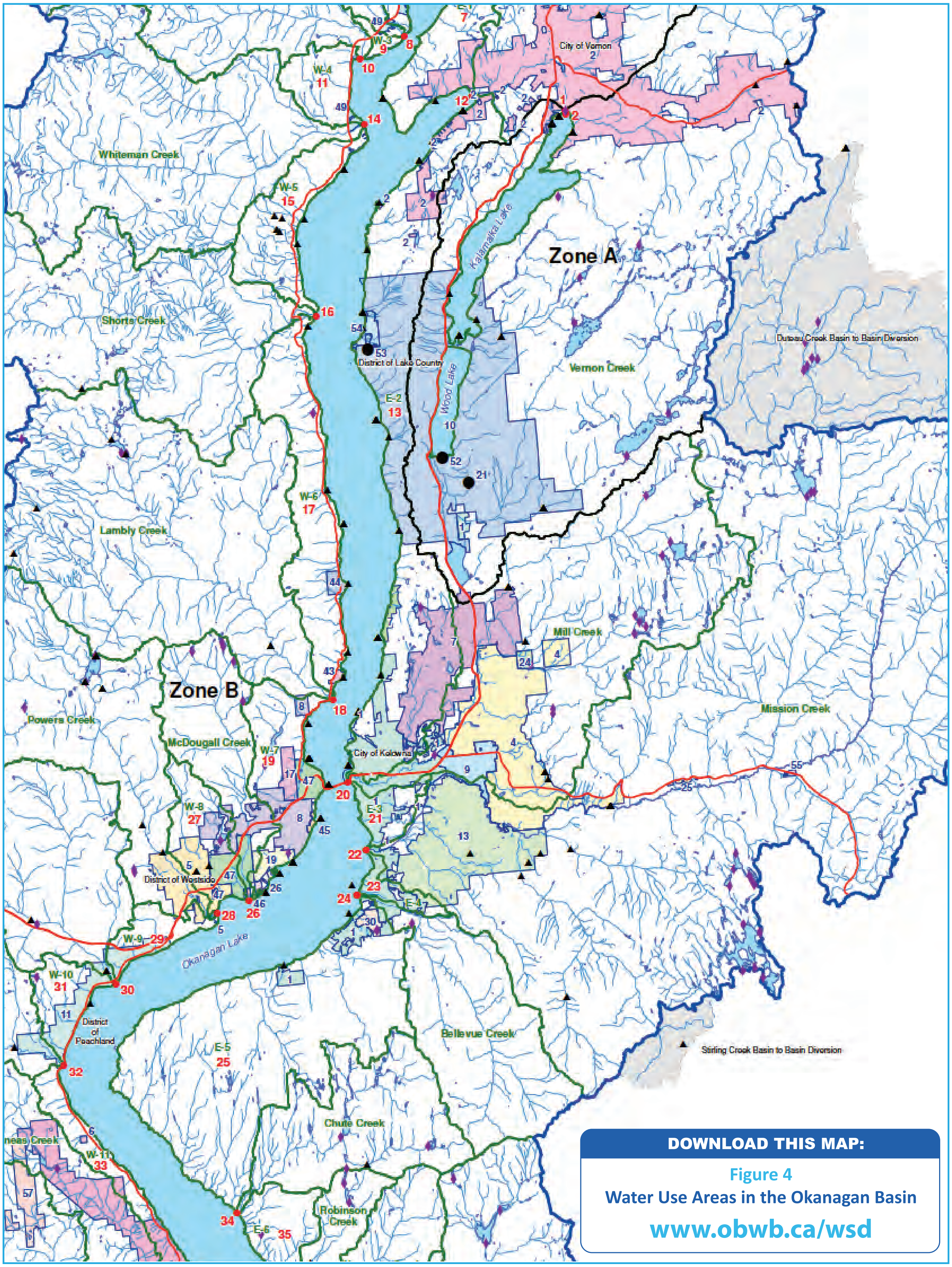
Although extracted water may return to the lakes and streams through excess irrigation or the release of treated wastewater, this water is not usually returned to the same location from which it was withdrawn. This can be an important water management consideration, particularly in drought-prone tributary watercourses where the effects of withdrawal can have a relatively larger impact than on a lake.

