FINAL REPORT

TREPANIER LANDSCAPE UNIT WATER MANAGEMENT PLAN

VOLUME 1: TEXT

Prepared for:

Regional District of Central Okanagan
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Project 571-02.01

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Ms. Leah Hartley, M.C.I.P.
Planner
Regional District of Central Okanagan
1450 K.L.O. Road
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Dear Ms. Hartley:

Re: Final Report: Trepanier Landscape Unit Water Management Plan

Summit Environmental Consultants Ltd. (Summit) is pleased to provide you with a final report of the Trepanier Landscape Unit (TLU) water management plan. The report concludes that with the expected influences of climate change and population growth, changes to water management in the TLU will be needed in the near future to sustain economic growth and maintain environmental quality. The report provides several recommendations for improved water management in the TLU.

Please call me at (250) 545-3672 if you have any further questions or comments on the report.

Yours truly,

Summit Environmental Consultants Ltd.

Brian T. Guy, Ph.D., P.Geo., P.H.
Senior Geoscientist
President

Attachments: Final Report

EXECUTIVE SUMMARY

Introduction and objectives:

The Trepanier Landscape Unit (TLU) water management plan was initiated by the B.C. Ministry of Sustainable Resource Management (MSRM) and the Regional District of Central Okanagan (RDCO). The Trepanier area was chosen because it is known to be relatively dry with a range of water users and growing pressures on the water resource. The objectives of the project were to conduct technical analyses and provide both practical tools and strategic direction to provincial and local planning agencies to incorporate sound water management decisions into land-use planning within the TLU. In particular, RDCO will be able to incorporate technical recommendations into Official Community Plans and servicing policies that will in turn guide land use decisions. The ability of MSRM to implement the objectives and strategies of the Okanagan-Shuswap Land and Resource Management Plan (LRMP) in the TLU will be increased, and MSRM will be able to identify water-related economic constraints and opportunities in the TLU.

Overview:

The study included analysis of current water conditions in the TLU, and of conditions expected in 2020 and 2050. The analyses of current conditions required significantly more effort than was originally envisioned, because of the state of the available information. This report makes several recommendations to address data shortcomings for planning purposes. Analyses of conditions in 2020 and 2050 were based on trends in population as well as the predicted effects of climate change. <u>The analyses conclude that expansion of water supply from streams, unless supported by storage, is not environmentally sustainable, nor does it permit population and economic growth to occur as planned. Failure to reduce rates of water use or seek alternative water sources will either constrain economic growth or impair environmental resource values, or both.</u> The report makes several detailed recommendations for improved water management in the TLU, including creation of a leadership group that will champion the cause of improved water management and encourage adoption and implementation of the recommendations.

The study was led by a Steering Committee comprised of MSRM, RDCO, Land and Water B.C. (LWBC) and the Ministry of Water, Land, and Air Protection (MWLAP). Technical advice was provided by a “Technical Advisory Working Group” (referred to in the report as the TAWG). The main report (Volumes 1 and 2) provides details of the technical studies and of several recommendations for improved water management. This Executive Summary highlights the key points. Technical terms are defined in a Glossary at the end of the main report (Volume 1).

Population and land use:

The TLU covers 990 km^2 (Figure 1), including five major watersheds on the west side of Okanagan Lake (Lambly, McDougall, Powers, Trepanier, and Peachland Creeks). Land use includes forestry, mining, agriculture (range, vineyards, orchards, pasture, and crops), recreation, and urban (commercial, industrial, and residential). The bulk of the land base is managed by the provincial crown. Private lands include one small municipality (Peachland), a First Nation community (Westbank I.R. #9 and I.R. #10), and the largest rural unincorporated area in B.C. Commercial and industrial operations include a nursery, two wineries, retail malls, an industrial park, several aggregate operations, and many small businesses. There are 982 ha of intensive agriculture in the TLU, much of which is irrigated. The population has doubled in the past 20 years to 36,366, and is expected to increase by 65% in the next 20 years.

Climate, surface water hydrology, and groundwater hydrology:
The area is relatively dry, with annual precipitation (total of rain and snow) averaging about 600 mm. Flows in the creeks rise in the spring as the winter snowpack melts, then decrease over summer to reach low levels in late summer, and flows stay low through the fall and winter. Streamflows are highly variable from year to year – the driest year in an average five-year period has only two-thirds of the runoff of an average year.

Flows in all five principal streams in the TLU have been altered by human intervention – largely by the construction and operation of reservoirs to regulate flow for water supply purposes. In this report, we have utilized estimates of "naturalized" flows at 14 locations (Figure 2) in the TLU (a "naturalized" flow is an estimate of a natural flow, i.e. of a flow that would exist if storage reservoirs didn't capture any water and water intakes did not operate). On an annual basis, current average annual flows (referred to in the report as "net" flows) at the mouths of the major creeks are 13% smaller than the "naturalized" flows, due to water removals for offstream use, as shown in Table 1. Offstream use means that the water is removed from a stream for human use. Although current flows are only 13% smaller than naturalized flows, water licences for offstream use that are already issued account for (on average) 28% of the naturalized flow in the TLU, as shown in Table 2. The amount of offstream use that is supported by storage varies widely, as shown in Table 2.

There is very little information on groundwater conditions or use in the TLU. Six large aquifers have been identified, all located in the vicinity of Westbank. There are likely additional, smaller aquifers in the upland area of the TLU that have not yet been identified. Detailed assessments of aquifer size and extent, aquifer yield and aquifer use are not possible due to a lack of basic hydrogeological information. Maximum groundwater extraction rates in the TLU are currently estimated at 400 L/s (i.e. 0.4 m^3/s, or 12.6 million m^3 per year), which is approximately equal to the estimated average annual recharge rate from precipitation. There is likely additional room to develop groundwater resources.

Water supply systems, water use, and water pricing:
Water service delivery is managed by four major utilities (Westbank and Lakeview Irrigation Districts, Peachland, and Westbank First Nation), and 16 small utilities (Figure 3). Water licences have been issued for the withdrawal of 53.674 million m^3 per year from 184 streams and waterbodies in the TLU (including Okanagan Lake). Actual annual offstream water use is estimated to be 24.554 million m^3 (i.e. about 46% of the licensed amount). Storage licences have been issued for 36.098 million m^3, of which 28.950 million m^3 is actually utilized. Two-thirds of the water used in the TLU is obtained from surface streams, of which 90% is obtained from the five major streams. Approximately 30% of the total water used is pumped from Okanagan Lake, and the remaining 4% is obtained from groundwater wells.

