Appendix C

OKANAGAN WATER MANAGEMENT AND USE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND

Dobson Engineering Ltd. was awarded a contract in July 2007 to lead an initial investigation into water management and use patterns in the Basin. The Dobson report (Dobson Engineering, 2008) is known as the Water Management and Use (WMU) Study.

Following a review in early 2009, the Working Group noted that additional investigation of an important sub-set of the data was warranted to further reduce uncertainty in some estimates. The Working Group also identified that a consistent method was needed to estimate water use (i.e. the volume used at the point of use) and water extraction (i.e. the volume obtained at the source) both under current (1996-2006) conditions and in the future. Since future water use estimates were to be based on the Okanagan Water Demand Model (the OWDM), it was decided that this model should also form the basis for current water use estimates.

The original Ministry of Agriculture and Lands (MAL) Agricultural Irrigation Model (see Section 2.0), developed prior to the beginning of the Phase 2 project, was enhanced during Phase 2 by adding other kinds of outdoor irrigation and by adding the indoor water uses. The enhanced model is known as the Okanagan Water Demand Model.

Finally, the Working Group identified the need for information to describe the complex linkage between the water source and the point of use. With this information, the water use estimates based on the OWDM could then be associated with water extractions at specific sources.

The work that followed the original WMU Study was performed by several consultants including Summit Environmental Consultants Ltd., Polar Geoscience Ltd., Agua Consulting Inc., RHF Systems Ltd., and ESSA Technologies Ltd. The work to develop the OWDM during Phase 2 was led by MAL, Agriculture and Agri-Food Canada (AAFC), and the Ministry of Community Services.

This Section of the report provides a summary of water use and management patterns in the Okanagan basin as determined during the WMU Study and the follow-up work program.

2.0 STUDY OBJECTIVES AND APPROACH

In addition to providing a comprehensive update to the water use studies summarized in the 1974 Okanagan Basin Study Report (Consultative Board 1974), the WMU Study results and follow-up work were intended to feed directly into subsequent Phase 2 studies, specifically surface water and groundwater supply modelling, and an investigation of in-stream (conservation) flow requirements.

The WMU Study involved the compilation and analysis of a large body of information on water management and use in the Basin and had two (2) main objectives:

- To develop a thorough understanding of water use and management in the Basin, and
- To investigate selected water balance parameters associated with water use and management in the Basin. This included the identification of six (6) parameters (Table 2.1) on a weekly time-step between January 1, 1996 and December 31, 2006[1]. Four (4) parameters, associated with surface water, were ultimately attributed to each of the 81 surface nodes defined in Phase 1 of the Phase 2 project *(*see *Geographic Scope* below*),* while two (2) parameters, associated with groundwater, were attributed to each of the 79 alluvial aquifers identified by the groundwater study team (Golder and Summit 2009).

[1] The 11-year period 1996 to 2006 was chosen as the "standard" period for the following reasons: 1) it reasonably reflects the current population, climate, land use, irrigation practices, and water distribution systems; 2) it includes three Canada Census years (1996, 2001, and 2006); and 3) it specifically includes the year 2006, which represents a reasonably average year for water supply and use for which data from water suppliers was available.

Table 2.1 List of water balance parameters investigated in the WMU Study

Source	Water Balance Parameter	Description
Surface Water	$Q_{R\ i,t}$	Upstream reservoir component of streamflow at node i during time t (positive during reservoir release, negative during reservoir filling)
	$RF_{S\ i,t}$	Surface component of return flow to node i during time t (e.g. sewage treatment plant discharges)
	$Q_{T\ i,t}$	Rate of water transfer to node i (into a stream) from outside the natural contributing area during time t
	$E_{S\ i,t}$	Volume extracted from surface sources within node i during time t
Groundwater	$R_{H\ j,t}$	Recharge to aquifer j during time t due to human activity (e.g. septic and irrigation throughflow)
	$D_{P\ j,t}$	Groundwater pumped from aquifer j during time t

Note: These water balance parameters are further described in Appendix B.

The WMU Study identified the main water suppliers and users in the Basin, and assembled as much information on surface and groundwater use as possible in order to develop a database for the required water balance parameters (Table 2.1). Since water use data was available from only a portion of the known water suppliers in the Basin, several assumptions and estimates were required during development of the database. As a result, the accuracy of the database parameters varied depending on the information available to the study team.

In an attempt to increase the accuracy of a small but important sub-set of the data (including Vernon, Mission, and Trout Creeks), additional detailed investigation was conducted in an effort to refine the estimates for the surface water terms in Table 2.1.

In order to explicitly describe the linkage between extractions at the water source and the end-use, the concept of Water Use Areas (WUAs) was introduced. WUAs are defined as areas on the land surface that receive or are likely to receive water from the same source or number of sources. For areas serviced by water purveyors, WUAs generally correspond to

boundaries of water distribution systems. In areas not serviced by purveyors, WUAs were estimated based on an analysis of water licence and groundwater well/aquifer information.

Within each WUA, water use by end use was modelled using the OWDM. Table 2.2 identifies the nine (9) water use parameters by end use that were estimated. Given that the water source for each WUA had been determined, the OWDM not only provided an estimate of the actual volume of water used in the WUA, but also provided an independent estimate of the volume of water extracted from each water source (i.e., water balance parameters $E_{S\ i,t}$ and $D_{P\ i,t}$). In order to maintain consistency between current and future model runs, the estimates of water extraction from surface and groundwater sources were ultimately based on the OWDM and WUA information; and the estimates of $E_{S\ i,t}$.and $D_{P\ i,t}$ from the original WMU Study were used for validation purposes.

Table 2.2 List of water balance parameters estimated using the OWDM.

End-use of water	**Water Balance Parameter**	**Description**
Agriculture	$U_{ag\ k,t}$	Volume of water used in water use area k during time t used for irrigation of agricultural land.
Golf Courses	$U_{golf\ k,t}$	Volume of water used in water use area k during time t used for irrigation of golf courses.
Parks/open space	$U_{park\ k,t}$	Volume of water used in water use area k during time t used for irrigation of parks and open spaces.
Domestic indoor	$U_{domin\ k,t}$	Volume of water used in water use area k during time t used for domestic indoor use.
Domestic outdoor	$U_{domout\ k,t}$	Volume of water used in water use area k during time t used for domestic outdoor use.
Institutional	$U_{inst\ k,t}$	Volume of water used in water use area k during time t used for institutional use.
Commercial	$U_{comm.\ k,t}$	Volume of water used in water use area k during time t used for commercial use.
Industrial	$U_{ind\ k,t}$	Volume of water used in water use area k during time t used for industrial use.
Losses	$U_{loss\ k,t}$	Volume of water used in water use area k during time t that is lost or unaccounted for.
Total	$U_{total\ k,t}$	Total volume of water used in water use area k during time t.

3.0 GEOGRAPHIC SCOPE

Consistent with Phase 1 of the Project, the geographic boundaries of the study area (the "Basin") for the WMU Study and follow-up work include the entire Okanagan River watershed upstream of the outlet of Osoyoos Lake.

As noted above, the Phase 2 project adopted the following three (3) fundamental "spatial layers":

- Surface nodes,
- Aquifers, and
- Water Use Areas (WUAs).

Surface water parameters were investigated for 81 surface nodes. These points-of-interest include 32 sub-basins (i.e., tributary watersheds), 40 "residual" areas (i.e., land parcels of interest, but not constituting watersheds), five (5) mainstem lakes, and four (4) locations on the mainstem of the Okanagan River (Table 3.1, Attachment 1). Groundwater parameters were associated with a total of 79 alluvial aquifers defined by the Groundwater Study (Golder and Summit 2009). Water use was associated with 259 Water Use Areas in the Basin.

Table 3.1 The 81 points-of-interest (or nodes) adopted for the WMU Study

Node		Node		Node		Node	
1	Vernon Creek at outlet of Kalamalka Lake	22	Mission Creek	43	Residual area W-13	64	Vaseux Lake
2	Kalamalka and Wood Lakes	23	Residual area E-4	44	Turnbull Creek	65	Residual area E-13
3	Deep Creek	24	Bellevue Creek	45	Residual area E-9	66	Vaseux Creek
4	Residual area W-1	25	Residual area E-5	46	Penticton Creek	67	Residual area W-20
5	Irish Creek	26	McDougall Creek	47	Okanagan Lake	68	Residual Area E-14
6	Residual area W-2	27	Residual area W-8	48	Okanagan River at Penticton	69	Park Rill
7	Residual area E-1	28	Powers Creek	49	Residual area W-14	70	Residual area W-21
8	Equesis Creek	29	Residual area W-9	50	Residual area E-10	71	Wolfcub Creek
9	Residual area W-3	30	Trepanier Creek	51	Shingle Creek	72	Residual area E-15
10	Nashwhito Creek	31	Residual area W-10	52	Ellis Creek	73	Okanagan River near Oliver
11	Residual area W-4	32	Peachland Creek	53	Residual area W-15	74	Residual area W-22
12	Vernon Creek (at mouth)	33	Residual area W-11	54	Residual area E-11	75	Residual area E-16
13	Residual area E-2	34	Chute Creek	55	Marron River	76	Testalinden Creek
14	Whiteman Creek	35	Residual area E-6	56	Residual area W-16	77	Residual area W-23
15	Residual area W-5	36	Eneas Creek	57	Residual area E-17*	78	Inkaneep Creek
16	Shorts Creek	37	Residual area W-12	58	Skaha Lake	79	Residual area E-17
17	Residual area W-6	38	Robinson Creek	59	Okanagan River at Okanagan Falls	80	Osoyoos Lake
18	Lambly Creek	39	Residual area E-7	60	Shuttleworth Creek	81	Okanagan River Oroville, Washington
19	Residual area W-7	40	Naramata Creek	61	Residual area W-18*		
20	Mill Creek	41	Residual area E-8	62	Residual area E-19		
21	Residual area E-3	42	Trout Creek	63	Residual area E-12		

*These areas are terminal basins that have no surface water connection to Okanagan River

4.0 WATER SUPPLIERS IN THE BASIN

Within the Basin, water is extracted from surface water (e.g. streams, lakes, and springs) and groundwater sources by a diversity of water suppliers and individuals. This includes the 101 water suppliers identified in Table 5.1, who collectively supply the bulk of the water used in the Basin. Over the 11 year period from 1996 to 2006, the average annual water use in the Basin by all users averaged 219,000 megalitres[2] (ML). Of this total, the 101 water suppliers identified in Table 5.1 supplied an estimated 83%. The remaining 17% of water used in the Basin was supplied privately or by other suppliers not identified in the study.