Outdoor irrigation, including agriculture, residential, golf courses and open spaces, is the largest use of water in the basin (86%) and there are many opportunities for demand reduction. Agriculture uses 55% of our water, but is the most efficient outdoor user.

Outdoor household use (lawns, gardens, etc.) accounts for **24% of our overall water use.**

The average Okanagan resident uses more than twice the water of the average Canadian.

Figure 4 – Water Use Areas in the Okanagan Basin



DOWNLOAD THIS MAP:

Figure 4
Water Use Areas in the Okanagan Basin
www.obwb.ca/wsd

Temporal scales are week, month and year. Although available, daily results are too theoretical to be utilized in decision-making. It is not advisable to rely on the Demand Model to calculate peak or maximum instantaneous demand. Longer time frames are more reliable for analysis.

Water extraction data may be obtained for the current period and future scenarios for each water use area. Available data includes average, minimum and maximum weekly volume of water extracted from surface sources to the nearest 1,000 ML, and estimates of average, minimum and maximum weekly volumes of groundwater pumping.

Water use estimates for **different types of use** are available for the current period and future scenarios.

Calculations can be performed for each of the 259 water use areas in the basin, or any combination of water use areas, to suit the needs of a local government or water purveyor.

It is estimated that
25,000 ML of water is returned to groundwater by
over-irrigation
every year.

While the water is returning to the overall basin, this water has been treated and distributed at great expense.

Reducing over-irrigation would reduce water servicing costs and save the irrigator money.

For more information on the Demand Model:
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 3.14 - Okanagan Water Demand Model (486Kb PDF)

Appendix C (ZIP archive)
Okanagan Water Management and Use Report

Appendix I1 (1.5Mb PDF)
Okanagan Water Demand Model Summary Report

Appendix I2 (1.1Mb PDF)
Irrigation Water Demand Model

Appendix I3 (166Kb PDF)
Residential, Industrial, Commercial and Institutional Water Use Report

For more information on the Okanagan Water Management and Use Studies:
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 2.6 - Water Management and Use (798Kb PDF)

Appendix C (ZIP archive)
Okanagan Water Management and Use Report

Further questions about the Demand Model or types of available data *may be directed to Ron Fretwell of RHF Systems Ltd. (fretwell@rhfsystems.com).*

OKANAGAN BASIN WATER ACCOUNTING MODEL

The **Okanagan Basin Water Accounting Model** (Accounting Model) brings together all parts of the Project and is used to calculate a water balance for the basin.

The model estimates the effects of reservoir storage, return flows, and water withdrawals on natural stream-flows, groundwater, and lake levels at 81 specific locations or "nodes" in the basin.

The model can be used to show how water management decisions can positively or negatively affect the entire basin, or one part of the basin, even if the water management activity is occurring in another part of the valley.

Deep Creek Watershed Sustainability:
Dr. Adam Wei at UBC-Okanagan is using the **Hydrology Model** and the **water balance (Accounting) model** to evaluate the effects of climate change and increasing water demand on the Deep Creek basin, to identify water availability and vulnerability in different areas.

The Accounting Model can also help evaluate the potential impacts of climate change, population growth, water use efficiency, agricultural land base expansion, and mountain pine beetle in future scenarios.

For more information on the Accounting Model:
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Part 3.16 - Okanagan Basin Water Accounting Model (468Kb PDF)

Appendix B (155Kb PDF)
Spatial Layers, Water Balance Terms, and Water Balance Equations Report

Appendix J (18.3Mb PDF)
Okanagan Basin Water Accounting Model

SCENARIOS

Fifteen climate, land use, water use, and population growth scenarios were examined in Phase 2 to estimate how these might influence water use and stream-flows in the future – only a small sampling of the range of possible water futures that illustrate the power of this tool.

