PART FOUR – SCENARIOS

Part Four summarizes the initial application of the Phase 2 models (OWDM, OBHM, and OBWAM) using 15 future scenarios. It summarizes the rationale for selection of these 15 scenarios, the work done to prepare the models for running scenarios, the scenario running process, the outputs of scenario runs, and the interpretation of scenario results.

17.0 SCENARIO SELECTION

One of the strengths of the Phase 2 models is that they can be used to examine alternative water scenarios. In Phase 2, only 15 of a very large number of possible future scenarios were examined. These particular scenarios were selected to demonstrate the power and utility of the models.

The 15 scenarios were selected to focus on the key factors that could affect water resources in the Okanagan in the future:

- Changes in climate;
- Changes in forest cover as a result of mountain pine beetle, wildfire, and forest harvesting;
- Changes in water use efficiency;
- Changes in the amount of agricultural land under irrigation; and
- Changes in population.

One of the most important drivers for the Okanagan Water Demand Model and the Okanagan Basin Hydrology Model is the climate dataset. As noted above, 12 different future climate datasets are available for the Okanagan. The Phase 2 Working Group selected one of these to run all 15 scenarios - the CGCM2 Model, using the A2 emission scenario. This is not necessarily the “best” climate dataset; rather it is one of several potentially realistic climate datasets.

Only one Mountain Pine Beetle scenario was evaluated: the expected progression of the pine beetle epidemic based on information and models obtained from the Province of B.C. Two possible rates of population growth were modelled: the expected rate and a high rate. The expected rate was based on provincial government estimates for the three Okanagan Regional Districts, and the actual growth rates from 2001 to 2006 in the major urban centres. The high growth rate was assumed to be 2.5% per year. Two possible future agricultural conditions were evaluated: the current amount of land under irrigation, and a larger area comprised of all reasonably irrigable land. Two possible trends in water use efficiency were studied: current trends[9], and a new trend represented by the Provincial Living Water Smart guideline of achieving 33% efficiency improvements by 2020.

Finally, recognizing the historic significance of the 1929-1931 drought sequence in the Okanagan, data were 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.

A summary of the 15 scenarios is presented in Table 17.1. Scenarios 1-4 were run for the 2011-2040 period using the future climate data with the expected CO_2 emissions, the expected progression of the Mountain Pine Beetle infestation, and current trends of gradually reducing per capita water consumption. Using these conditions as a base, these scenarios examine the impacts of increased water usage due to increasing the population growth rate, and expanding the agricultural land base to all reasonably irrigable lands.

Scenarios 5-8 were run for the 2011-2040 period using the future climate data with the expected CO_2 emissions, expected progression of Mountain Pine Beetle infestation, and an accelerated implementation of water efficiency measures with 33% efficiency achieved by 2020. Using these conditions as a base, these scenarios examine the impacts of increased water usage due to increasing the population growth rate, and expanding the agricultural land base to all reasonably irrigable lands.

Scenarios 17-20 were run for the 3-year drought period using the future climate data with the expected CO_2 emissions, expected progression of Mountain Pine Beetle infestation, and current trends of gradually reducing per capita water consumption. Using these conditions as a base, these scenarios examine the impacts of increased water usage due to increasing the population growth rate, and expanding the agricultural land base to all reasonably irrigable lands.

Scenario 25 was run for the 2011-2040 period using the future climate data with the expected CO_2 emissions, expected progression of Mountain Pine Beetle infestation, present conditions of water consumption, present conditions of irrigation, and the present population. This scenario was used to isolate the impacts of climate change between the baseline condition and the 2011-2040 period.

[9] The assumed current trend is a 33% efficiency improvement between 2011 and 2040, or 1.1% per year over that period.

Scenario 26 is the same as scenario 25, except that the time period covers 2041-2070. This scenario was used to compare the impacts of climate change between the 2011-2040 period and the 2041-2070 period.

Scenario 27 was run for the 3-year drought period with expected CO_2 emissions, present levels of Mountain Pine Beetle infestation, present conditions of water consumption, present conditions of irrigation, and present population.

To evaluate the impacts of future climate change against historical conditions, it was necessary to run the OBWAM for the 1996-2006 period using climate data generated by the same model that was used to generate the future climate data. This provided a consistent baseline set of modelling results, which are referred to herein as the Baseline condition.