5.0 WATER LICENCES (SURFACE WATER)

There are nearly 4,000 active water licences to store or use surface water in the Basin. Approximately 443,000 ML of surface water is allocated annually for offstream use[3], and 351,000 ML is allocated for in-stream (conservation) and other (non-consumptive) uses. These uses are supported by 163,000 ML of licensed storage (Table 5.2). The 57 major water suppliers identified in the WMU Study hold approximately 95% of the water licensed for offstream use in the Basin. The 57 major water suppliers also hold approximately 88% of the licensed storage in the Basin (Table 5.3).

[2] 1 megalitre (ML) is equal to 1 dam^3 (cubic decameter) or 1,000,000 litres. For reference, an Olympic-sized swimming pool has a volume of 2.5 ML.
[3] See Table 5.2 for the end-uses that are classified as offstream use.

Table 5.1 List of (101) known water suppliers in the Basin in alphabetical order

No.	Water Supplier	No.	Water Supplier	No.	Water Supplier
21	Alto Utility		Fintry Estates Waterworks	48	Penticton Indian Band
	Antler Beach		Gallaghers Lake Waterworks	18	RDOS – Naramata
	Belair Estates Mobile Home Park	7	Glenmore Ellison Improvement District	27	Rolling Hills Water Works District
4	Black Mountain Irrigation District		Golden Arrow Trailer Park	9	Rutland Waterworks District
	Bobtail Ranch	34	Grandview Waterworks District		Sage Mesa Water System
	Boucherie Beach		Greata Ranch		Shannon Lake Golf Course
28	Boundary Line Irrigation District	2	Greater Vernon Water Utility		Shuttleworth Creek Irrigation District
	Burrowing Owl Vineyards		Green Bay Water Utility		Silver Star RV Park
19	Bylaw 1083 – Sunnyside	55	Greystoke Improvement District	56	Skaha Lake Estates Water Utility
25	Bylaw 369 - Falcon Ridge	35	Highlands Park Waterworks District	13	South East Kelowna Irrigation District
	Bylaw 434 - Killiney Beach		Holiday Park Resort	30	South Okanagan Mission Improvement District
	Bylaw 571 - Dietrich (Star Place)		Idle-O-Apartments		St Andrews By the Lake
17	Bylaw 597 - West Kelowna Estates	46	Jennens Road Water Users	39	Stardel Waterworks District
	Bylaw 695 - Westshore Estates		Kal Pine Estates	40	Steele Springs Waterworks District
26	Bylaw 793 - Pritchard/Shanboolard	15	Kaleden Irrigation District	42	Sun Valley Improvement District
24	Bylaw 981 - Sunset Ranch		Kelowna Springs Golf Course		Tamri Motel & Campground
	Cabana Beach Campground		La Casa	12	Town of Oliver
	Canadian Lakeside Developments		Lake Country Irrigation District	16	Town of Osoyoos
32	Canyon Waterworks District	53	Lakepine Utility	43	Traders Cove Waterworks District
45	Casa Loma Water Utilities Ltd.	29	Lakeshore Waterworks Ltd.		Twin Lakes Water Utility
	Cedar Creek Winery	8	Lakeview Irrigation District	31	Vaseux Lake Improvement District
14	City of Armstrong	36	Landsdowne Waterworks District		Waltons Mountain
1	City of Kelowna	37	Larkin Waterworks District		Weeping Willow Mobile Home Park
3	City of Penticton	41	Lower Nipit Improvement District	20	West Bench Irrigation District
	Claremont Utilities		McIntyre Bluff Ranch	47	Westbank First Nation
6	Corporation of the District of Summerland	57	Meadow Valley Irrigation District	5	Westbank Irrigation District
	Covert Farms	51	Meighan Creek		Whitewood Neighborhood Utility

Table 5.1 cont'd.

	Crown Villa	22	Okanagan Falls Irrigation District		Willow Beach Utility
10	District of Lake Country	49	Okanagan Indian Band		Willowbrook Water Utility
11	District of Peachland		Okanagan Landing Utilities	44	Wilson's Landing Utilities Inc. (RDCO)
33	Eagle Rock Waterworks District	50	Osoyoos Indian Band		Winfield Mobile Home Park
54	Eastside Utility Ltd.	22	Osoyoos Water Utility (RDOS)		Woods Lake Resort
	Edgewater Pines	38	Otter Lake Waterworks Improvement District	52	Woodsdale Utility
	Faulder Community System		Peachland Ponderosa		

Note: The water suppliers identified with a number are those identified in the WMU Study. The remaining water suppliers were identified during the follow-up work program.

Table 5.2 Summary of active water licences in the Okanagan Basin

End use		Ministry of Environment Water License Classification	Number of active licences	Annual volume of water licensed (ML)
Storage		Storage, Conservation – stored water	293	163,094
		Sub-total:	***293***	***163,094***
Offstream Use	Irrigation	Irrigation, Irrigation local authority, Residential lawn/garden, Watering	1,661	243,919
	Waterworks	Waterworks local authority, Waterworks (other)	257	168,046
	Industrial, commercial, institutional	Enterprise, Amusement park, Dust control, Bottle sales, Ponds, Game farm, Camps, Fish hatchery, Public facilities, Heat exchangers, Cooling, Fire protection, Frost protection, Greenhouses, Institutions, Mineral trading – bath, Processing, Kennel, Swimming pool, Water delivery	75	28,819
	Domestic	Domestic, Incidental – domestic	1,814	2,051
	Stock watering	Stockwatering	148	382
		Sub-total:	***3,955***	***443,217***
In-stream Use (non-consumptive)	Conservation	Conservation – use of water	20	24,450
		Sub-total:	***20***	***24,450***
Other (non-consumptive)	Land improvement	Land improvement	25	296,225
	Power	Power – residential, Power – general, Power – commercial,	4	15,925
	Conservation (construction)	Conservation – construction of works	19	14,042
		Sub-total:	***48***	***326,192***

Table 5.3 Summary of active water licences held by the 57 major water suppliers identified in the WMU Study

Water Supplier No.	Water Supplier	Annual volume of water licensed for off-stream use		Annual volume of water licensed for storage	
		(ML)	% of total	(ML)	% of total
1	City of Kelowna	47,116	10.6	-	
2	Greater Vernon Water	60,843	13.7	3,870	2.4
3	City of Penticton	25,167	5.7	14,276	8.8
4	Black Mountain Irrigation District	27,558	6.2	19,459	11.9
5	Westbank Irrigation District	11,055	2.5	9,811	6.0
6	District of Summerland	28,206	6.4	18,738	11.5
7	Glenmore Ellison Improvement District	13769	3.1	8,502	5.2
8	Lakeview Irrigation District	9,606	2.2	8,564	5.3
9	Rutland Waterworks District				
10	District of Lake Country	25,784	5.8	25,653	15.7
11	District of Peachland	10,922	2.5	6,370	3.9
12	A. Town of Oliver B. Town of Oliver (rural)	50,352	11.4	-	
13	South East Kelowna Irrigation District	37,693	8.5	20,039	12.3
14	City of Armstrong	3,805	0.9	135	0.1
15	Kaleden Improvement District	3,435	0.8	-	
16	A. Town of Osoyoos B. Town of Osoyoos (rural)	24,361	5.5	-	
17	West Kelowna Estates (RDCO)				
18	Naramata Water Utility (RDOS)	14,623	3.3	2,386	1.5
19	Sunnyside Water Utility (RDCO)				
20	West Bench Irrigation District	1,348	0.3	-	
21	Alto Utility				
22	Okanagan Falls Irrigation District				
23	Osoyoos Water Utility (RDOS)	1,903	0.4	-	
24	Sunset Ranch Water Utility (RDCO)	4,441	1.0	14	<0.1
25	Falconridge Water Utility (RDCO)				
26	Pritchard / Shanboolard Water Utility (RDCO)	114	<0.1	-	
27	Rolling Hills Waterworks District				
28	Boundary Line Irrigation District	450	0.1	-	
29	Lakeshore Waterworks District	320	0.1	-	

Table 5.3 cont'd.

Water Supplier No.	Water Supplier	Annual volume of water licensed for off-stream use (ML)	Annual volume of water licensed for off-stream use % of total	Annual volume of water licensed for storage (ML)	Annual volume of water licensed for storage % of total
30	South Okanagan Mission Irrigation District				
31	Vaseux Lake Improvement District				
32	Canyon Waterworks District				
33	Eagle Rock Waterworks District	146	<0.1	147	0.1
34	Grandview Waterworks District	214	<0.1	-	
35	Highlands Park Waterworks District				
36	Landsdowne Waterworks District	32	<0.1	-	
37	Larkin Waterworks District				
38	Otter Lake Waterworks District				
39	Stardel Waterworks District				
40	Steele Springs Waterworks District	59	<0.1	-	
41	Lower Nipit Irrigation District				
42	Sun Valley Irrigation District				
43	Traders Cove Waterworks District	165	<0.1	-	
44	Wilson's Landing Utilities Inc.	14	<0.1	-	
45	Casa Loma	275	<0.1	-	
46	Jennens Road Water Users				
47	Westbank First Nation	1,447	0.3	-	
48	Penticton Indian Band	2,872	0.6	1,223	0.7
49	Okanagan Indian Band	6,936	1.6	1,945	1.2
50	Osoyoos Indian Band (Vincor)	4,407	1.0	245	0.2
51	Meighan Creek				
52	Woodsdale Utility				
53	Lakepine Utility	81	<0.1	-	
54	Eastside Utility	93	<0.1	-	
55	Greystoke I.D.				
56	Skaha Estates Water Utility				
57	Meadow Valley Irrigation District	1,648	0.4	1,132	0.7
	Sub-total:	**421,260**	95	**142,509**	88
	All other water licenses	21,957	5	20,585	12
	Total:	**443,217**	**100**	**163,094**	**100**

6.0 RESERVOIR STORAGE

Since the bulk of the annual runoff in the Basin results from snowmelt, the operation of storage reservoirs in the uplands is critical to the management of surface water. Most of the larger upland reservoirs in the Basin are managed to capture snowmelt runoff in spring (roughly from April 1 to June 30) and to release water during the summer and remainder of the year (July 1 to March 31) as demands require. The majority of the water released from a reservoir in any year typically occurs between July and September. The actual amount of water released from upland reservoirs reflects the bulk volume of water required by water suppliers and users downstream. Reservoir releases are usually about 15% more than the volume extracted downstream to account for conservation (in-stream) purposes, losses to groundwater through the streambed, and daily peak usage by customers of the water suppliers. The storage of water in upland reservoirs and its subsequent release is denoted by the symbol Q_R (Appendix B).