The residential water use rate in the TLU is 789 litres per person per day (year-round average), which is very high - more than double the Canadian average, and almost double the B.C.

average. In Kelowna and Vernon, water use rates are 550 to 600 L per person per day – above the B.C. average but 30% less than in the TLU. Prior to implementation of demand management measures, use rates in Kelowna and Vernon were similar to those in the TLU. Approximately 41% of the total water used in the TLU is used for residential purposes, 20% is used for commercial/industrial purposes, and 34% is used for agriculture (including golf courses). The final 5% is accounted for by distribution system losses.

A variety of water pricing systems is in use in the TLU, but the flat rate system is by far the most common. Very few residential, commercial or agricultural users are connected to water meters. Without meters, volume-based billing cannot be applied, and economic tools to encourage conservation are unavailable. TLU residents pay only about \$0.25 per m^3 for water, which is less than half the B.C. average (which is about \$0.63 per m^3) and much less than the Canadian average (which is about \$0.93 per m^3). Similarly, commercial, industrial, and agricultural water users in the TLU pay relatively low prices for water.

Water quality and fisheries resources:
Water quality in the streams in the TLU is influenced by a number of natural and human-caused processes. Land use effects on water quality include urban development, agriculture, forestry, mining, recreation, and tourism. A number of measures have been implemented by RDCO to reduce impacts from existing urban areas and to avoid water quality effects from development. Range activity on Crown Land can result in damage to riparian areas and stream banks, and introduction of pathogens to the water supply. Few issues have been identified with forest practices, and water quality protection is an integral part of forest development planning in the TLU. Water quality concerns over recreation include existing development and the potential for increased development on upland reservoirs, and erosion from ATV traffic.

Water quality data are available through the provincial Environmental Management System (EMS) database for sites within the Lambly Creek (6 locations), Peachland Creek (6 locations), Trepanier Creek (6 locations including McDonald Creek), Powers Creek (3 locations), and McDougall Creek (2 locations) watersheds. Other data not in the EMS is available from water purveyors and others. Provisional Water Quality Objectives were set for Trepanier and Peachland Creeks in 1992. MWLAP is currently revising and/or developing new Water Quality Objectives for Lambly, Peachland, Trepanier, and Powers Creeks based on monitoring conducted between 1996 and 2000, with the reports expected in spring 2004.

In general, water in TLU streams can be characterized as having neutral to alkaline pH with moderate concentrations of dissolved solids. All of the major streams that serve as sources of domestic and irrigation water occasionally have turbidity, coliform bacteria, and true colour concentrations that do not meet the B.C. water quality guidelines for raw water, and thus require treatment. The causes of the above-guideline concentrations of these variables include both natural factors and land use effects. Boil water advisories have occasionally been implemented to address risks from bacteria. Noranda continues to treat the discharge from the Brenda Mine site under permit from MWLAP and monitors for molybdenum, copper, and other parameters. By far the majority of sampling results are within guidelines/objectives, however, exceedances for molybdenum and copper have occurred on occasion in Trepanier and Peachland Creeks.

Preliminary analyses of the EMS datasets indicate changes in the concentrations of some water quality variables as the streams flow through urbanized areas.

Streams in the TLU support a variety of fish species, including rainbow trout and kokanee salmon. Fish populations have faced pressures in recent decades due to flow withdrawals from tributaries and habitat impacts, particularly in the lower reaches of TLU creeks below the intakes of the major municipal water purveyors. Instream water uses (e.g. water required for fish) are in general not protected by water licences. Instead, efforts have been made to negotiate "conservation" flows in the major streams of the TLU. The conservation flows that have been proposed are based on a percentage of the mean annual discharge, with the percentage changing each month. In many stream reaches these flows will produce optimal flows for fish as opposed to minimum flows. In a year with average runoff, the proposed conservation flows are close to the naturalized flows during the low-flow months. In drier than average years, conservation flows exceed naturalized flows, suggesting that conservation flows may be set too high. However, even in an average runoff year, water withdrawals for offstream use leave insufficient water behind in some months to satisfy conservation flows. Additional effort to set realistic conservation flows is recommended.

Water management issues and barriers:
The TAWG identified several water-related issues in the TLU, including unregulated groundwater use, over-licensed streams, reductions in flow affecting fish, urban development near streams, increasing competition for water, and water quality impacts associated with land use.

There are several provincial and federal Acts and regulations that govern water in B.C. In addition, the Okanagan-Shuswap LRMP and four Official Community Plans (OCPs) in the TLU provide a long list of goals, objectives, and policies for managing water. The TAWG members reported that their rates of implementation of LRMP and OCP policies were relatively low. These agencies identified several challenges to water management in the TLU, including ineffective management tools, lack of data, limited education on water value and use, organizational barriers, and differing institutional priorities and conflicting objectives. These barriers will have to be overcome for water management to improve in the TLU. The recommendations of this report should help achieve that goal.

Technical analysis of future pressures on water:
RDCO predicts that the population of the TLU will increase from 36,336 at present to 59,937 by 2020. If that growth rate continues, the TLU population will be 97,201 by 2050. Along with the associated economic growth, water demand will be 41% higher by 2020 and 91% higher by 2050 due to population growth alone, as shown in Table 3.

In addition, the climate is changing, which will further increase the demand for water because the growing season will be longer, drier, and warmer. In total, water demand in the TLU will increase by 55% by 2020 and by 128% by 2050 under the combined influences of population growth and climate change, as shown in Table 4.

These changes are summarized on Figure 4. The effects of increased water demands on the five major streams in the TLU (assuming that all of the increased demand is satisfied from surface streams) are shown on Figure 5.

In addition to its effect on water demand, climate change will have a second effect on the TLU's streams – it will substantially reduce water supply. Predictions of three global circulation models and the UBC watershed model (Figures 12.1 through 12.5 of the main report) show that natural streamflows will be about 15% smaller in 2020 and 35% smaller in 2050 than they are now, even if water use does not increase in future. These changes are summarized in Table 5.