The scenarios evaluated the influence of:

- **Climate Change** using the CGCM2 A2 model, the carbon emissions scenario considered most likely by the International Panel on Climate Change.
- **Population Growth** - the expected rate versus a higher rate.
- **Agricultural Conditions** - the current amount of land under cultivation versus a larger area that includes all reasonably irrigable land.
- **Water Use Efficiency** - current trends versus the Provincial guideline of achieving 33% efficiency improvements by 2020.
- **A Three-Year Drought**, similar to the historically significant Okanagan drought of 1929-1931.
- **Mountain Pine Beetle** progression based on Provincial models.

Three Year Drought Scenario
To recognize the historical significance of the **1929-1931 drought** in the Okanagan, a scenario with three consecutive years of drought was developed.

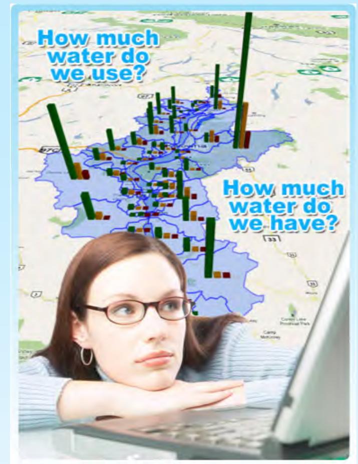
Data was chosen from the future climate dataset (2010-2100 - Appendix N) to simulate a possible future three-year dry sequence. The three driest years - 2076, 2033, and 2026 - were selected and assumed to occur in succession.

Interestingly, the Okanagan drought of 1929-1931 was even more severe than the simulated three-year drought scenario, indicating that more work is required to improve the climate models.

Selecting a different global climate model will produce different scenario results, which will be examined in the next phase of the Project.

Some scenario findings include:

- **The Okanagan will have a longer growing season,** increasing water demand from crops, landscaping, and natural areas.
- **Increasing Air Temperatures**:
  Although the climate model suggests that the average total annual precipitation won't change significantly in future, air temperatures are expected to increase.
  - The average temperature increases.
  - The number of days with temperatures below zero Celsius decreases significantly.
- **Less Water Stored as Snow:**
  Although the amount of annual precipitation may not change significantly, increasing air temperatures means that winter precipitation will come more often as rain than snow and on average, there will be less water stored as snow.
  - The maximum snow depth decreases by almost 30% and occurs almost 3 weeks earlier.
  - Spring snowmelt runoff is shifted 2-4 weeks earlier in the year, with lower peak flows.
  - Upland reservoirs start emptying sooner and have an average of 10% less storage available at the end of the summer.



Okanagan Water Supply & Demand Viewer

The Viewer provides graphical and statistical information about the current state of water supply and demand at various locations in the Okanagan valley, and examines the likely future influences of population growth, climate change, land use, and other factors.

www.okanaganwater.ca

- **Meeting Demand During Low Flow Summers:**
  Due to changes in the timing and volume of the spring snowmelt, it will become progressively more difficult to meet increasing demands during the low flow summer season under current operating conditions.
  - Improved water efficiency measures will be necessary to conserve water supply during the summer months, and particularly during dry years.

A number of assumptions were utilized to develop these scenarios, including growth patterns, the amount of lands in the Agricultural Land Reserve, and theoretical conservation improvements.

To assist local governments with decision-making, **user-specific scenarios** may be generated by request to simulate future water conditions and estimate the influence of climate change and human decisions on water use and stream-flows.

For more information about the Scenarios:
Okanagan Water Supply & Demand Project Phase 2 Summary Report

Parts 3.17 & 3.18 - Scenario Selection and Scenario Results (555Kb PDF)

Appendix O (130Kb PDF)
Okanagan Water Demand Scenario Modeling Report

Resources

ONLINE RESOURCES

BC Ministry of Environment:

- **EcoCat: Ecological Reports Catalog**
  www.env.gov.bc.ca/ecocat
- **Habitat Wizard**
  www.env.gov.bc.ca/habwiz
- **Fish Wizard**
  www.fishwizard.com
- **BC Water Resource Atlas**
  www.env.gov.bc.ca/wsd/data_searches/wrbc
- **Water Stewardship**
  www.env.gov.bc.ca/wsd
- **BC Water Licences Query**
  a100.gov.bc.ca/pub/wtrwhse/water_licences.input