There are 36 large upland storage reservoirs[4] operated by the major water suppliers in the Basin (Table 6.1). In total, these reservoirs have a developed storage capacity of about 133,000 ML, or about 82% of the licensed storage in the Basin.

Table 6.1 Major upland storage reservoirs in the Basin

Water Supplier No.	Water Supplier	Reservoir	Sub-basin	Developed storage capacity (ML)
2	Greater Vernon Water	Grizzly	Duteau Creek*	5,280
		Aberdeen	Duteau Creek*	11,150
		Haddo	Duteau Creek*	2,730
		King Edward	Node 1: Vernon Creek	1,356
3	City of Penticton	Grayback	Node 46: Penticton Creek	12,330
		Ellis	Node 52: Ellis Creek	1,230
		Greystoke	Node 22: Mission Creek	5,103

[4] There are several other smaller reservoirs in the Basin, but their capacity is relatively small in comparison to the 36 larger reservoirs.

Table 6.1 cont'd.

Water Supplier No.	Water Supplier	Reservoir	Sub-basin	Developed storage capacity (ML)
4	Black Mountain Irrigation District	Ideal	Node 22: Mission Creek	6,780
		Greystoke	Node 22: Mission Creek	5,103
		Fish Hawk	Node 22: Mission Creek	1,850
		James	Node 20: Mill Creek	1,825
5	Westbank Irrigation District	Tadpole	Node 18: Lambly Creek	3,601
		Horseshoe/Dobbin	Node 28: Powers Creek	1,724
		Jackpine	Node 28: Powers Creek	1,233
		Lambly	Node 28: Powers Creek	3,490
6	District of Summerland	Headwaters	Node 42: Trout Creek	4,472
		Tsuh, Canyon, Isintok, Cresent, Whitehead	Node 42: Trout Creek	3,673
		Thirsk	Node 42: Trout Creek	6,490
		Eneas, Garnet	Node 36: Eneas Creek	2,360
7	Glenmore Ellison Improvement District	Posthill, Bulman, South	Node 20: Mill Creek	7,869
8	Lakeview Irrigation District	Big Horn	Node 18: Lambly Creek	3,454
		Rose Valley	Node W7	4,922
10	District of Lake Country	Oyama	Node 1: Vernon Creek	7,137
		Crooked	Node 1: Vernon Creek	2,383
		Swallwell	Node 1: Vernon Creek	11,880
11	District of Peachland	MacDonald	Node 32: Peachland Creek	5,303
13	Southeast Kelowna Irrigation District	McCulloch, Browne, Fish, Long Meadow	Node 22: Mission Creek	17,545
Total:				**132,589**

*Flows from Duteau Creek, a tributary to Shuswap River, are imported to the Okanagan Basin.

7.0 INTER-BASIN AND SUB-BASIN TO SUB-BASIN DIVERSIONS

There are eight (8) known water suppliers that divert water across sub-basin or Okanagan Basin boundaries (Table 7.1) in order to supplement the existing water supply. This routing of water is denoted by the symbol Q_T. In total, an estimated 17,000 ML of water is imported to the Basin on average each year (Table 9.1). However between 1996 and 2006 imports have varied from 14,000 ML in 1997 to 20,000 ML in 2003.

In the detailed work completed to define water routings within the Basin during the water use studies, the water balance parameter Q_T was defined to include only water imports across sub-basin boundaries that flow directly into a stream. Since the Duteau Creek, Okanagan Lake, Stirling Creek, and Fortune Creek diversions direct water directly into a water distribution system (i.e. system of pipes) or into a reservoir, they were accounted for by the water use (U_{total}) or reservoir storage (Q_R) parameter analysis.

Table 7.1 List of known streamflow diversions across Okanagan Basin or sub-basin boundaries

Water Supplier No.	Water Supplier	Transfer from:	Transfer to:	Estimated average annual (1996-2006) diversion volume (ML)	Notes
1	City of Kelowna	Node 20: Mill (Kelowna) Creek	Node 22: Mission Creek (at flood flows)	8,200	Assumed diversion occurs April 1 to June 15
2	Greater Vernon Water	Duteau Creek*	Nodes 1 & 2: Vernon Creek and Node 7: Residual area E-1	na	Water is routed directly into water distribution system from Duteau Creek
5	Westbank Irrigation District	Node 18: Lambly Creek and Nicola River watershed*	Node 28: Powers Creek (via the Alocin Creek* diversion)	220	It is assumed 50% of water is sourced from the Lambly Creek sub-basin and 50% from the Nicola River watershed between April 1 and June 15
10	District of Lake Country	Okanagan Lake	Node 1: Vernon Creek	na	Water is routed into water distribution system from Okanagan Lake
11	District of Peachland	Node 29: Trepanier Creek	Node 30: Peachland Creek (MacDonald Creek diversion at Brenda Mine)	200	Assumed diversion occurs between April 1 and September 30
13	South East Kelowna Irrigation District	Stirling Creek in the Kettle River watershed*	Node 22: Mission Creek	na	Water from Stirling Creek is routed into McCulloch Reservoir
14	City of Armstrong	Fortune Creek in the Shuswap River watershed*	Node 3:Deep Creek.	na	Water is routed into water distribution system from Fortune Creek
18	Naramata Water Utility (RDOS)	Node 34: Chute Creek	Node 38: Robinson Creek (via diversion ditch into Elinor Lake)	670 +/-	Assumed diversion occurs April 1 to June 15
		Node 38: Robinson Creek	Node 40: Naramata Creek (via high line diversion)	670 +/-	Assumed diversion occurs between July 1 and September 30

*This represents an import of water from outside the Okanagan Basin.

8.0 WATER USE

The average annual water use in the Basin totals an estimated 219,000 ML. However, during the 1996-2006 period, total annual water use ranged from about 187,000 ML in 1997 to 247,000 ML in 2003. The year-to-year distribution of water use among the end-uses is relatively consistent, with the greatest proportion used on average for agriculture. This is followed by domestic outdoor, domestic indoor, commercial, golf courses, parks and open spaces, industrial and institutional water use. Table 8.1 and Figure 8.1 present the estimates of total annual water use in the Basin by the nine (9) end uses, for each year in the 1996-2006 period. Figure 8.2 aggregates the data for the individual years into a single average value, and presents a pie-chart of average water use by category for the entire 1996-2006 period.

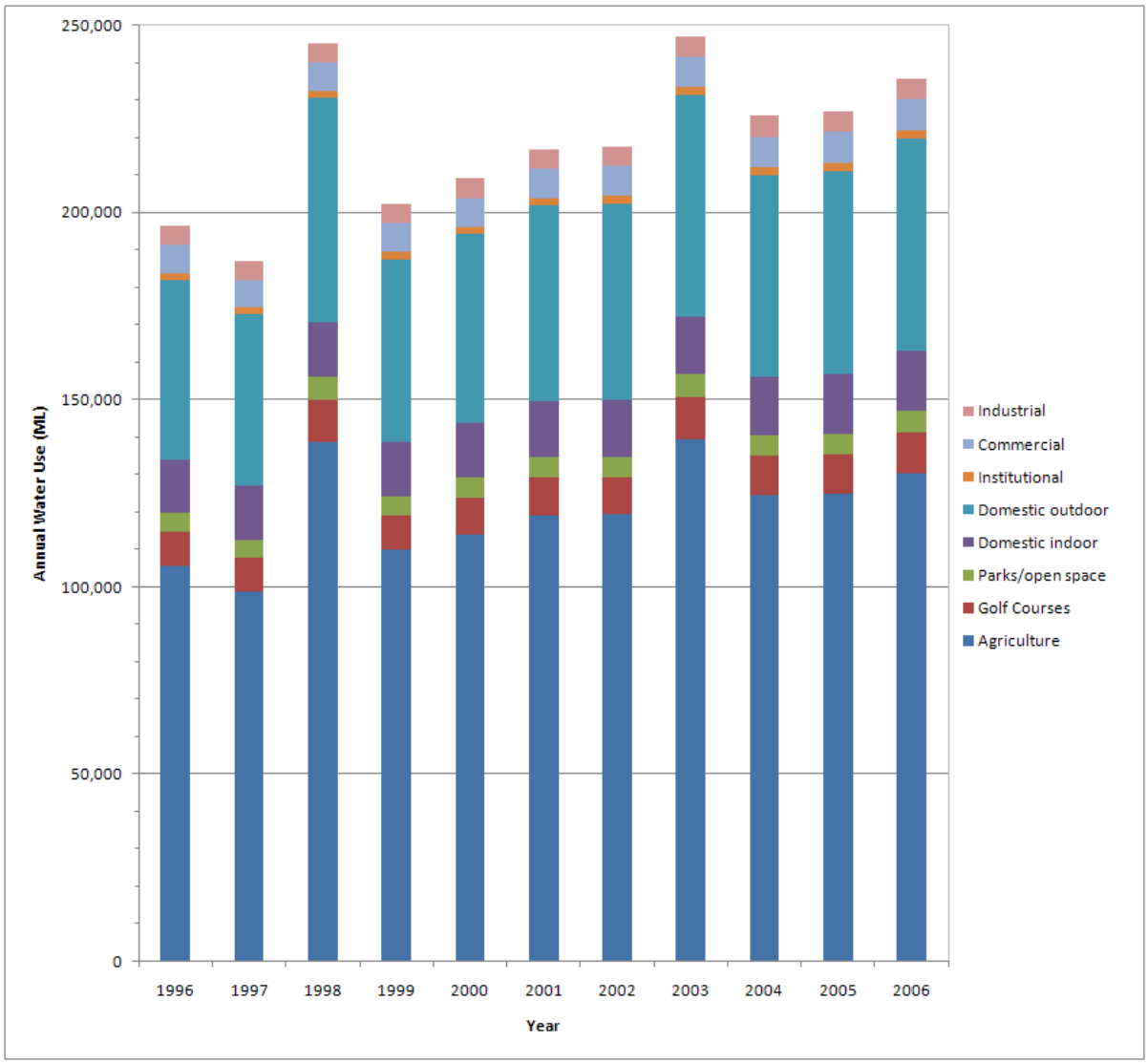
8.1 AGRICULTURAL (IRRIGATION)

As noted above, agricultural water use represents the largest end-use of water in the Basin. On average, 120,000 ML (or 55% of the total Basin water use) is used to irrigate an area of approximately 18,300 ha (Table 8.2). The value 18,300 ha excludes approximately 200 ha of land that have irrigation systems installed but are not in use. This water use represents a Basin-wide average application of 660 mm of water during the irrigation season. Locally, however water application rates vary by crop, irrigation system, soil and climate.