Detailed analyses were done on the effects of population growth (increased water use) and climate change (increased water use and reduced streamflow) on the five major streams of the TLU. The output consists of 56 graphs (Figures 14.1 through 14.56 of the main report - one for each of 14 locations on five creeks), for each of the following four future scenarios:

<u>Scenario 1: Effects of Population Growth only</u>

- Scenario 1.1: Effects of Population Growth to 2020
- Scenario 1.2: Effects of Population Growth to 2050

<u>Scenario 2: Effects of Population Growth and Climate Change</u>

- Scenario 2.1: Effects of Population Growth and Climate Change to 2020
- Scenario 2.2: Effects of Population Growth and Climate Change to 2050

The analysis relied on several key assumptions, including that all future water demand is satisfied from surface streams (not groundwater or Okanagan Lake), and that no intervention is made to prevent future water conflicts. We also examined the effect of conservation measures, specifically the effects of 10%, 20%, and 30% reductions in demand due to implementation of conservation measures. Detailed spreadsheets and analysis of the output are provided in Appendices I through M and O of the main report (Volume 2).

The technical analyses are summarized in Figures 6 through 10. These figures show the combined effects of future changes in both demand and supply, <u>and demonstrate clearly that present-day water resource issues and conflicts will be substantially intensified throughout the TLU in future</u>.

Summary of current conditions and future pressures:

The following points summarize present conditions in the TLU, and future water-related pressures:

1. Water agencies and stakeholders have identified many water-related issues in the TLU, which are currently being managed under a wide variety of regulations, goals, objectives, and policies. Analyses of water licences, land use, flows, water quality, and fisheries information confirm that water resources are presently under pressure in the TLU and that there are several barriers to more effective water resource management in the TLU.
2. There are data gaps that should be filled to fully understand water resources and water use in the TLU. Streamflow data is only collected on an ongoing basis on two of the five major streams in the TLU, water licence information is maintained in a complex format that is

difficult to use and the data are difficult to interpret, there is virtually no information on rates of groundwater supply or demand or on groundwater quality, and fish conservation flows in some streams may be set unrealistically high because of a lack of actual data on natural historic flows.

3. Flows in the five major streams of the TLU have already been reduced from historic levels due to offstream withdrawals, by an average of 13%. Streamflows are highly variable from year to year. A 5-year drought year has only 67% of the streamflow of an average year in the Okanagan.
4. Water quality generally meets water quality guidelines (or water quality objectives where they have been set) although exceedances for turbidity, colour, and coliform bacteria (raw water) are not uncommon. However, water quality conditions are such that all major utilities chlorinate their water. There are existing and future threats to water quality, including recreational use of upland lakes, motorized recreational vehicle impacts on streams, and livestock access to surface water bodies. Though poorly studied in the TLU, experience from other locations suggests that residential, agricultural, and commercial development could affect water quality in stream reaches downstream of the major water supply intakes. These activities could contribute to pollution loads of groundwater and low-elevation stream reaches.
5. Downstream of the major water intakes, streamflows in summer and fall are often lower than recommended “fisheries conservation flows”.
6. Total annual water use in the TLU is about 24.55 million cubic metres (66% from surface sources, 30% from Okanagan Lake, and 4% from groundwater). Water use is distributed as follows: residential - 41% (36,366 population); agriculture (including golf courses) - 34%; commercial/industrial - 20%, and leakage - 5%. Actual water withdrawn from surface sources is about half of the total amount currently licensed for withdrawal. In three of the five principal streams (Lambly, McDougall, Trepanier), neither licensed offstream use nor actual offstream use is fully supported by storage, but in Peachland and Powers Creeks, both licensed and actual offstream use are fully supported by storage.
7. Rates of water use in the TLU are very high (residential use averages 789 L/person per day on a year-round basis – about double the B.C. average) and prices are relatively low (residential rates average about 25 cents per cubic metre – less than half the B.C. average). Agricultural and commercial/industrial rates are even cheaper. Effective water conservation measures could reduce water use by 30% to 50%.
8. Population in the TLU is forecast to grow from 36,336 in 2001 to 59,937 in 2020 and 97,201 in 2050. Water use in the TLU is expected to grow by 41% by 2020 and 91% by 2050, if it is assumed that the climate does not change over that time period. However, if the effects of climate change currently predicted by computer models are accounted for, total water use in the TLU will increase by 55% by 2020 and 128% by 2050, relative to 2003.
9. In addition to affecting water demand, climate change will also reduce streamflows throughout the TLU. Based on three representative climate models and the UBC Watershed Model, streamflow would become an average of 15% smaller by 2020, and 35 % smaller by 2050 even if water withdrawals from the streams did not change.

Conclusions:

Specific predictions of the effects of population growth and climate change on streamflows in the five principal streams of the TLU for the years 2020 and 2050 have been made. These predictions make many assumptions, including that future demand is satisfied entirely from tributary sources, and that no changes in management to prevent conflicts takes place. On this basis, the following conclusions are drawn:

1. If potential climate changes are ignored, streamflows in 2020 will be smaller than today due simply to population and economic growth, but the predicted flow reductions will be relatively small. Nevertheless, the flow allocation, fish habitat, and water quality issues that are experienced now will intensify. Conservation flows will not be met in Powers Creek. Streamflows in 2050 will decrease further, resulting in more substantial flow reductions and associated water quality and fisheries impacts, which will be concentrated in Lambly, McDougall, and Powers Creeks.
2. If climate change is accounted for, significant streamflow reductions (averaging 25%) are expected <u>in all five major creeks by 2020</u> due to increased use and reduced supply. This will result in zero flow at some locations for parts of the year in an average year. An average year will be like a 5-year drought year today, and a 5-year drought year will be like a 20-year drought year today. Current licences will not be sufficient to satisfy demand on Powers Creek.
3. These impacts will be even more severe by 2050, when annual flows will be reduced by an average of 56%, resulting in conservation flows not being met at many locations, and zero flow in all creeks for parts of the year. An average year will be like a 20-year drought year today, and a 5-year drought year in 2050 will be like a 50-year drought year today. Current licences will not be sufficient to satisfy demand on Powers and Lambly Creeks.
4. Streamflow impacts will be much larger downstream of the intakes of the major water purveyors than further upstream.
5. If future demands are satisfied from sources other than tributary streams, the predicted impacts on the tributaries will be smaller than indicated here. For example, if groundwater were developed to its currently estimated capacity, increased use of tributaries and Okanagan Lake could be avoided until about 2020.
6. If the climate does not change, demand management alone to 2020 would allow future demand to be satisfied from tributaries alone, and permit population and economic growth to occur without streamflow reductions relative to 2003, and the associated water quality and fisheries impacts.
7. However, by 2050 (even without climate change), both demand management and alternate supplies will be needed to prevent streamflow reductions and associated environmental impacts.
8. If the climate does change as predicted, augmentation of the water supply will be needed (along with demand management) to prevent streamflow reductions and associated environmental impacts by 2020.