Several steps were necessary to facilitate the modelling of future scenarios in the three models (OWDM, OBHM, and OBWAM). Details on how drivers such as future population growth, water use efficiency, and agricultural land base expansion were addressed in the OWDM are provided in Appendix O. Details on how the OBHM and OBWAM were modified to account for future changes in climate, changes in land cover (e.g., disturbance by mountain pine beetle), and changes to water management are provided in Section 4.2 of Appendix J.

Table 17.1 Phase 2 scenario names and acronyms

Scenario number	Time Period	CO_2 Emission scenario	Mountain Pine Beetle	Efficiency	Agricultural Land Base	Population growth	Description	Acronym
1	2011-2040	Expected	Expected	Current use patterns and current trends	Present conditions	Expected rate	2011-2040 - current trends continued	T1C1M1E1A1P1
2	2011-2040	Expected	Expected	Current use patterns and current trends	Present conditions	High rate	2011-2040 - current trends, except rapid population growth	T1C1M1E1A1P2
3	2011-2040	Expected	Expected	Current use patterns and current trends	Irrigate all	Expected rate	2011-2040 - current trends except expanded agriculture	T1C1M1E1A2P1
4	2011-2040	Expected	Expected	Current use patterns and current trends	Irrigate all	High rate	2011-2040 - current trends except rapid population growth and expanded agriculture	T1C1M1E1A2P2
5	2011-2040	Expected	Expected	33% Efficiency	Present conditions	Expected rate	2011-2040 - efficient water use, otherwise current trends continued	T1C1M1E2A1P1
6	2011-2040	Expected	Expected	33% Efficiency	Present conditions	High rate	2011-2040 - efficient water use, rapid population growth, otherwise current trends	T1C1M1E2A1P2
7	2011-2040	Expected	Expected	33% Efficiency	Irrigate all	Expected rate	2011-2040 - efficient water use, expanded agriculture, otherwise current trends	T1C1M1E2A2P1
8	2011-2040	Expected	Expected	33% Efficiency	Irrigate all	High rate	2011-2040 - efficient water use, rapid population growth, expanded agriculture, expected climate and pattern of MPB	T1C1M1E2A2P2
17	3 driest years 2011-2100	Expected	Expected	Current use patterns and current trends	Present conditions	Expected rate	3 successive drought years - current trends continued	T2C1M1E1A1P1
18	3 driest years 2011-2100	Expected	Expected	Current use patterns and current trends	Present conditions	High rate	3 successive drought years - current trends, except rapid population growth	T2C1M1E1A1P2
19	3 driest years 2011-2100	Expected	Expected	Current use patterns and current trends	Irrigate all	Expected rate	3 successive drought years - current trends except expanded agriculture	T2C1M1E1A2P1
20	3 driest years 2011-2100	Expected	Expected	Current use patterns and current trends	Irrigate all	High rate	3 successive drought years - current trends except rapid population growth and expanded agriculture	T2C1M1E1A2P2
25	2011-2040	Expected	Expected	Present conditions	Present conditions	Present conditions	2011-2040 - effect of climate change alone	T1C1M1E3A3P3
26	2041-2070	Expected	Expected	Present conditions	Present conditions	Present conditions	2041-2070 - effect of climate change alone	T3C1M1E3A3P3
27	3 driest years 2011-2100	Expected	Present	Present conditions	Present conditions	Present conditions	3 successive drought years starting 2011	T2C1M2E3A3P3

Notes:

3 driest years 2010-2100 occur in 2076, 2033, 2026

CO_2 emissions: 1. Expected = CGCM2 A2

MPB: 1. Expected: Expected pattern of current MPB infestation and associated vegetation changes
2. Present conditions (assume 2011, 2012, 2013)

Efficiency: 1. Current use patterns and current trends: Based on current use patterns and current trends in efficiencies (both irrigation and non-irrigation water uses); irrigation demand driven by climate
2. 33% Efficiency improvement in all water use by 2020, no reductions past 2020 (per LWS plan); irrigation demand driven by climate

Ag Land Base 1. Present conditions: current crops and systems
2. Irrigate all: Irrigation of all reasonable possible irrigable land

Population growth 1. Expected rate
2. High rate

Assumptions: For MPB, Efficiency and Population growth:
3 driest years 2011-2100 (scenarios #17-20) - assume 2038-2040

18.0 SCENARIO RESULTS

Scenario results are presented in three parts: the first part illustrates the expected climate change impacts on Basin hydrology; the second part illustrates how water use is expected to change under the selected scenarios; and the third part identifies how changing water use can affect Basin hydrology. To simplify the evaluation of the consequences of the scenarios this Summary Report focusses on the identification and interpretation of long-term trends in the results rather than evaluating specific results at particular locations and times.