Table 8.1 Estimated total annual water use by end-use in the Okanagan Basin.

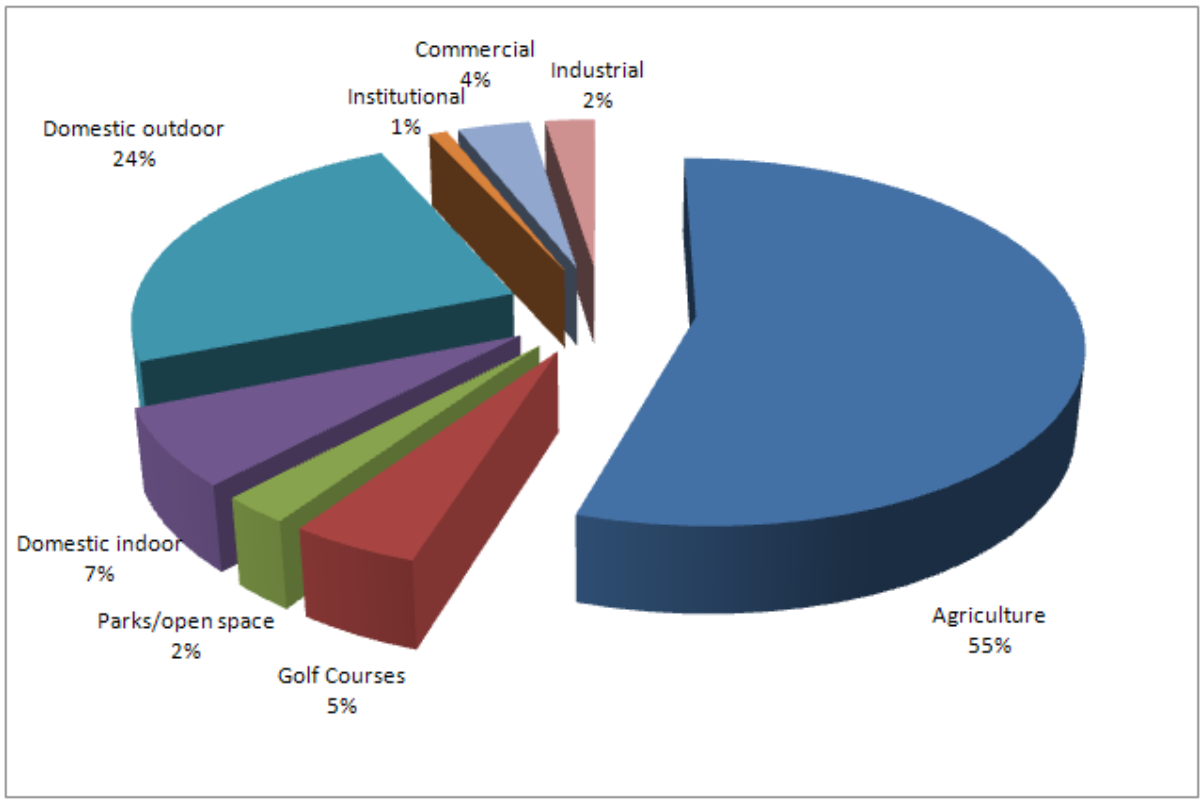
Year	Agriculture			Golf Courses			Parks/open space			Domestic indoor			Domestic outdoor			Institutional			Commercial			Industrial			Volume of water used (all end-uses)	Losses (all end-uses)	OVERALL TOTAL (all end-uses)
	Volume of water used	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*	*Volume of water used*	*Losses*	*Total*			
1996	78,331	27,152	*105,484*	6,930	2,428	*9,358*	3,629	1,334	*4,963*	13,616	681	*14,296*	34,909	12,984	*47,893*	1,792	90	*1,882*	7,084	354	*7,437*	4,831	242	*5,072*	*151,121*	*45,265*	***196,386***
1997	73,291	25,489	*98,780*	6,770	2,369	*9,139*	3,475	1,276	*4,752*	13,710	686	*14,396*	33,273	12,358	*45,631*	1,805	91	*1,895*	7,133	356	*7,489*	4,864	243	*5,107*	*144,321*	*42,868*	***187,189***
1998	102,498	36,028	*138,526*	8,475	2,982	*11,457*	4,421	1,635	*6,057*	13,842	692	*14,534*	43,748	16,376	*60,124*	1,823	92	*1,913*	7,201	360	*7,561*	4,911	246	*5,156*	*186,918*	*58,410*	***245,329***
1999	81,731	28,190	*109,921*	6,795	2,378	*9,172*	3,695	1,359	*5,054*	13,973	699	*14,672*	35,491	13,201	*48,691*	1,840	92	*1,932*	7,269	363	*7,633*	4,957	248	*5,205*	*155,752*	*46,531*	***202,280***
2000	84,561	29,436	*113,997*	7,287	2,556	*9,843*	3,820	1,408	*5,228*	14,144	707	*14,850*	36,570	13,632	*50,202*	1,862	93	*1,955*	7,358	368	*7,726*	5,018	251	*5,269*	*160,620*	*48,452*	***209,071***
2001	88,157	30,775	*118,932*	7,560	2,653	*10,213*	3,933	1,449	*5,382*	14,237	712	*14,949*	38,157	14,226	*52,383*	1,875	94	*1,968*	7,406	370	*7,777*	5,051	253	*5,303*	*166,376*	*50,532*	***216,907***
2002	88,647	30,778	*119,425*	7,343	2,575	*9,918*	3,940	1,452	*5,392*	14,444	723	*15,167*	38,298	14,277	*52,576*	1,902	96	*1,997*	7,514	375	*7,890*	5,124	256	*5,381*	*167,213*	*50,532*	***217,745***
2003	103,245	36,241	*139,486*	8,282	2,914	*11,197*	4,421	1,634	*6,056*	14,651	733	*15,384*	43,220	16,176	*59,397*	1,929	97	*2,025*	7,622	381	*8,003*	5,198	260	*5,458*	*188,569*	*58,436*	***247,006***
2004	92,028	32,315	*124,342*	7,799	2,743	*10,542*	4,044	1,494	*5,538*	14,900	745	*15,644*	39,323	14,701	*54,024*	1,961	98	*2,060*	7,751	387	*8,139*	5,286	265	*5,551*	*173,092*	*52,748*	***225,839***
2005	92,486	32,213	*124,698*	7,832	2,753	*10,585*	4,105	1,514	*5,619*	15,066	754	*15,820*	39,665	14,800	*54,465*	1,984	100	*2,083*	7,838	392	*8,229*	5,345	267	*5,612*	*174,321*	*52,792*	***227,111***
2006	96,616	33,805	*130,421*	8,105	2,851	*10,956*	4,228	1,564	*5,792*	15,272	764	*16,036*	41,124	15,380	*56,504*	2,011	101	*2,111*	7,945	397	*8,342*	5,418	271	*5,689*	*180,719*	*55,133*	***235,851***
Ave.	89,235	31,129	***120,365***	7,562	2,655	***10,216***	3,974	1,465	***5,439***	14,350	718	***15,068***	38,525	14,374	***52,899***	1,890	95	***1,984***	7,466	373	***7,839***	5,091	255	***5,346***	*168,093*	*51,063*	***219,155***
Min.			*98,780*			*9,139*			*4,752*			*14,296*			*45,631*			*1,882*			*7,437*			*5,072*			***187,189***
Max.			*139,486*			*11,457*			*6,057*			*16,036*			*60,124*			*2,111*			*8,342*			*5,689*			***247,006***
% of overall total			*54.9%*			*4.7%*			*2.5%*			*6.9%*			*24.1%*			*0.9%*			*3.6%*			*2.4%*			*100.0%*

Note: All values are in ML and are significant to the nearest 1,000 ML. Note that the total volume of water attributed to each end-use includes the estimated volume of water beneficially used and the losses associated with those end-uses.



Note that losses associated with each end-use category are included.

Figure 8.1 Estimated 1996-2006 water use in the Basin by end-use



Note that losses associated with each end-use are included within each category.

Figure 8.2 Typical (1996-2006 average) distribution of total water use by end-uses in the Okanagan Basin.

Table 8.2 Estimated total areas under irrigation in the Okanagan Basin

End-use	**Estimated area currently irrigated (ha)**
Agricultural	18,300
Parks and open spaces	590
Golf courses	1,060
Domestic outdoor	5,935
Total	**25,885**

8.2 GOLF COURSE (IRRIGATION)

A total of 41 golf courses, located throughout the Basin, were identified in the WMU Study (Table 8.3). Between 1996 and 2006, golf courses used an average of about 10,000 ML or 5% of the total water used in the Basin to irrigate approximately 1,060 ha (Table 8.1). This amounts to an average golf course water application of about 960 mm. Unlike agricultural irrigation practices however, most golf courses irrigate only at night. For many of the golf courses that privately supply their water, water is typically diverted into local storage during the day.