Recommendations for improved water management:
On the basis of the key findings and conclusions of the study, several recommendations are made for improved water management. The recommendations are consistent with the goals and policies for water management contained within the Okanagan-Shuswap LRMP and the four OCPs in the TLU. They are listed in approximate priority order.

1. Demand management
Demand-side management approaches for the TLU should be adopted and implemented before 2010. Measures should include at least the following approaches, as described in Section 15.0 of the main report:

- A minimum water use reduction target should be set;
- Public education programs (to promote water conservation and to encourage changes such as xeriscaping and improvements in irrigation application techniques and irrigation scheduling);
- Universal metering;
- Financial incentives (use of a volume-based rate system and potentially other incentives);
- Ensuring full cost-recovery pricing; and
- Regulations (including requiring water conserving fixtures, restrictions on water use in peak periods).

It is expected that 30% reductions in water demand, which would reduce residential per capita water use to the same levels as experienced in Kelowna and Vernon, are attainable in the TLU with these basic approaches. It is recommended that as soon as metering is in place, additional measures (that depend on meters) be implemented:

- Utilities should implement a leak detection program;
- Utilities should conduct water audits to determine locations and amounts of water use and leakage;
- Improvements in irrigation application techniques should continue to be made; and
- A program of irrigation scheduling should be implemented.

Finally, the following measures that do not depend on meters should be implemented:

- Promotion of land use changes. Local governments should encourage developments with lower per capita water use such as multi-family residential vs. large single-family lots, and low impact development designs including xeriscaping and onsite retention and infiltration of stormwater runoff. The low density of development in the TLU, combined with substantial future development potential, provides opportunities for significantly affecting water use and quality through urban design;
- Promotion of crops that require less irrigation, considering the economic implications within and beyond the TLU;
- Implementation of recycling and reuse of wastewater by businesses and jurisdictions; and
- The potential for achieving water supply and distribution efficiencies through combining water systems should be investigated.

Although realizing the benefits of these actions may take years, they can generate substantial reductions in water use. Regardless of the return period, however, such actions should be implemented as soon as possible, and before 2010. Some of the planning changes (such as changes in urban form) generate other secondary benefits, such as reduced vehicle use and road area, and more efficient servicing patterns (for water, power, sewer, drainage, and transportation). Low impact development techniques often accompany new urban forms, reducing runoff peaks and improving the quality of stormwater runoff.

Adoption of all of these conservation measures could result in total water savings near 50%. It is recommended that all of these demand-side approaches be applied throughout the TLU, and adjusted to reflect local conditions and the potential benefit of implementing the identified opportunities.

2. Supply Side Management

In order to prevent exacerbation of present-day water management issues and conflicts, development of additional water supplies will likely be necessary by 2020 if climate change is accounted for, and by 2050 if only projected population changes are considered. Since it is likely that the climate is changing, it is recommended that all utilities that rely on surface water sources develop additional water supplies before 2020.

Supply-side management strategies recommended for the TLU include (in approximate chronological order):

- Operational improvements, including achieving operational efficiencies, leakage reduction in the primary conveyance systems, and reductions in system pressure;
- Additions to or development of new upstream storage on the plateau;
- Pumping from Okanagan Lake; and
- Increased use of groundwater.

Although a great deal of upland storage has already been developed and licensed, there is likely some remaining opportunity to increase storage in upland areas. An assessment of the potential for increases in storage is beyond the scope of this report. Each water utility should evaluate the extent to which additional storage can be developed in the areas under their management. In the short term, increased storage is likely to be the most cost-effective approach to increasing supply. In the longer term, however, tributary storage will become more difficult and costly to develop, and there is a limit to the availability of water from this source.

It is recommended that the province carefully consider any proposed sale of Crown land around upland lakes or storage reservoirs, because private shoreline ownership could constrain the development of increased storage.

Because of limits to the availability of new upland storage, it is recommended that investigation and development of Okanagan Lake and groundwater become higher priorities than they have been in the past. However, current knowledge of groundwater is limited, so large-scale groundwater development should not occur before the resource has been properly evaluated (see Recommendation 8). It is noteworthy that while the use of Okanagan Lake and groundwater to service future demands represents a medium to long-term solution, there is a limit to the use of these alternative supplies. Groundwater-surface water interactions could cause reductions in baseflows in surface streams if groundwater is overused. Also, water use from Okanagan Lake will eventually become significant enough to affect lake levels, which has negative implications for lake water quality and downstream flows. Already it is estimated that consumptive water use (i.e. water that is permanently lost) from the TLU represents 2 to 4 cm annually lost from the lake, and with continued economic growth, this figure will rise.

Increased use of tributary flow without upstream storage development, and inter-basin diversions into the TLU are two supply-side options that are not consistent with the goals and policies for water management contained in the Okanagan-Shuswap LRMP, and are not recommended for the TLU. Even though Table 2 indicates that Powers and Peachland Creeks may have sufficient storage to support current offstream use, the detailed scenario output summarized above indicates that increased withdrawals without supporting storage are not recommended on these creeks.

Prior to embarking on supply augmentation programs, it is recommended that each of the three major water utilities in the TLU that obtain water from surface sources conduct detailed analyses, specific to their particular water supply system, of future supply-side and demand-side management options, including analyses of costs and benefits, and determine which of the demand or supply options described in this report are most appropriate for implementation.

It is recommended that RDCO assist the smaller water utilities with similar utility-specific analyses to determine the optimal adaptation approach in each case. Many of these smaller utilities obtain water directly from Okanagan Lake, so detailed analyses of alternative sources of supply is not likely necessary. However, analyses of demand reduction strategies will be relevant to these utilities. Utilities using Okanagan Lake water may need to be convinced of the merits of demand reduction.