Okanagan Basin Water Board
www.obwb.ca

Okanagan Water Supply & Demand Project Website
The access point for all tools, models and data developed by the Okanagan Water Supply & Demand Project.
www.obwb.ca/wsd

Okanagan Waterwise
An Okanagan Basin Water Board outreach initiative that encourages conserving & protecting the Okanagan's most valuable natural resource - water.
www.okwaterwise.ca

Groundwater Bylaws Toolkit
Developed as an appendix to the Green Bylaws Toolkit by the OBWB and partners to help local governments protect the quality and quantity of groundwater within their own geographic and legislative jurisdictions.
www.obwb.ca/groundwater_bylaws_toolkit

Green Bylaws Toolkit
Created to help local governments conserve sensitive ecosystems and develop green infrastructure
www.greenbylaws.ca

Irrigation Industry Association of BC
Landscape and agricultural irrigation scheduling calculators, weather and soil calculators, etc.
http://www.irrigationbc.com

Water Balance Model
A rainwater management decision support tool that bridges engineering and planning.
www.waterbalance.ca

Waterbucket
A key part of the communications strategy for the Water Sustainability Action Plan for British Columbia
www.waterbucket.ca

Public Infrastructure Engineering Vulnerability Committee
Created to conduct an engineering assessment of the vulnerability of Canada's public infrastructure to the impacts of climate change.
www.pievc.ca

GLOSSARY

Aquatic	With reference to water.
Aquifer	An underground formation that stores groundwater.
Aquifer Saturated Thickness	For a confined aquifer, the saturated thickness at any point in the aquifer is equal to the aquifer thickness. For an unconfined aquifer, the saturated thickness at any point is the distance from the top of the water table to the bottom of the aquifer.
Basin	Land area from which water drains towards a common point.
Bathymetry	The measurement of the depth of bodies of water.
Bedrock	Rock at or near the Earth's surface that is solid and relatively unweathered.
Cadastre	Property boundary.
Calibrate	To check, adjust, or determine by comparison that a computer model will produce results that meet or exceed some defined criteria within a specified degree of confidence.
Ecosystem	A system in which populations of species group together into communities and interact with each other and the non-living environment.
Evaporation	The process of a liquid converting to the gaseous state.
Evapotranspiration	The combined processes of evaporation and transpiration.
Fracture-flow System	A bedrock aquifer in which the flow takes place primarily within fractures in bedrock.
Groundwater	Water existing below the ground surface in aquifers.
Heat Units	Temperature-based units that are related to the rate of development of crops.
Hydraulic Conductivity	The capacity of a porous medium (ground) to transmit water as expressed in units of length/time.
Hydraulic Gradient	Slope of the groundwater level or water table.
Hydrologic	Adjective of the noun hydrology.
Hydrology	The science dealing with the properties, distribution, and circulation of water.
Instream Flow	The flow of water in a natural watercourse required to support and sustain

Needs	fish and other aquatic dependent species.
Naturalized Flow	Flows that would have existed without human use or management.
Nodes	Locations at which surface water properties are reported, such as the mouths of tributaries.
Percolation	Vertical movement of water from the surface to the subsurface.
Recharge	Refers to water entering a groundwater aquifer through percolation from the surface or through lateral movement from an adjacent upslope aquifer.
Reservoir	An artificial lake used to store water.
Salmonid	Of, belonging to, or characteristic of the family Salmonidae, which includes salmon, trout, and whitefish.
Saturated Hydraulic Conductivity	The hydraulic conductivity that exists when the medium is saturated.
Stream-flow	The flow of water in a river or stream channel.
Stream-flow Naturalization	The process of estimating the stream-flow that would exist in the absence of human water management activities.
Surface Water	Water that flows in streams and rivers, and exists in natural lakes, wetlands, and in reservoirs.
Transpiration	Loss of water vapour from plants.
Topography	The relief exhibited by a surface.
Unsaturated Flow	Underground water flow through soil or rock where the void spaces are filled partly with water and partly with air.
Water Demand	Water use determined using an estimation approach, such as a model.
Water Licence	A licence issued by the B.C. government to store water, or to withdraw water from a surface water source for a particular purpose.
Water Use	Volume or rate of water diverted or withdrawn from a water body (e.g. a stream, lake, or groundwater aquifer) for use by humans on the land surface. Actual water use is determined through direct measurement. Water demand is an estimate of actual water use.
Water Use Area	An area of the land surface that obtains water from a common location or locations.
Watershed	See Basin.