Climate Change Impacts on Basin Hydrology

Average precipitation and evapotranspiration in the Basin are not likely to change appreciably over the long term. However, maximum temperature, minimum temperature, and average temperature will likely increase over the long term. The maximum amount of water held in the upper elevation snowpack in winter will likely decline over time and the date that the snowpack reaches its maximum extent will likely become earlier (Figure 18.1). As a result, snowmelt runoff will likely peak earlier in spring, and the spring snowmelt process will likely provide a smaller amount of runoff.

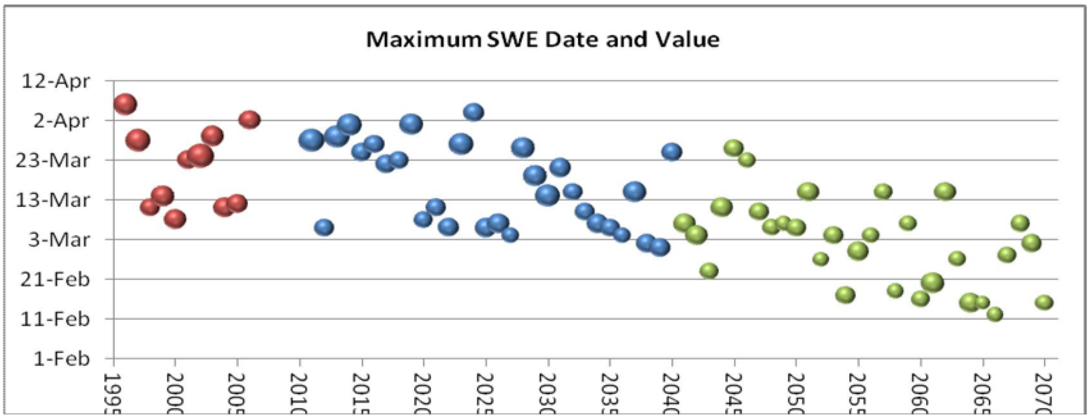

Figure 18.1 Maximum snow water equivalent (SWE) value and date of occurrence.

In Figure 18.1, the size of the bubbles indicates the relative value of the annual maximum snow water equivalent (SWE); the red bubbles represent the baseline condition (1996-2006), the blue bubbles represent the 2011-2040 scenario, and the green bubbles represent the 2041-2070 scenario.

Although there is likely to be little change in the annual total net inflow to Okanagan Lake, the scenario modelling suggests a clear shift in the timing and magnitude of the inflows to Okanagan Lake over time, as described below (Figure 18.2):

- Warmer winter temperatures will likely result in more winter precipitation in the form of rain, resulting in increased inflow during winter.
- In the spring, peak inflows will likely occur earlier and the magnitude of the peak inflow will be reduced, as a result of less snow accumulation during winter.
- The summer low flow period will likely increase in duration over the long-term.