Table 8.3 List of golf courses in the Basin

Node	Water Supplier	Golf Course Name
1	Greater Vernon Water	Hillview Golf Club
	District of Lake Country	Aspen Grove
3	City of Armstrong	Royal York Golf Course (Armstrong)
	Other / Private	Spallumcheen Golf and Country Club
4	Okanagan Indian Band	Unknown
7	Greater Vernon Water	Unknown
12	Greater Vernon Water (WTP)	Vernon Golf and Country Club
13	Glenmore Ellison Improvement District	Kelowna Golf and Country Club
	Greater Vernon Water	Predator Ridge Golf Resort (Vernon)
17	Other / Private	Lake Okanagan Resort Golf Course
19	Westbank First Nation	Unknown
20	Black Mountain Irrigation District	Tower Ranch Golf Club; Black Mountain Golf Club
	Other / Private; Glenmore Ellison Improvement District	Okanagan Golf Club
	Other / Private	Kelowna Springs Golf Club; Shadow Ridge Golf Club (Kelowna); Sunset Ranch Golf and Country Club (Kelowna)
21	Other / Private	Eagle Quest (Kelowna)

Table 8.3 cont'd.

Node	Water Supplier	Golf Course Name
22	City of Kelowna	Mission Creek Golf Club
	Southeast Kelowna Irrigation District	Gallagher's Canyon Golf and Country Club; The Harvest Golf Club; Orchard Greens Golf Club
26	Other / Private	Unknown
	Westbank First Nation	Unknown
27	Other / Private	Vintage Hills Golf Course
30	District of Peachland	Unknown
31	District of Peachland	Ponderosa Golf and Country Club
33	District of Summerland	Unknown
42	District of Summerland	Summerland Golf and Country Club
43	Other / Private	Sage Mesa Golf Centre (Penticton)
46	City of Penticton	Pleasant Valley Par 3 Golf
49	Other / Private	Unknown
50	City of Penticton (WTP)	Penticton Golf and Country Club
53	Other / Private	Unknown
55	Other / Private	Unknown
61	Other / Private	Unknown
72	Osoyoos Indian Band (Vincor)	Unknown
74	Town of Oliver (rural)	Fairview Mountain Golf Club (Oliver)
77	Town of Osoyoos	Osoyoos Golf and Country Club; Desert Springs Golf Course (Osoyoos)
79	Town of Osoyoos	Unknown

8.3 PARKS AND OPEN SPACES (IRRIGATION)

Based on the Okanagan Water Demand Model, there are an estimated 590 ha of irrigated park land and other open "green" spaces in the Basin (Table 8.2). Between 1996 and 2006, it is estimated that approximately 5,000 ML (3% of total Basin use) of water was applied to these areas. This equates to a watering application of 920 mm over the irrigation season.

8.4 DOMESTIC

Domestic water use includes both indoor and outdoor components. Water is typically used indoors for cooking, bathing, drinking, laundry, and toilets. Outdoors, water is used typically for irrigation, washing, and recreation. Indoor domestic water use is generally a function of the population. Outdoor domestic use is a function of the population and the type of housing (e.g. single-family vs. multi-family), which primarily influences the requirements for irrigation and watering.

Based on cadastral and BC Assessment data obtained during development of the Okanagan Water Demand Model, average annual indoor domestic water use between 1996 and 2006 has been estimated to be 15,000 ML per year (7% of total Basin use). Over the same period, per capita indoor domestic water use averaged 150 L/person/day. Population data is given in Table 8.4. On average, between 1996 and 2006 an estimated 53,000 ML (24% of total Basin use) was used to irrigate a total domestic outdoor area of 5,935 ha. This equates to annual average irrigation application of 890 mm per year.

Combined, indoor and outdoor domestic use averages 68,000 ML, which represents 31% of the water use in the Basin. On a per capita basis, total Basin-wide domestic water use between 1996 and 2006 ranged from 624 to 769 L/person/day, and averaged 675 L/person/day.

8.5 INSTITUTIONAL, COMMERCIAL, AND INDUSTRIAL (ICI)

Institutional, commercial, and industrial (ICI) water users include schools, hospitals, care facilities, businesses, and industrial operations. In most, but not all cases, the main use of water is for indoor domestic-type purposes (e.g. drinking, washing, etc.). However, it is possible that some, relatively smaller proportion, is also used for outdoor uses (e.g. watering of lawns and plants)

Since data on ICI water use data is limited, ICI water use was estimated by identifying the ICI connections in the Basin and applying unit rates of water use for each type of connection (based on analysis of available water supplier records and BC Assessment data) (Miles 2009). In total, over 5,000 ICI connections were identified in the Basin in the WMU Study. These users were estimated to use an average of 15,000 ML (7% of the total Basin use) annually. Approximately 2,000 ML is associated with institutional users, 8,000 ML is associated with commercial users, and 5,000 ML is associated with industrial users.

8.6 LOSSES OR UNACCOUNTED FOR WATER (UFW)

Losses or unaccounted for water (UFW) include water lost to deep percolation through over-watering, irrigation system inefficiencies, distribution system losses (e.g., leakage in the water supplier`s distribution systems or at the point-of-use), and water theft. Based on limited records, distribution system losses for all end-use categories have been assumed to be 5% of the total volumes conveyed through the systems. Unless noted, the losses are included in the quoted values above. Totalled, however, losses from all end-uses average an estimated 51,000 ML.

Table 8.4 Estimated population in the Okanagan Basin between 1996 and 2006

Year	Population	Year	Population	Year	Population
1996	261,009	2000	271,131	2004	285,616
1997	263,540	2001	273,661	2005	289,601
1998	266,070	2002	277,646	2006	293,561
1999	268,600	2003	281,631	*Average*	*275,642*

Note: 1996, 2001 and 2006 were years with available data from the Canada Census. Intervening years were estimated assuming linear growth rates.

9.0 SURFACE WATER EXTRACTION

On average, an estimated 147,000 ML (67%) of the total water used in the Basin was obtained from surface water sources including streams, lakes, and springs (Table 9.1). This represents 33% of the total surface water licensed for offstream use in the Basin. The annual volume of water extracted from surface sources varied from roughly 126,000 ML in 1997 to 164,000 ML in 2003 (Figure 9.1). Figure 9.2 aggregates the data for the individual years into a single average value, and presents a pie-chart of average water use by source for the entire 1996-2006 period. In the supply and demand models used in Phase 2, surface water extractions are given the symbol E_S.

Figure 9.3 presents the average, minimum and maximum weekly volume of water extracted from surface sources in the Basin. During the late fall and winter periods, when outdoor irrigation has ceased, surface water extraction in the Basin is typically about 500 ML/week. However, with the onset of outdoor irrigation in spring, water extraction rates increase steadily until peaking in late July to mid August. On average, water extraction rates peak at about 8,500 ML/week, but in dry years water extraction can exceed 10,000 ML/week.

Figure 9.4 presents the average (1996-2006) surface water extraction by node. A logarithmic scale is used on the plot to present the wide range in water extraction volumes between nodes. The largest volume of water in the Basin is extracted from Okanagan Lake, followed by Mission Creek and Kalamalka/Wood Lake. Table 9.2 presents the surface water extraction estimates in tabular format, in declining order of extraction volume.

Table 9.1 Total annual volumes of water extracted from surface and groundwater sources, imported, and recycled in the Basin

Year	Annual volume of water extracted in the Okanagan Basin (ML)		Annual volume of water imported from sources outside the Okanagan Basin (ML)	Annual volume of (recycled) wastewater used (ML)	Total volume of water used in the Okanagan Basin (ML)
	Surface water sources	Groundwater			
1996	132,833	42,553	14,596	6,405	196,386
1997	126,536	40,805	13,754	6,094	187,189
1998	162,773	54,124	19,888	8,543	245,329
1999	137,314	43,709	14,581	6,675	202,280
2000	140,585	45,837	15,737	6,912	209,071
2001	145,697	47,384	16,495	7,331	216,907
2002	146,488	47,639	16,458	7,159	217,745
2003	164,233	54,537	19,669	8,567	247,006
2004	149,226	50,494	18,195	7,924	225,839
2005	152,311	49,919	17,149	7,733	227,111
2006	157,285	51,971	18,455	8,141	235,851
Average	**146,844**	**48,089**	**16,816**	**7,408**	**219,156**
Minimum	126,536	40,805	13,754	6,094	187,189
Maximum	164,233	54,537	19,888	8,567	247,006