In summary, both augmentation of water supply and reduction in water demand will be needed in order to ensure economic development and maintenance of environmental quality in the Trepanier Landscape Unit in the future. Demand management should be the first priority. If it is assumed that the climate is not changing, both approaches will be needed by 2050. If it is assumed that the climate is changing, both approaches will be needed by 2020. <u>We recommend that demand management be implemented by 2010, and that additional water supplies be developed as a second priority by 2020.</u>

3. Surface Water Allocation

If current licences for offstream use were fully utilized, water withdrawals from surface sources would exceed those in Scenario 2.2 (year 2050, assuming climate change takes place) by 10.2 million m^3 per year, or 18%. Therefore, it is recommended that, despite the fact that there is room available within the scope of existing licences for additional withdrawals from the five major tributaries, no increases to offstream withdrawals should be made without an equivalent increase in upstream storage to support the withdrawal. This recommendation is consistent with current practice.

Future water licence applications for surface streams in the TLU should be accompanied by proof that all reasonable alternatives have been pursued for obtaining water from already licensed sources, and that demand management measures are incapable of meeting the water requirements of the applicant.

4. Protection of Water Quality

It is recommended that appropriate effort be directed at protecting water quality on both Crown Land and private land by the appropriate agencies. On Crown Land, this may take the form of source assessments under the *Drinking Water Protection Act*, potentially followed by Drinking Water Protection Plans. On private land, this could take the form of measures to control development in order to minimize development impacts on hydrologic response and water quality. This recommendation is particularly salient, since the province is considering the sale of Crown land along the shorelines of upland lakes and reservoirs, which may result in increased development pressures.

5. Protection of Streamside Corridors

It is recommended that the appropriate agencies ensure that sufficient protection is provided to streamside areas within the TLU to maintain the functioning of riparian and floodplain processes at adequate levels, and minimize the negative impacts to the aquatic ecosystem that will be associated with reduced future streamflows.

Recommendations to improve water information:

Each of the above water management recommendations should be implemented without waiting for additional data or information. However, this study revealed several issues with respect to data and information in the TLU. The following recommendations are made to improve the quality and quantity of the data available in the TLU for making water management decisions. They are organized approximately in order of priority. They are all important, and it is recommended that they all be implemented before 2010.

6. Water Licence Information System

A thorough examination of the Water Licence Information System is recommended in order to identify improvements for access and querying. A map and database (GIS) approach should be pursued, in which a user could easily identify existing water licences upstream of a particular location on a stream network. In order to facilitate analysis, metric units should be adopted. At a minimum, metric units should be provided along with traditionally used (non-metric) units.

The Provincial government should become more proactive in cancelling licences that are no longer in use, so that water managers will be able to more easily identify currently active instream and offstream licences.

7. Measurement of Water Use

It is recommended that all water utilities in the TLU measure their rate of water withdrawal from primary sources (surface streams, Okanagan Lake, and groundwater).

It is recommended that customers of each of the water utilities in the TLU be metered, whether the water source is tributaries, groundwater, or Okanagan Lake. Meters are most urgent where customers are supplied from tributary sources.

It is recommended that water utilities conduct an audit or survey of water withdrawal rates, and indoor and outdoor use among their residential and commercial customers after a one or two year period. Such information can guide conservation programs, water pricing decisions, and public education messages. This information can also be used to update the estimates of water use and other analyses presented in this report.

8. Groundwater
Improvements in groundwater management depend on obtaining improved groundwater inventory and use information, which should be done prior to significant new groundwater development. It is recommended that the Provincial government enact legislation to regulate groundwater use in British Columbia – including establishing standards for well construction, and requiring reporting of relevant information, including yields.

It is recommended that (even in the absence of provincial legislation) RDCO, Peachland, and the Westbank First Nation implement a program of voluntary provision of groundwater information. Owners of selected properties in the TLU would be asked to allow monitoring of well yields, water table depth, water use, and water quality. The costs of such a program could be covered by the provincial government, and the results would be used to better understand and assess groundwater resources and use in the TLU.

Aquifer mapping, based on surficial geology mapping, anecdotal evidence and limited field mapping, should be considered for the upland areas of the TLU. Detailed hydrogeological data and information should be generated for the six identified aquifers so detailed assessments of aquifer yield and sustainability can be completed. Information for this task would be obtained from the voluntary monitoring program and from other sources. Detailed aquifer vulnerability mapping that considers land use, zoning and levels and types of development should be considered for the six identified aquifers. Finally, the need for wellhead protection plans and groundwater protection areas should be assessed, based on the results of the updated vulnerability mapping and the monitoring program.

9. Streamflow Inventory
In order to reduce reliance on regional flow estimation, it is recommended that hydrometric stations be re-established in all five major watersheds of the TLU, at least near the mouths of each stream, and also preferably above major intake locations and below major storage reservoirs. Flows in all significant municipal and irrigation diversions should be monitored - at least those of the Westbank and Lakeview Irrigation Districts and the District Municipality of Peachland. All data collection in the TLU should be managed by a single agency, which would disseminate the information to all stakeholders.

10. Water Quality
The following recommendations are made to further the existing understanding of water quality and to provide the information needed to manage water sources in the future:

- RDCO, water utilities, and other water agencies and stakeholders should review the forthcoming water quality assessment reports from MWLAP, including the basis for any new Water Quality Objectives that are set;
- MWLAP should update the EMS database to include the recent MWLAP data and any other available data (e.g. data collected by water purveyors, Noranda, or Riverside);
- Water quality monitoring should continue in all the water supply watersheds, and the list of monitoring parameters should be expanded beyond the minimum requirements in the

Drinking Water Protection Act. The list and sampling schedule should be customized for each stream depending on uses (e.g. drinking water or aquatic life), but should include at least turbidity and/or total suspended solids, total dissolved solids, pH, water temperature, and true colour (or another measure of organic carbon). Sampling for metals, nutrients, parasites (e.g. *Cryptospridium parvum*), trihalomethanes, or other parameters will be of value at some sites.