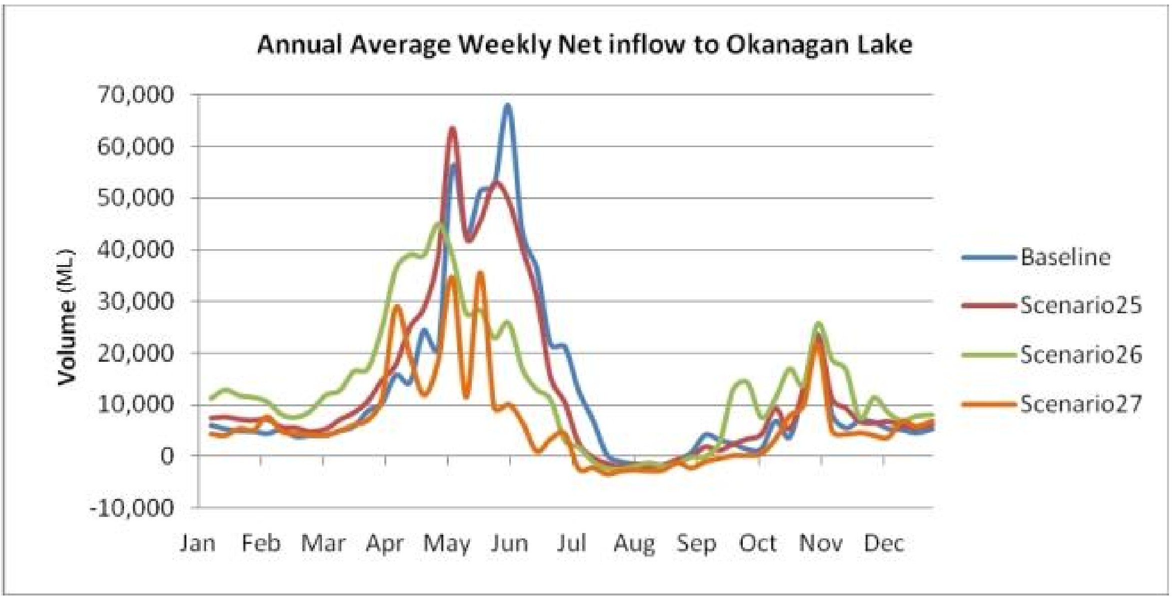

Figure 18.2 Average weekly net inflows to Okanagan Lake for the baseline condition (1996-2006) and the three scenarios that isolate the effect of climate change.

Over the long-term, Okanagan Lake will likely still operate within the 'normal' range of lake levels, but it will likely operate near or below the 'normal' range during conditions represented by the scenario 27 (Figure 18.3).

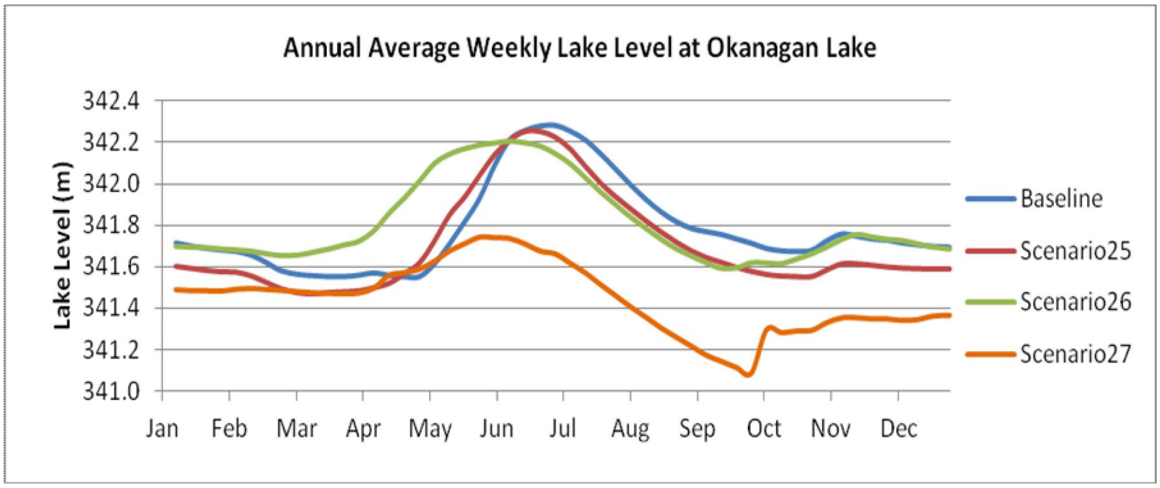

Figure 18.3 Average weekly Okanagan Lake levels for several scenarios.

In general, all of the tributaries examined in detail (e.g. Mission Creek, Figure 18.4) and the Okanagan River exhibit the same response to climate change as described above; i.e., higher flows throughout the winter months, due to warmer conditions resulting in rainfall-generated runoff; an earlier start to the spring snowmelt runoff, likely due to an earlier onset of warm spring temperatures; and a lower peak flow during the spring snowmelt runoff, likely due to less snow accumulation over winter.