Note: values significant to nearest 1,000 ML

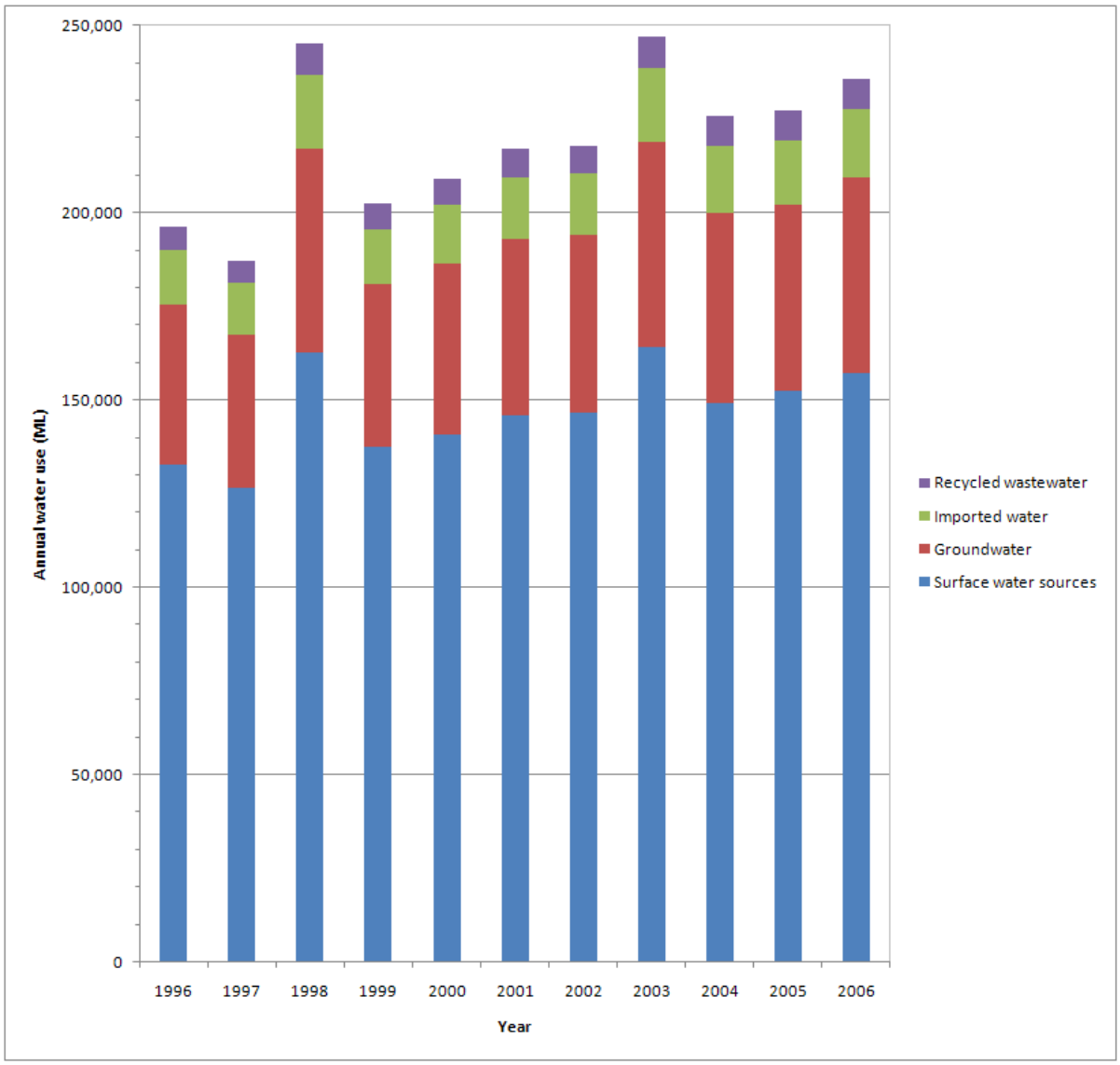


Figure 9.1 Estimated 1996-2006 water use in the Basin by source

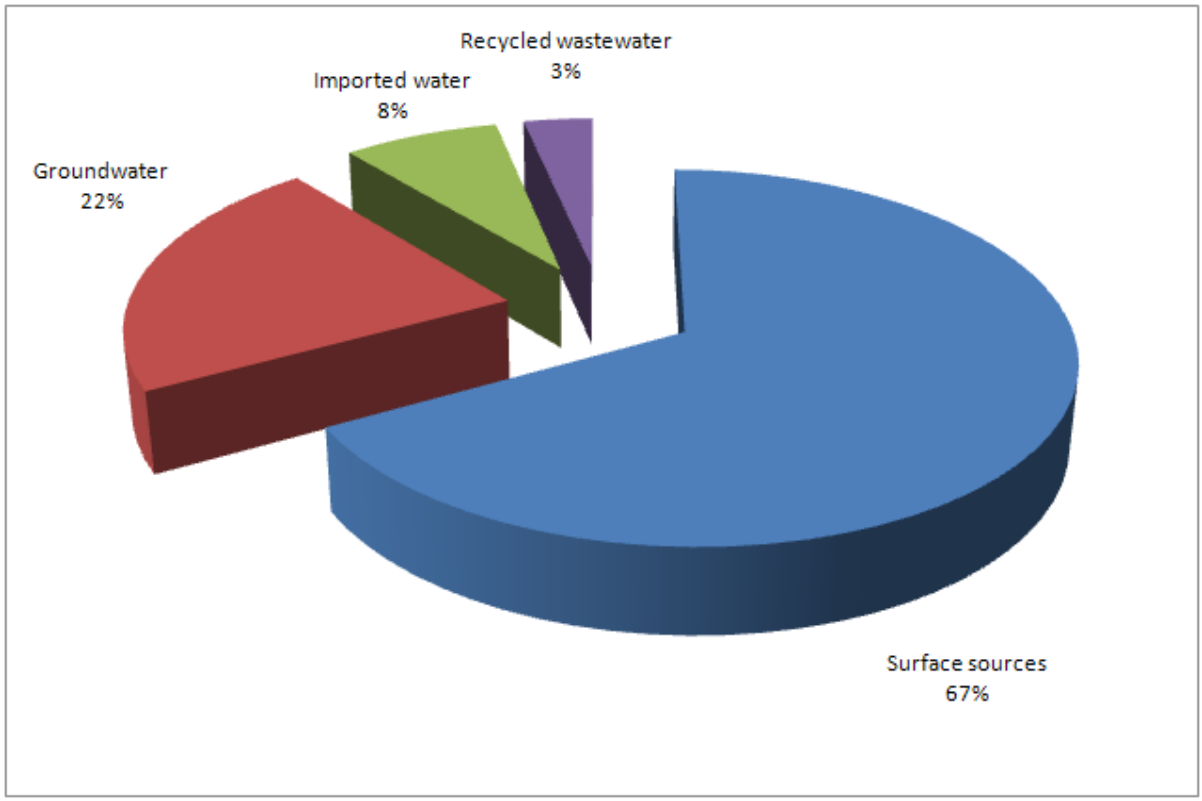
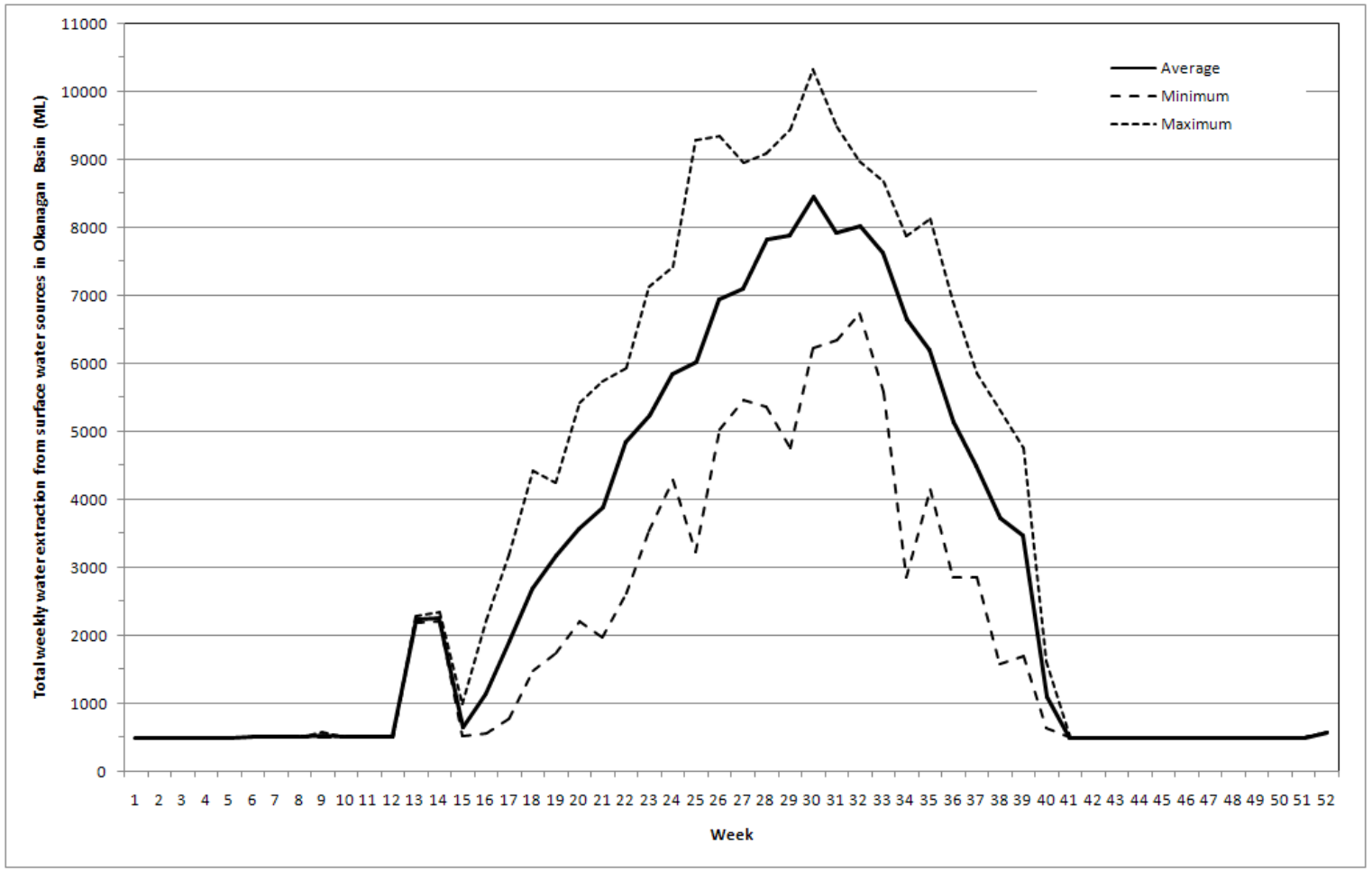
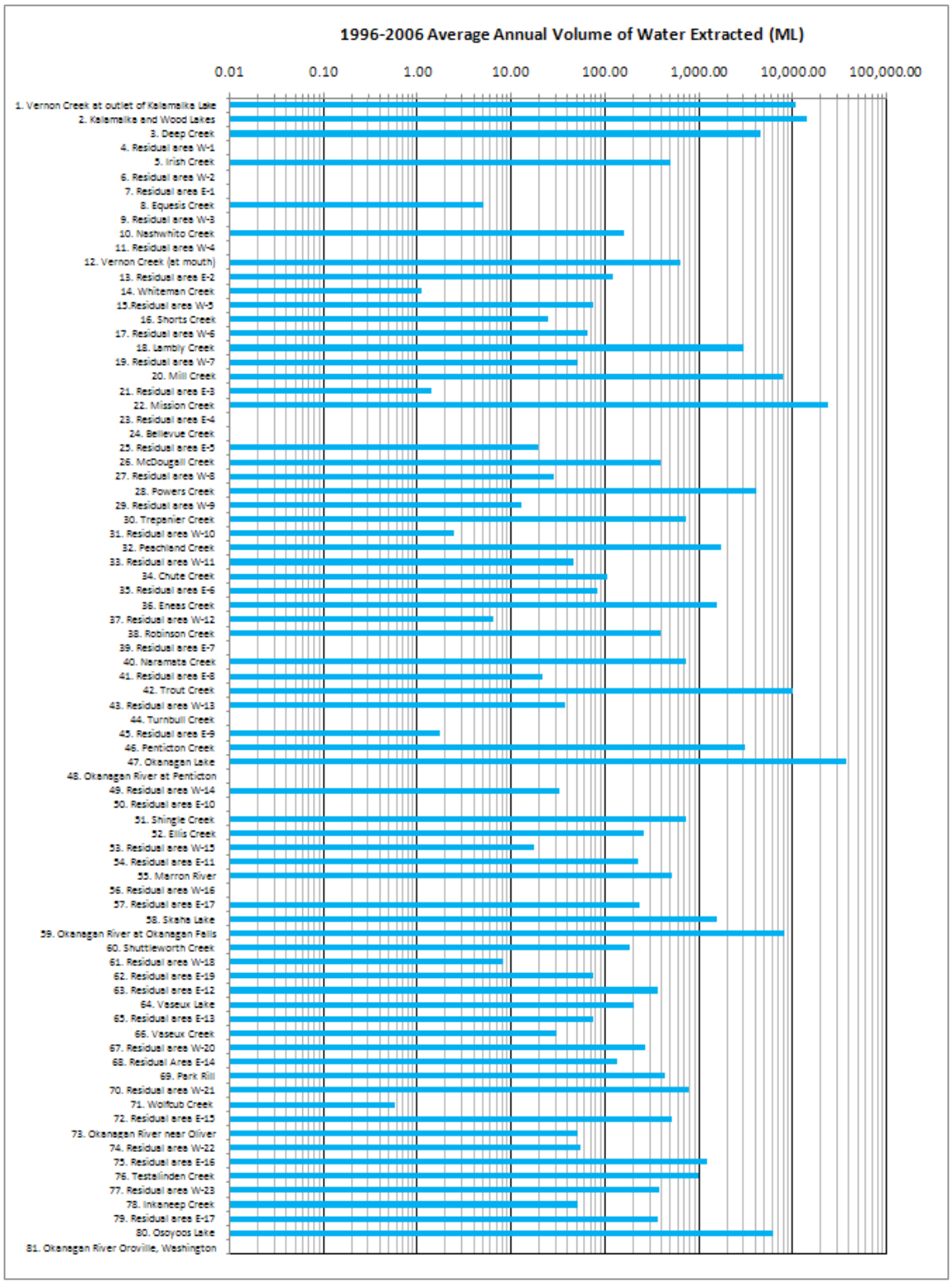