- The monitoring should take place at the water intakes (in addition to whatever sampling within the system that the water utilities conduct). If additional sampling sites are considered beneficial they would ideally be located at the sites of any new hydrometric stations because flow data assists in data interpretation.
- Future water quality monitoring programs should be designed carefully to ensure that the goals of the program are well understood and can be achieved. A specialist in statistical study design should be consulted early in the design process.
- Opportunities for cost sharing of the monitoring should be explored among the water utilities, forest licensees, RDCO, Interior Health Authority, and other stakeholders, and all stakeholders should be involved in development of the study design.

11. Fish Conservation Flows

The following recommendations are made to advance the process of setting conservation flows in TLU tributaries:

- Consider adopting conservation flows that vary depending on the naturalized flows (i.e., flows without water storage, release, or diversion) in any given year, i.e. are not intended to preserve “optimal” conditions at all times. In particular, during low-flow periods, conservation flows should be no greater than the total naturalized flows available. Sufficient information should be collected on habitat-flow relationships to enable explicit evaluation of the implications of managing flow on this basis.

However, if an approach based on preserving “optimal” conditions for fish is selected:

- Complete field assessments of fish habitat-flow relationships in order to calibrate the conservation flow recommendations. The assessments should concentrate on the nature of the relationship at flows near the range of reasonable conservation flows, as determining the shape of the curve in this flow range is critical.
- Determine whether conservation flows in those sections of channel not containing kokanee can reasonably be reduced during the fall/winter months from the proposed universal conservation flows, keeping in mind that rainbow trout require sufficient flows for over-wintering.
- Careful consideration should be given to determining which life history stage is most limiting to each fish population, then structuring conservation flows accordingly. Additionally, it should be confirmed that flow is the primary controlling factor for each population, as opposed to temperature or another factor that may be beyond the influence of water managers.
- Incorporate water temperature moderation into future conservation flows, if there is evidence that this is a key fish production bottleneck in the streams of interest.
- Finally, it is recommended that once conservation flow discussions have been concluded, instream licences should be issued for these amounts, to ensure that instream uses are legally protected. Even though these licences will rank low in terms of priority, they will provide

more protection than if there was no licence in place. In addition, such licences could facilitate use of the Fish Protection Act to ensure conservation flows are maintained.

12. Water Information Accessibility
It is recommended that an Okanagan water information clearinghouse be developed, and that local and provincial agencies with water-related mandates in the TLU support such an initiative.

Next steps:
The analyses conducted in support of the Trepanier Landscape Unit water management plan indicate very specifically where and by how much streamflows in the TLU will be affected in future. Recommendations have been made to mitigate these impacts, beginning with substantial reductions in water demand beginning before 2010, and including development of alternative water sources beginning before 2020. Failure to change rates of water use or seek alternative water sources will either constrain economic growth or impair environmental resource values, or both.

The recommended next steps are as follows:
- creation of a leadership group that will champion the cause of improved water management and encourage adoption and implementation of the recommendations presented in this report;
- holding stakeholder and public consultations to agree on goals, strategies, and action items, using the recommendations of this report as a starting point;
- creation of a water management implementation plan; and
- implementation of improved water management actions using a variety of existing mechanisms.

These points are outlined in more detail below.

1. Establish a leadership group
It is recommended that a Water Management Advancement Team be established as a strategic alliance of key stakeholders to administer the water management plan and champion improved water management in the TLU. The group could be lead by RDCO or another of the members of the Steering Committee created for the present study, or another body, and would consist of a cross-section of agencies with a mandate to manage water in the TLU. The Water Management Advancement Team could be formally established under an existing mechanism (such as RDCO or the Okanagan Basin Water Board). It would work to improve water management in the TLU, foster the development of partnerships as needed to implement recommendations, seek funding to complete technical studies, oversee technical studies, conduct monitoring and data management, ensure access to data, and coordinate educational programs.

2. Hold stakeholder and public consultations and develop an implementation plan
It is recommended that the recommendations contained herein be used as a basis for development of a water management implementation plan for the TLU. The implementation plan would include broader stakeholder consultation than has been possible in the course of this study, and seek agreement on key goals for water management in the TLU among key stakeholders. The water management implementation plan should contain, at a minimum:

- water management goals and policies;
- priorities among action items;
- targets for water conservation and quality;
- assigned responsibilities for implementing plan elements;
- schedules to ensure timely attainment of targets and implementation of identified actions; and
- budgets for action items, including statements of cost-effectiveness and identification of sources of funding.

3. Implement improved water management

Once a water management implementation plan has been adopted for the TLU, it is recommended that recommendations be adopted as appropriate into Official Community Plans and servicing bylaws, Water Use Plans, Drinking Water Protection Plans, and specific management objectives for community watersheds under the Forest and Range Practices Act.

Firm commitments need to be gained for the water management implementation plan and its elements in associated plans and bylaws. Once committed, the responsible agencies need to be accountable for implementation. The Water Management Advancement Team can aid in plan implementation and finding solutions that are acceptable to water managers, purveyors, and users.

Table 1 Comparison of naturalized flow and net flow for the five major creeks of the TLU

	Naturalized flow	Net flow
o Lambly Creek:	1.77 m^3/s	1.58 m^3/s
o McDougall Creek:	0.119 m^3/s	0.084 m^3/s
o Powers Creek:	0.920 m^3/s	0.849 m^3/s
o Trepanier Creek:	1.09 m^3/s	1.03 m^3/s
o Peachland Creek:	0.570 m^3/s	0.515 m^3/s

Table 2 Comparison of actual and licensed offstream water use (expressed as a percent of the naturalized flow) and of storage

	Licensed Offstream Use	Actual Offstream Use	Percentage of Licensed Offstream Use Supported by Storage
o Lambly Creek:	23%	11%	37%
o McDougall Creek:	30%	30%	43%
o Powers Creek:	29%	18%	191%
o Trepanier Creek:	13%	5%	19%
o Peachland Creek:	43%	10%	115%

Table 3 Present and future TLU water use (in millions of m^3/year) assuming that climate change does not occur.

Land use	2003	2020	2050
Residential	10.2	16.8	27.3
Commercial / Industrial	4.9	7.8	9.1
Agricultural[1]	8.3	8.3	8.3
Distribution system losses	1.2	1.6	2.2
TOTAL	**24.6**	**34.5**	**46.9**

Note: 1. includes water used by golf courses.

Table 4 Present and future TLU water use (in millions of m^3/year) accounting for climate change.