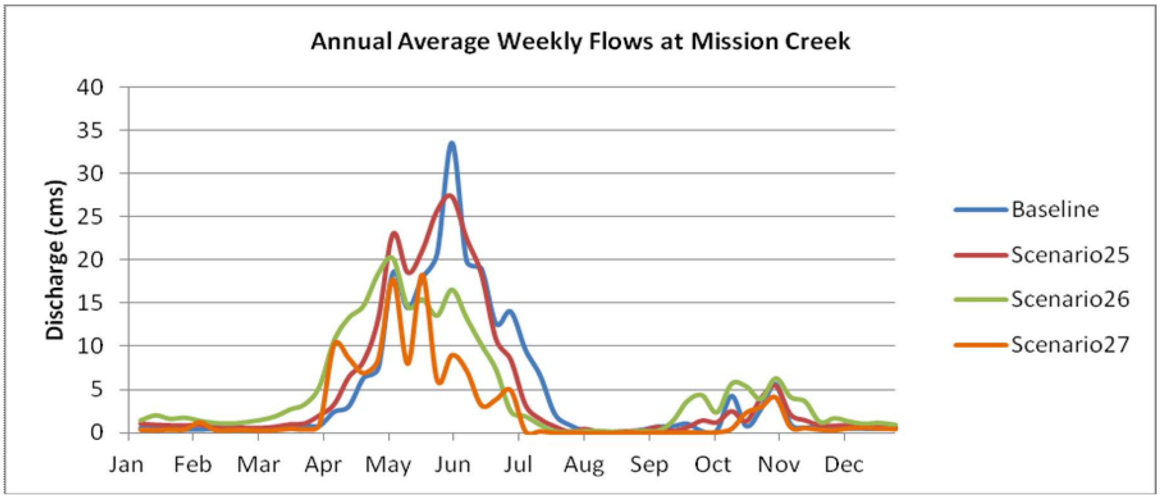

Figure 18.4 Average weekly Mission Creek flows for several scenarios.

Future trends in upland reservoir storage (Figure 18.5) show a similar response to climate change as those noted above:

- Earlier increases in water stored, likely due to an earlier onset of spring temperatures;
- Lower peak storage, likely due to lower snow accumulation;
- Earlier drawdown of storage, likely due to smaller spring snowmelt runoff volumes; and
- Significantly less stored water available in the late summer due to a longer summer season.

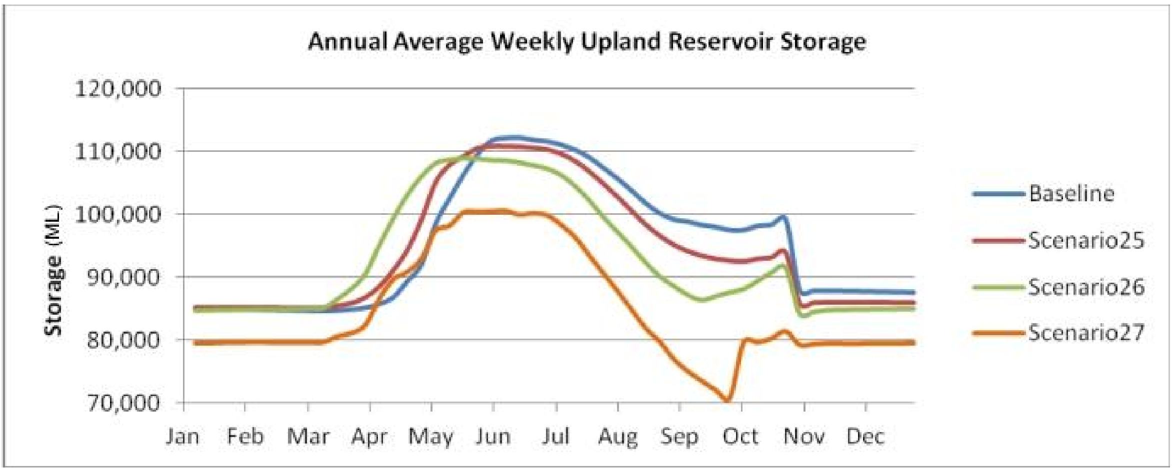

Figure 18.5 Average total weekly storage in upland reservoirs for several scenarios.

Future Water Use Changes

Future water use under each of the 15 scenarios, as estimated by the Okanagan Water Demand Model, is summarized in Figure 18.6. The key findings are as follows:

- If we assume that only climate changes and everything else (population, land use, amount and type of irrigated area, and water use efficiency) remains the same as it is currently, total water use is expected to increase by 10% for the 2011-2040 period and 17% for the 2041-2070 period relative to the present (i.e. scenarios 25 and 26 relative to the baseline condition (1996-2006).