SOURCES

Okanagan Water Supply & Demand Project: **Phase 1 Literature and Data Review.** Summit Environmental Consultants Inc., 2005. 1.3Mb PDF
http://www.obwb.ca/fileadmin/docs/Supply_Demand_Phase1.pdf

Okanagan Water Supply & Demand Project: **Phase 2 Summary Report and Appendices.** Summit Environmental Consultants Inc., July 2010.
http://www.obwb.ca/wsd

Okanagan Water Supply & Demand Project – **Okanagan Water Resource Information Database** (Okanagan Water Science Library)
http://www.obwb.ca/obwrid/

Groundwater Bylaws Toolkit: An Appendix to the Green Bylaws Toolkit. Okanagan Basin Water Board. 2009.
http://www.obwb.ca/groundwater_bylaws_toolkit/

Okanagan Sustainable Water Strategy. Okanagan Basin Water Board 2008. 4.4Mb PDF.
http://www.obwb.ca/fileadmin/docs/osws_action_plan.pdf

Province of BC – Living Water Smart – Modernization of BC's *Water Act*
http://www.livingwatersmart.ca/

Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. Department of Soil Science and Biological and Agricultural Engineering North Carolina State University Raleigh, North Carolina. Technical Bulletin 311. September 1997.
http://www.soil.ncsu.edu/publications/BMPs/glossary.html

"Paleoecological studies show that the 20th century was the wettest of the last 4,000 years."
D.W. Schindler OC, AOE, DPhil, FRSC, FRS - Killam Memorial Chair and Professor of Ecology, University of Alberta, Edmonton

Turner, R.J.W., Franklin, R.G., Taylor, B., Ceh, M., Grasby, S.E., Symonds, B., Adams, M., Armour, G., Carmichael, V., Curtis, J., Davis, D., Epp, P., Harlow, C., Journeay, M., Machin, D., Molyneux, T., Neilsen, D., Simpson, R., Stephens, K., & van der Gulik, T. (2006). **Okanagan Basin Waterscape;** Geological Survey of Canada, Miscellaneous.

APPENDICES

Appendix 1
TABLE OF CONTENTS
Okanagan Water Supply and Demand Project Phase 2
FINAL SUMMARY REPORT

Summit Environmental Consultants Inc., July 2010.

VIEW this report ONLINE
DOWNLOAD reports & maps

www.obwb.ca/wsd

Okanagan Water Supply & Demand Project

Follow the links below to download sections of the Summary Report, or download the full report (7Mb PDF).

- **EXECUTIVE SUMMARY** (800Kb PDF)

PART ONE – BACKGROUND (78Kb PDF)
See webpages under "**Introduction**".
Provides the context for the Phase 2 work.

- 1.0 INTRODUCTION
- 2.0 PHASE 2 PROJECT OVERVIEW
-

PART TWO – DATA AND DATABASES (2Mb PDF)
See webpages under "**Water Use**" and "**Data**". Describes the datasets and databases developed during Phase 2, and summarizes the major technical studies completed during Phase 2. The technical studies provided the foundation for the models developed in Part Three, and are reproduced in their entirety in electronic form in the Appendices.