Land use	2003	2020	2050
Residential	10.2	18.3	32.0
Commercial / Industrial	4.9	8.5	10.6
Agricultural[1]	8.3	9.6	10.8
Distribution system losses	1.2	1.8	2.7
TOTAL	**24.6**	**38.2**	**56.1**

Note: 1. includes water used by golf courses.

Table 5 Predicted reductions in annual flow caused by climate change

	2020	2050
o Lambly Creek:	11%	30%
o McDougall Creek:	11%	36%
o Powers Creek:	17%	34%
o Trepanier Creek:	20%	39%
o Peachland Creek:	18%	34%
Average	**15%**	**35%**

Note: This table represents the changes that are likely to occur if the climate changed but future water usage remained the same as it is today. Percentage reductions are based on 2003 levels.

Figure 1 Boundaries of the Trepanier Landscape Unit.

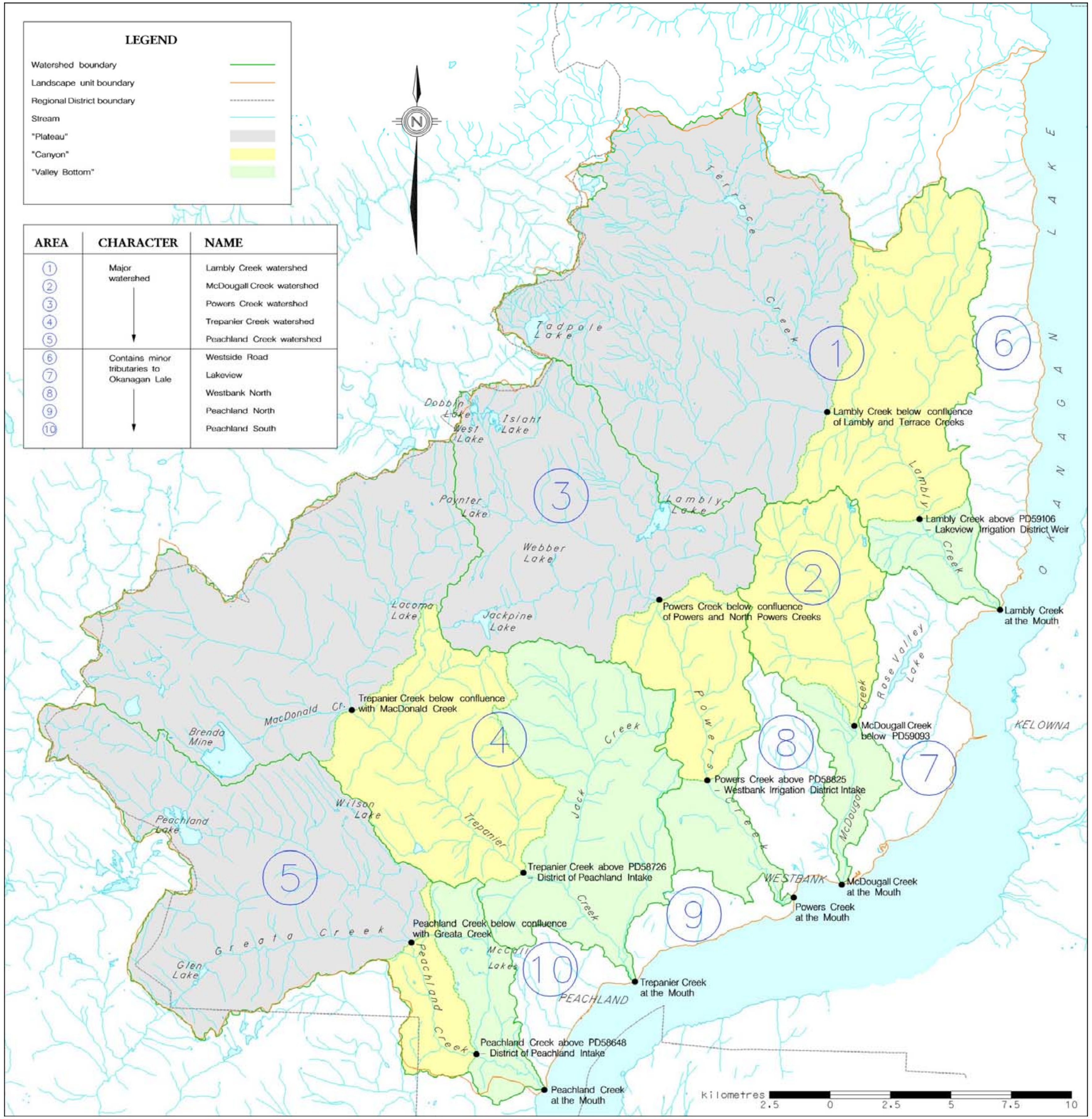

Figure 2 Map of the TLU indicating the 14 points-of-interest at which flows have been estimated.