- If we assume that the population grows as expected, and assume that water use efficiencies continue to improve at present rates, the average water use over the 2011 – 2040 period will be 4% less than it is today (i.e. scenario 1 relative to scenario 25). But if the population grows faster than the estimated rate, with present rates of improvements in water use efficiency, total water use will be roughly the same as it is currently (i.e. scenario 2 relative to scenario 25).

- If all reasonably possible agricultural land becomes irrigated, over the 2011-2041 period, annual water use will be 13% higher than it is currently (i.e. both scenario 3 relative to scenario 1 and scenario 4 relative to scenario 2).

- Assuming accelerated implementation of water efficiency measures with 33% efficiency achieved by 2020, water use is expected to decrease by 6-7% (i.e. scenario 5 relative to scenario 1; scenario 6 relative to scenario 2; scenario 7 relative to scenario 3, and scenario 8 relative to scenario 4).

- Under the modelled drought conditions, climate change alone is expected to increase water demands by 16% relative to the present (scenario 27 relative to the baseline condition). However, the effect of population growth alone during drought conditions will likely be outweighed by improved efficiencies (at the present rate of improvement) (scenario 17 relative to scenario 27 and scenario 18 relative to scenario 27). Expansion of the irrigated agricultural land base is however expected to result in a 25% increase in water use during drought conditions (i.e. scenario 19 relative to scenario 17 and scenario 20 relative to scenario 18).