- 3.0 PART TWO OVERVIEW
- 4.0 BASIC TECHNICAL CONCEPTS
- 5.0 DEVELOPMENT OF CLIMATE DATA SETS
- 6.0 WATER MANAGEMENT AND USE (798Kb PDF)
- 7.0 GROUNDWATER RESOURCES (921Kb PDF)
- 8.0 LAKE EVAPORATION (13Kb PDF)
- 9.0 SURFACE WATER RESOURCES (20Kb PDF)
- 10.0 INSTREAM FLOW NEEDS FOR THE OKANAGAN (20Kb PDF)
- 11.0 OKANAGAN WATER DATABASE
    - o See the Okanagan Water Database (Registered users only, account required)
- 12.0 OKANAGAN WATER INFORMATION REFERENCE LIBRARY
    - o Access the searchable OBWRID Okanagan Water Science Library in the right-side column of the Project website at **www.obwb.ca/wsd**

PART THREE – MODELS (468Kb PDF)
See webpages under "**Models**". Summarizes the three models developed during Phase 2: the Okanagan Water Demand Model (OWDM), the Okanagan Basin Hydrology Model (OBHM), and the Okanagan Basin Water Accounting Model (OBWAM).

- 13.0 HOW OKANAGAN WATER CYCLES ARE SIMULATED
- 14.0 OKANAGAN WATER DEMAND MODEL
- 15.0 OKANAGAN BASIN HYDROLOGY MODEL
- 16.0 OKANAGAN BASIN WATER ACCOUNTING MODEL

PART FOUR – SCENARIOS (555Kb PDF)
See webpages under "**Scenarios**" and "**Implications for the Future**". Describes the outcomes of the 15 Phase 2 scenarios.

- 17.0 SCENARIO SELECTION
- 18.0 SCENARIO RESULTS

PART FIVE – KEY FINDINGS AND RECOMMENDATIONS (55Kb PDF)
See webpages under "**Key Findings**". Lists the major findings and recommendations of Phase 2, and recommends next steps for subsequent phases of the Water Supply and Demand Project.

- 19.0 KEY FINDINGS (55Kb PDF)
- 20.0 RECOMMENDATIONS (55Kb PDF)
- 21.0 GLOSSARY
- 22.0 ACRONYMS
- 23.0 REFERENCES

APPENDICES

- Appendix A User Needs Assessment Report (1.8Mb PDF)
- Appendix B Spatial Layers, Water Balance Terms, and Water Balance Equations Report (155Kb PDF)
- Appendix C Okanagan Water Management and Use Report
- Appendix D Okanagan Groundwater State of the Basin Report
- Appendix E Okanagan Conceptual Groundwater Model Report
- Appendix F
  - F1: Lake Evaporation Summary Report (254Kb PDF)
  - F2: Assessment of the Capability to Compute Evaporation using the Existing Database (1.5Mb PDF)
- Appendix G Okanagan Hydrology State of the Basin Report
- Appendix H Okanagan Instream Flow Needs Assessment Report (9.4Mb PDF)
- Appendix I
  - I1: Okanagan Water Demand Model Summary Report (1.5Mb PDF)
  - I2: Irrigation Water Demand Model – Technical Description (1.1Mb PDF)
  - I3: Residential, Industrial, Commercial, and Institutional Water Use Report (166Kb PDF)
- Appendix J Okanagan Basin Water Accounting Model (18.3Mb PDF)
- Appendix K Okanagan Water Database System Documentation
  - Refer to the Okanagan Water Database (Registered users only, account required)
- Appendix L Okanagan Water Information Reference Library Database Files
  - Refer to the OBWRID Water Science Library
- Appendix M Study Team and Funding Partners
  - See Project Partners
- Appendix N Development of Climate Datasets (715Kb PDF)
- Appendix O Okanagan Water Demand Scenario Modeling Report (130 Kb)

ATTACHMENTS

- Map 1 – Okanagan Basin Surface Water Sub-basins (8Mb PDF)
- Map 2 – Okanagan Basin Groundwater Aquifers (1Mb PDF)
- Map 3 – Water Use Areas in the Okanagan Basin (8.7Mb PDF)
- Map 4 – Hydrometric Network in the Okanagan Basin (1.8Mb PDF)

LIST OF FIGURES