Figure 9.2 Typical (1996-2006 average) distribution of total water use in the Okanagan Basin by source.



Note: Average, minimum, and maximum weekly totals over the 1996 to 2006 period are shown. Weeks 1-12 and 41-52 are periods when little to no irrigation occurs. The assumption of constant indoor water use is the reason for no variability during these weeks.

Figure 9.3 Total weekly water extraction from surface sources in the Okanagan Basin



Note: The scale is logarithmic.

Figure 9.4 Estimated average 1996-2006 surface water extraction in the Okanagan Basin by node

Table 9.2 1996-2006 average annual surface water extraction by node.

Node	1996-2006 Average Annual Surface Water Extraction (ML)	Node	1996-2006 Average Annual Surface Water Extraction (ML)	Node	1996-2006 Average Annual Surface Water Extraction (ML)
47. Okanagan Lake	22,862	26. McDougall Creek	365	27. Residual area W-8	28
22. Mission Creek	13,707	77. Residual area W-23	357	16. Shorts Creek	24
2. Kalamalka and Wood Lakes	10,318	63. Residual area E-12	355	41. Residual area E-8	21
1. Vernon Creek at outlet of Kalamalka Lake	9,609	79. Residual area E-17	255	25. Residual area E-5	19
42. Trout Creek	7,961	67. Residual area W-20	253	53. Residual area W-15	17
59. Okanagan River at Okanagan Falls	7,587	52. Ellis Creek	225	29. Residual area W-9	13
20. Mill Creek	6,026	57. Residual area E-17	216	61. Residual area W-18	8
80. Osoyoos Lake	4,451	54. Residual area E-11	196	37. Residual area W-12	6
3. Deep Creek	3,976	64. Vaseux Lake	176	8. Equesis Creek	5
28. Powers Creek	3,035	60. Shuttleworth Creek	152	31. Residual area W-10	2
46. Penticton Creek	2,893	10. Nashwhito Creek	132	45. Residual area E-9	2
18. Lambly Creek	1,665	68. Residual Area E-14	119	21. Residual area E-3	1
32. Peachland Creek	1,522	13. Residual area E-2	103	14. Whiteman Creek	1
36. Eneas Creek	1,488	34. Chute Creek	0	71. Wolfcub Creek	1
58. Skaha Lake	1,164	35. Residual area E-6	83	24. Bellevue Creek	<0
75. Residual area E-16	951	15.Residual area W-5	74	4. Residual area W-1	-
76. Testalinden Creek	758	65. Residual area E-13	74	6. Residual area W-2	-
70. Residual area W-21	705	62. Residual area E-19	73	7. Residual area E-1	-
51. Shingle Creek	705	17. Residual area W-6	63	9. Residual area W-3	-
40. Naramata Creek	696	74. Residual area W-22	54	11. Residual area W-4	-
30. Trepanier Creek	607	19. Residual area W-7	50	23. Residual area E-4	-
12. Vernon Creek (at mouth)	490	73. Okanagan River near Oliver	50	39. Residual area E-7	-
55. Marron River	490	78. Inkaneep Creek	50	44. Turnbull Creek	-
72. Residual area E-15	473	33. Residual area W-11	45	48. Okanagan River at Penticton	-
5. Irish Creek	425	43. Residual area W-13	36	50. Residual area E-10	-
69. Park Rill	383	49. Residual area W-14	31	56. Residual area W-16	-
38. Robinson Creek	380	66. Vaseux Creek	30	81. Okanagan River Oroville, WA	-

10.0 GROUNDWATER PUMPING

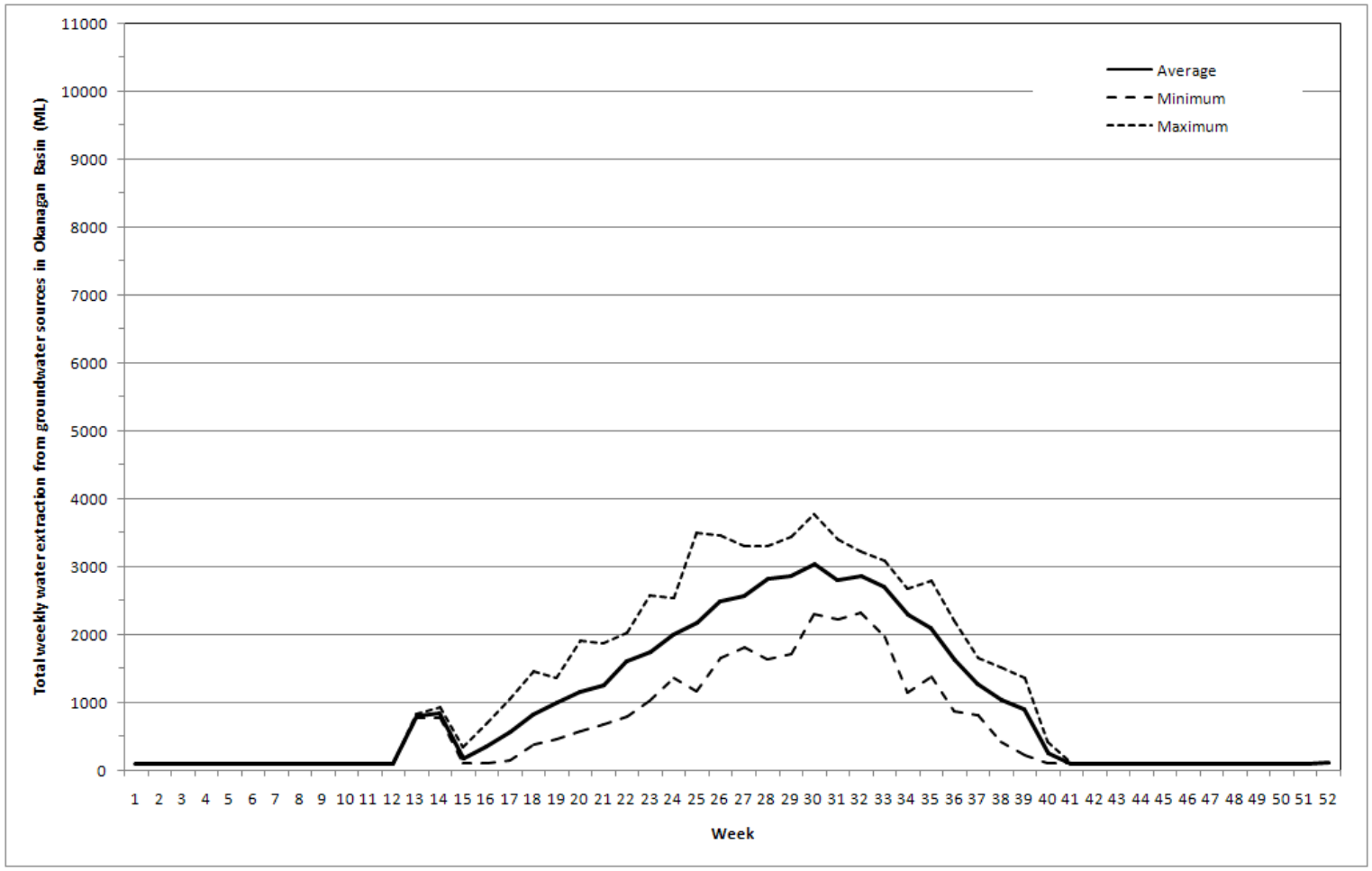
Groundwater is increasingly being used throughout the Basin. The WMU Study identified 23 water suppliers (with a total of 74 active wells) who likely extract the bulk of the groundwater in the Basin (Table 10.1). On average between 1996 and 2006, these water suppliers along with numerous private water users pumped an average of 49,000 ML of groundwater in the Basin (Table 9.1 and Figure 9.1). This represents 22% of the total water used in the Basin. Although this is significantly smaller than the surface water extraction volumes, it is becoming an increasingly important and utilized source of water.