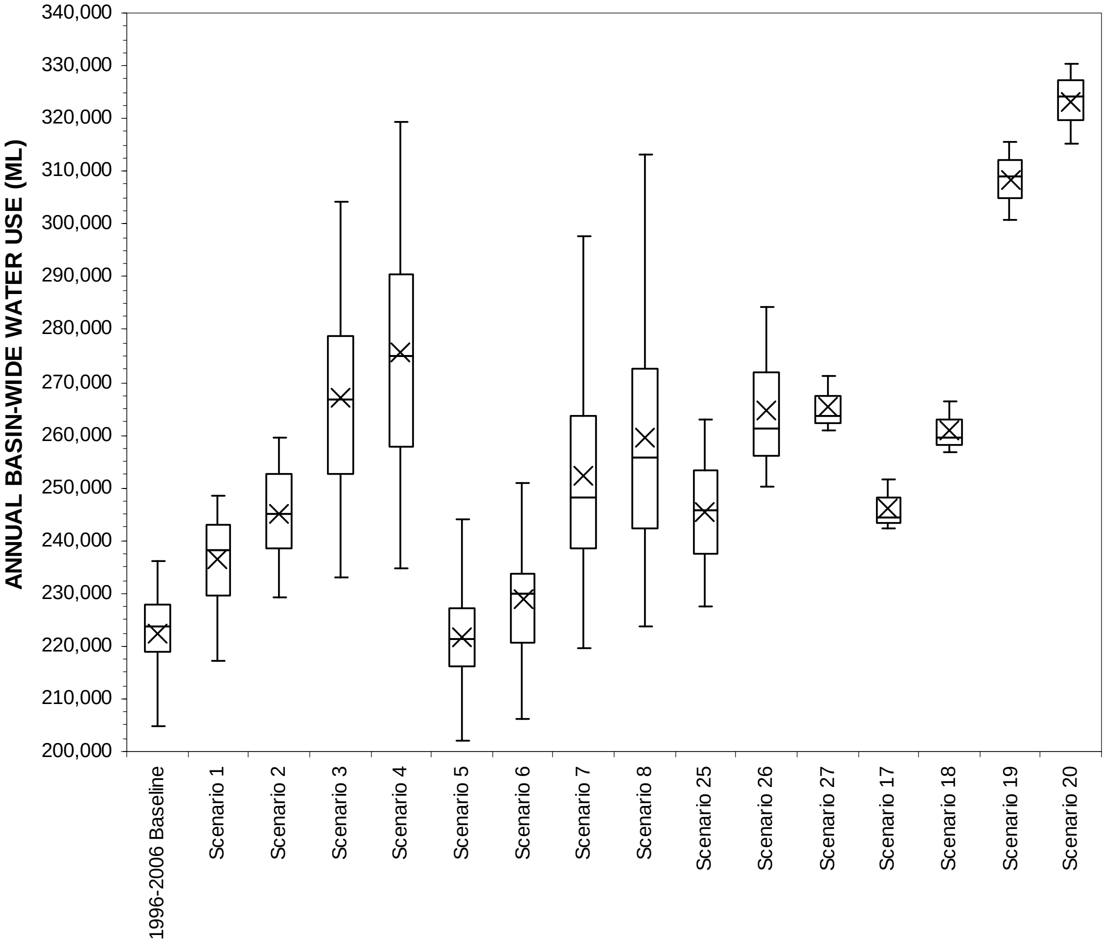

Figure 18.6 Box plot summarizing annual Basin-wide water use under the 15 scenarios.

The upper, middle and lower horizontal lines on each box on Figure 18.6 indicate the 75th percentile, the median, and the 25th percentile, respectively. The "X" indicates the average value over the simulation period, and the upper and lower "whiskers" indicate the maximum and minimum value under each scenario. Note that scenarios 27 and 17-20 are based on only three years.

Water Use Impacts on Basin Hydrology

The effects of the different combinations of future water use on Basin hydrology were examined by comparing the relative difference in model results between scenarios 1-8 relative to scenario 25. The key results are outlined here.

Water use efficiency measures will not have a significant impact on the annual net inflows to Okanagan Lake (Figure 18.7). There is sufficient water supply on an annual basis in the Basin to meet water demands now and well into the future. Although this seems like good news, it is not the whole story because the problems with water supply occur mostly during the summer when the supply is low and the demand is high. It is important to focus only on the trends in Figure 18.7, not on results for particular years, as the models cannot make predictions for specific years.

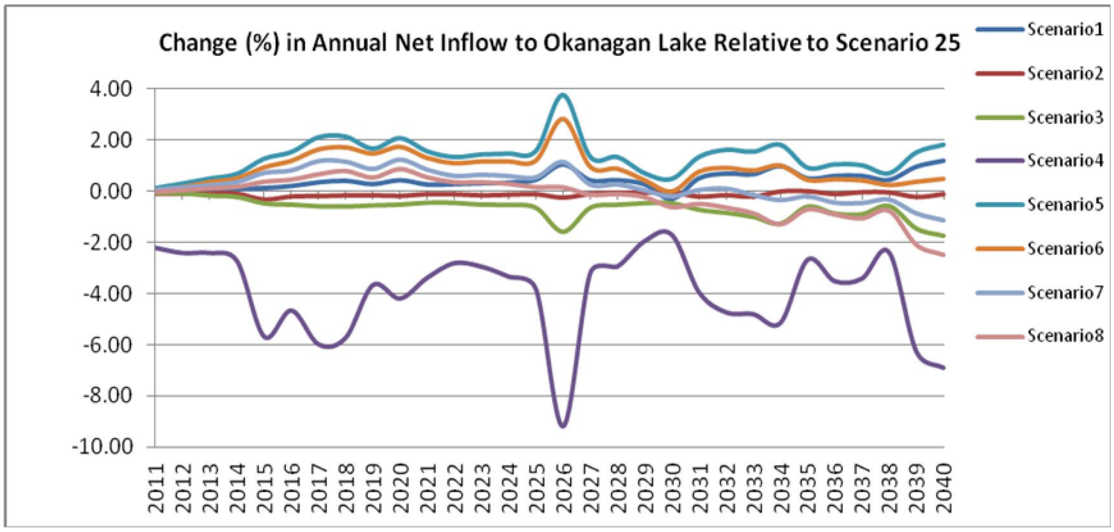

Figure 18.7 Change in annual net inflow to Okanagan Lake relative to scenario 25.

Water use has a much more significant impact on net inflows to Okanagan Lake during the summer months (i.e. June to September) when the natural runoff is usually low and demand is relatively high (Figure 18.8). For example, during the dry period from 2015-2018, the accelerated water use efficiency measures in scenario 8 will require 20% less of the available net inflow to Okanagan Lake than the worst case represented by scenario 4. As for Figure 18.7, Figure 18.8 cannot be used to infer that this specific four year period (2015-2018) will be dry - rather that there could be a similar four-year dry period sometime in the future.

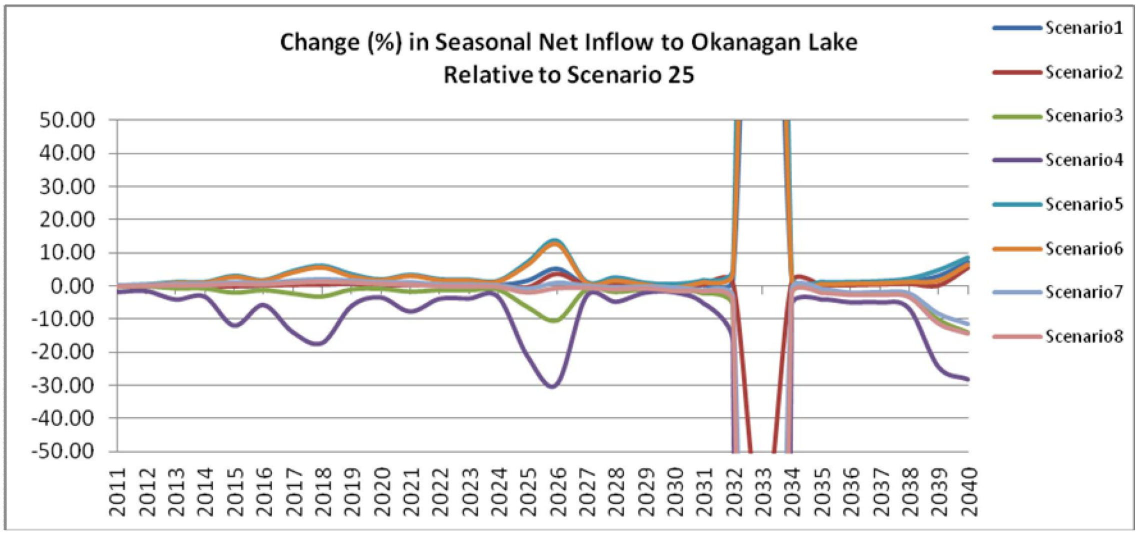

Figure 18.8 Change in seasonal (June – September) net inflow to Okanagan Lake relative to scenario 25.

As with inflows to Okanagan Lake, water use impacts on tributary streams are minimal on an annual basis, but can be significant on a seasonal basis and during periods of drought. For example, on Mission Creek (Figure 18.9) accelerated water use efficiency measures can have a positive impact (up to 25%) on summer flows.

As discussed previously, the flows in the tributaries will likely begin declining earlier in the year, and the withdrawals for human use will be significant relative to the available streamflow for longer periods of the summer. As such, even moderate reductions in water withdrawals will likely make a significant difference in either the available flows in the tributaries, or the amount of water required to be released from the upland reservoirs.

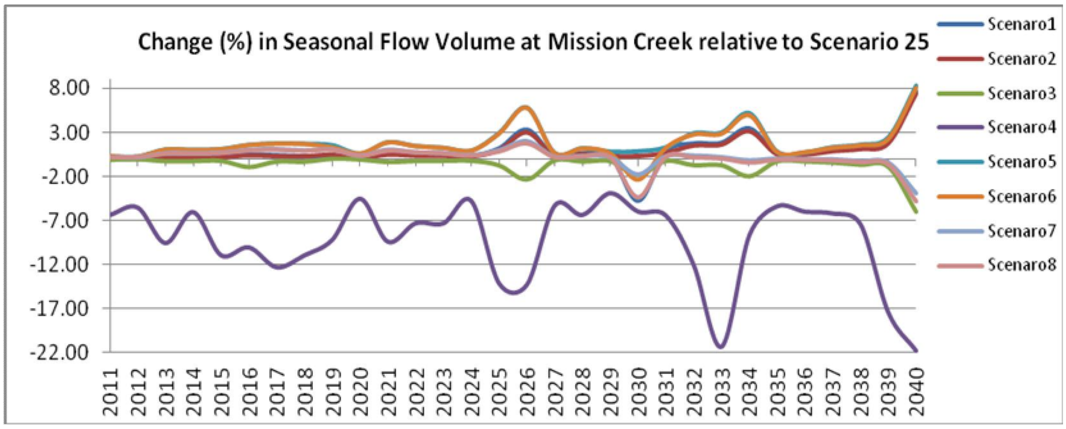

Figure 18.9 Change in average seasonal (June - September) flow in Mission Creek relative to scenario 25.