Figure 10.1 presents the average, minimum and maximum weekly volume of groundwater pumped in the Basin. During the late fall and winter periods, when outdoor irrigation has ceased, groundwater pumping rates in the Basin is typically about 100 ML/week. However, similar to surface water extraction, in spring groundwater pumping rates increases until late July to mid August. On average, water extraction rates peak at about 3,000 ML/week, but in dry years, water extraction approach 4,000 ML/week.

Table 10.1 List of known water suppliers using groundwater in the Basin as determined in the WMU Study

Water Supplier No.	Water Supplier	No. of active wells
1	Greater Vernon Water	4
4	Black Mountain Irrigation District	2
6	District of Summerland	2
7	Glenmore Ellison Improvement District	5
9	Rutland Waterworks District	12
10	District of Lake Country	2
11	District of Peachland	3
12	Town of Oliver (total)	6
13	Southeast Kelowna Irrigation District	3
14	District of Armstrong	2
16	Town of Osoyoos (total)	6
21	Alto Utility	2
22	Okanagan Falls Irrigation District	5
24	Sunset Ranch Water Utility	2
27	Rolling Hills Waterworks District	1
31	Vaseux Lake Improvement District	1
33	Eagle Rock Waterworks District	2
34	Grandview Waterworks District	2
38	Otter Lake Waterworks District	1
42	Sun Valley Irrigation District	1
48	Penticton Indian Band	4
49	Okanagan Indian Band	6

Note: This table excludes numerous private water users that extract groundwater.



Note: Average, minimum, and maximum weekly totals over the 1996 to 2006 period are shown. Weeks 1-12 and 41-52 are periods when little to no irrigation occurs. The assumption of constant indoor water use is the reason for no variability during these weeks.

Figure 10.1 Total weekly water extraction from groundwater sources in the Okanagan Basin

11.0 RETURN FLOWS

Wastewater treatment plants (WTPs) represent the main surface component of return flows due to human activity in the Basin. The WMU Study identified 10 WTPs in the Basin, located at the major urban centres (Table 11.1). However, only four (4) of these ten (10) WTPs (City of Kelowna, City of Penticton, District of West Kelowna, and District of Summerland) discharge to surface water bodies, namely Okanagan Lake and Okanagan River. These four (4) WTPs discharge approximately 17,000 ML of effluent on average each year. Approximately 75% is discharged to Okanagan Lake while 25% is discharged to Okanagan River near Penticton.

Several water suppliers (including Greater Vernon Water, Town of Oliver, City of Armstrong, and Town of Osoyoos) are supplementing their water supply by utilizing WTP effluent for irrigation of agricultural lands. On average between 1996 and 2006, 7,000 ML of water has been "recycled" for this purpose (Table 9.1).

Table 11.1 List of wastewater treatment plants in the Basin

Water Supplier No.	Water Supplier / Municipality	Effluent discharged to:	Estimated average annual municipal wastewater treatment plant (WTP) outflow to surface water bodies (ML)
1	City of Kelowna	Okanagan Lake	10,400
2	Greater Vernon Water (City of Vernon)	Agricultural land	-
3	City of Penticton	Okanagan River	4,200
-	District of West Kelowna	Okanagan Lake	2,000
6	District of Summerland	Okanagan Lake	600
10	District of Lake Country	Groundwater	-
12	A. Town of Oliver B. Town of Oliver (rural)	Agricultural land	-
14	City of Armstrong	Agricultural land	-
16	A. Town of Osoyoos B. Town of Osoyoos (rural)	Agricultural land	-
22	Okanagan Falls Irrigation District (Okanagan Falls)	Groundwater	-
		Total	**17,200**

12.0 AQUIFER RECHARGE

Two sources of aquifer recharge were identified in the WMU Study: 1) water that enters groundwater via septic systems and 2) water that recharges groundwater as a result of over-irrigation. The latter is also known as *deep percolation*, and represents the volume of water that is not beneficially used by vegetation but rather infiltrates beyond the root zone to groundwater. Since irrigation accounts for the bulk of the water use in the Basin and since the majority of the population is serviced by sanitary sewer systems rather than septic systems, deep percolation was considered the dominant source of aquifer recharge associated with humans and therefore the main focus of the investigation of human-influenced aquifer recharge. In the supply and demand models used in Phase 2, aquifer recharge is denoted by the symbol R_H.

Deep percolation was estimated using the Okanagan Water Demand Model, which considers soil texture, maximum soil water depth (which in turn depends on the crop rooting depth, soil water carrying capacity and an availability coefficient representing the crop's ability to extract water from the soil), and type of irrigation system used. Within the model, parameters that reflect irrigation management practices, which vary from "poor" to "good", were assumed to be "average". On average over the 1996 to 2006 period, aquifer recharge due to deep percolation is estimated to be 25,000 ML (Table 12.1).

A preliminary estimate of aquifer recharge as a result of septic systems was developed in the original WMU Study, but only for 2006. In that study the number of residential properties not serviced by sanitary sewer systems was identified, and a rate of wastewater production of 250 L/person/day was assumed. As a result, in 2006 aquifer recharge due to septic systems was estimated at about 10,000 ML. However, given the assumptions and preliminary nature of this estimate, aquifer recharge due to septic systems is not currently included in the R_H term.

Table 12.1 Total annual aquifer recharge in the Basin as a result of deep percolation

Year	Total annual aquifer recharge as a result of deep percolation (ML)
1996	22,452
1997	21,258
1998	28,809
1999	22,959
2000	23,884
2001	24,924
2002	24,898
2003	28,687
2004	25,878
2005	25,977
2006	27,118
Average	**25,168**
Minimum	21,258
Maximum	28,809

Note: These values exclude aquifer recharge as a result of septic systems.

13.0 CONCLUSIONS

As a result of the WMU Study and follow-up work program, comprehensive information on current (1996-2006) water use and management patterns in the Okanagan Basin is now available. The following outlines the key findings of this work:

- There are 101 known water suppliers in the Basin that supply approximately 82% of the total water used in the Basin.
- There are currently over 4,000 active water licences to store or use surface water in the Basin.
- In total, 443,000 ML of surface water is allocated annually for offstream use and 350,642 ML is allocated for in-stream (conservation) use and other non-consumptive uses.
- Approximately 163,000 ML of licensed storage supports some of the water uses.

- About 95% of the total volume of water licensed for offstream use is held by 57 of the main water suppliers in the Basin. These same suppliers hold 88% of the licensed storage in the Basin.
- There are 36 large upland reservoirs in the Basin with a total developed storage capacity of 133,000 ML.
- There are eight (8) water suppliers that import water from outside the Basin or divert water between sub-basins to supplement existing water supplies.
- The 1996-2006 average annual volume of water imported from outside the Okanagan Basin is 17,000 ML. This represents about 8% of the total water used in the Basin. Most of this water is routed directly to water supplier distribution systems or reservoirs.
- The 1996-2006 average annual volume of water extracted, imported and recycled in the Basin is 219,000 ML.
- Water used in the Basin is derived from several sources, in the following proportions:
    - Surface water sources: 67%
    - Groundwater: 22%
    - Imported water: 8%
    - Recycled wastewater: 3%
- Amongst the surface water sources, the three (most) utilized are:
    - Okanagan Lake
    - Mission Creek
    - Kalamalka – Wood Lake
- Groundwater is becoming an increasingly utilized source of water. There are currently 23 main water suppliers and numerous private users that pump groundwater in the Basin.
- Of the total water that is extracted, imported or recycled in the Basin, the proportions used by each end-use category is as follows:
    - Agriculture: 55%
    - Golf courses: 5%

  - Parks and open spaces: 2%
  - Domestic indoor: 7%
  - Domestic outdoor: 24%
  - Institutional: 1%
  - Commercial: 4%
  - Industrial: 2%
- Outdoor basin wide irrigation areas and requirements (including losses) are as follows:
  - Agriculture: 18,300 ha require an average of 120,000 ML (660 mm),
  - Golf courses: 1,060 ha require an average of 10,000 ML (960 mm),
  - Parks and open spaces: 590 ha require an average of 5,000 ML (920 mm)
  - Domestic outdoor: 5,935 ha require an average of 53,000 ML (890 mm)
- Total annual irrigation requirements for 1996-2006 average 188,000 ML or 86% of the total water use in the Basin.
- Between 1996 and 2006, combined indoor and outdoor domestic use averaged 675 L/person/day. An estimated 78% of this water use was for outdoor uses, while 22% was for indoor uses.
- Approximately 5,000 industrial, commercial and institutional connections were identified, which use an estimated 15,000 ML per year on average. This represents about 7% of the total Basin water use.
- Between all end-uses, approximately 51,000 ML or 23% of all water extracted, imported or recycled in the Basin is lost or unaccounted for. The majority of this is associated with over-irrigation resulting in deep percolation or water below the root zone.
- The surface component of return flows (i.e. from wastewater treatment plants) accounts for 17,200 ML or 8% of the total water used annually in the Basin.
- About 25,000 ML or 11% of all water used in the Basin recharges aquifers as a result of losses by deep percolation. Preliminary estimates suggest an additional 10,000 ML may also be recharging aquifers through septic systems.

14.0 REFERENCES

Consultative Board. 1974. Main report of the Consultative Board (including Comprehensive Framework Plan). Prepared under the Okanagan Basin Agreement. March 1974.

Dobson Engineering Ltd. 2008. Water Management and Use Study: Phase 2 Okanagan Water Supply and Demand Project. Report prepared for the Okanagan Basin Water Board. December 2008.

Golder Associates and Summit Environmental Consultants Ltd. (Golder and Summit). 2009. Phase 2 Okanagan Water Supply and Demand Project: Groundwater Objectives 2 and 3 Basin Study. Prepared for the Okanagan Basin Water Board.

Miles, J. 2009. Residential, Commercial, Industrial, and Institutional Actual Water Use in Vernon and Kelowna. A Report Prepared for the OBWB. April 29, 2009.

Summit Environmental Consultants Ltd. (Summit). 2005. Okanagan Basin Water Supply and Demand Study: Phase 1. Report prepared for Land and Water B.C. Inc. May 2005.