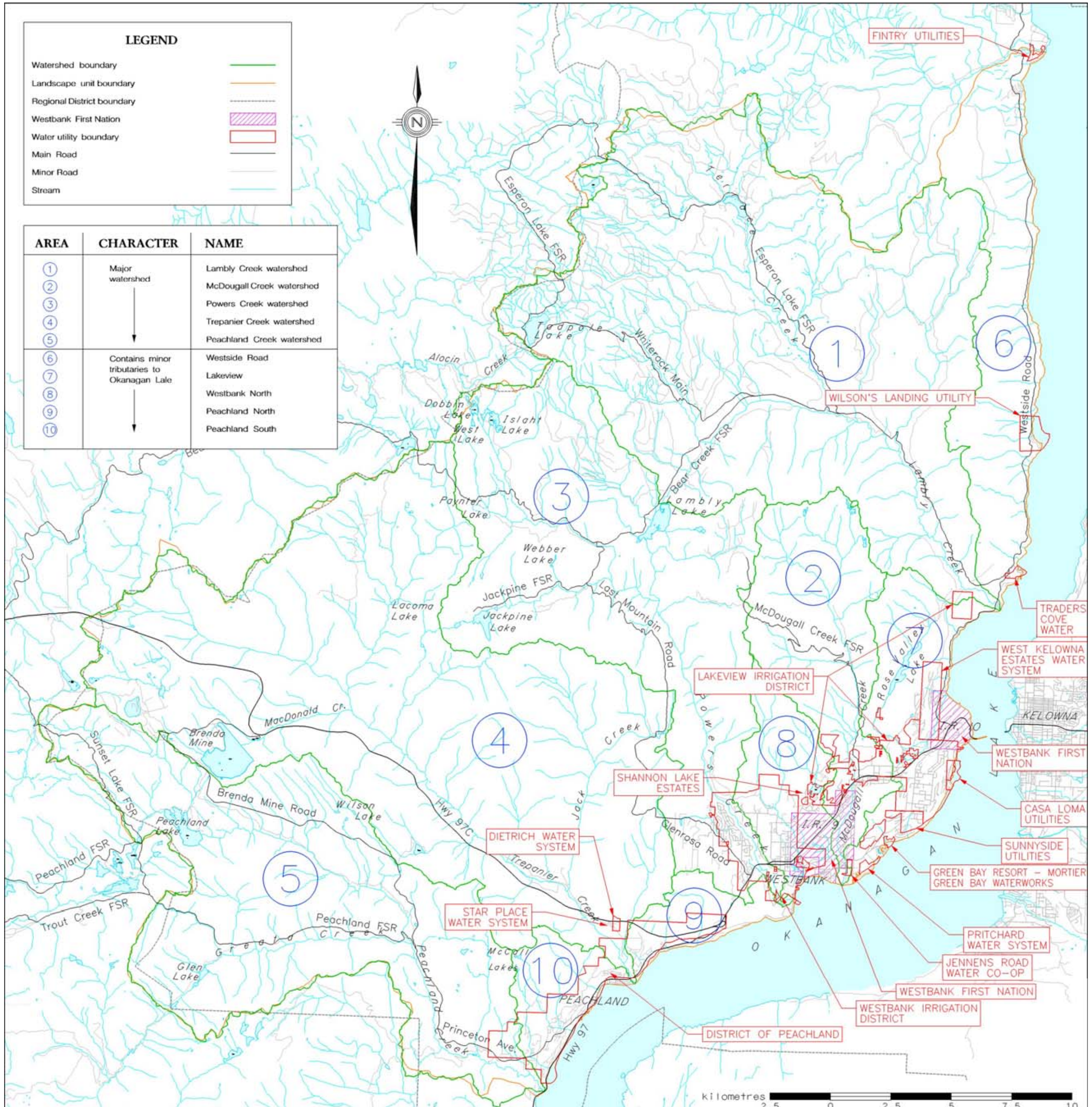

Figure 3 Distribution areas of the water utilities present in the TLU.

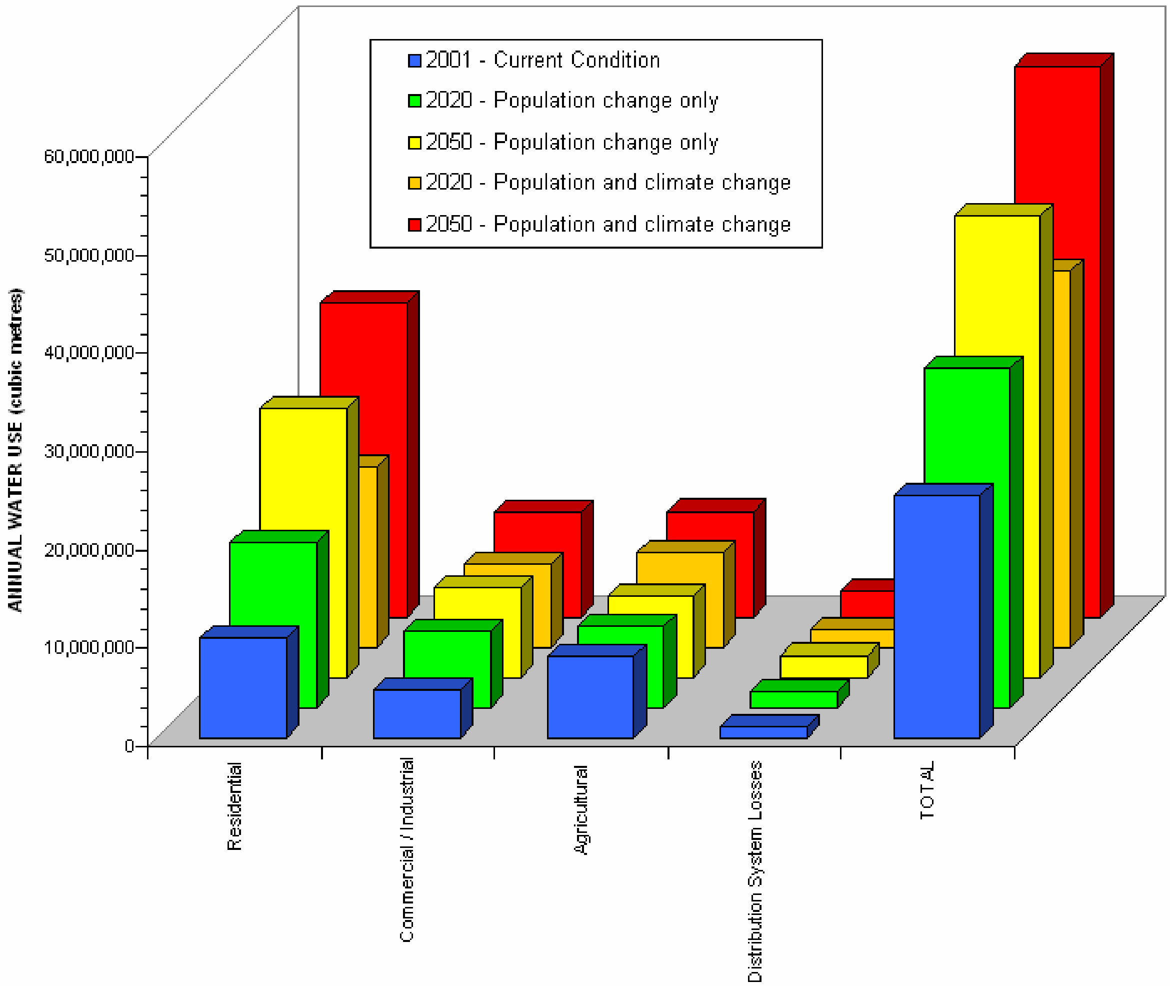

Figure 4 Estimated annual water use in the Trepanier Landscape Unit by land use.

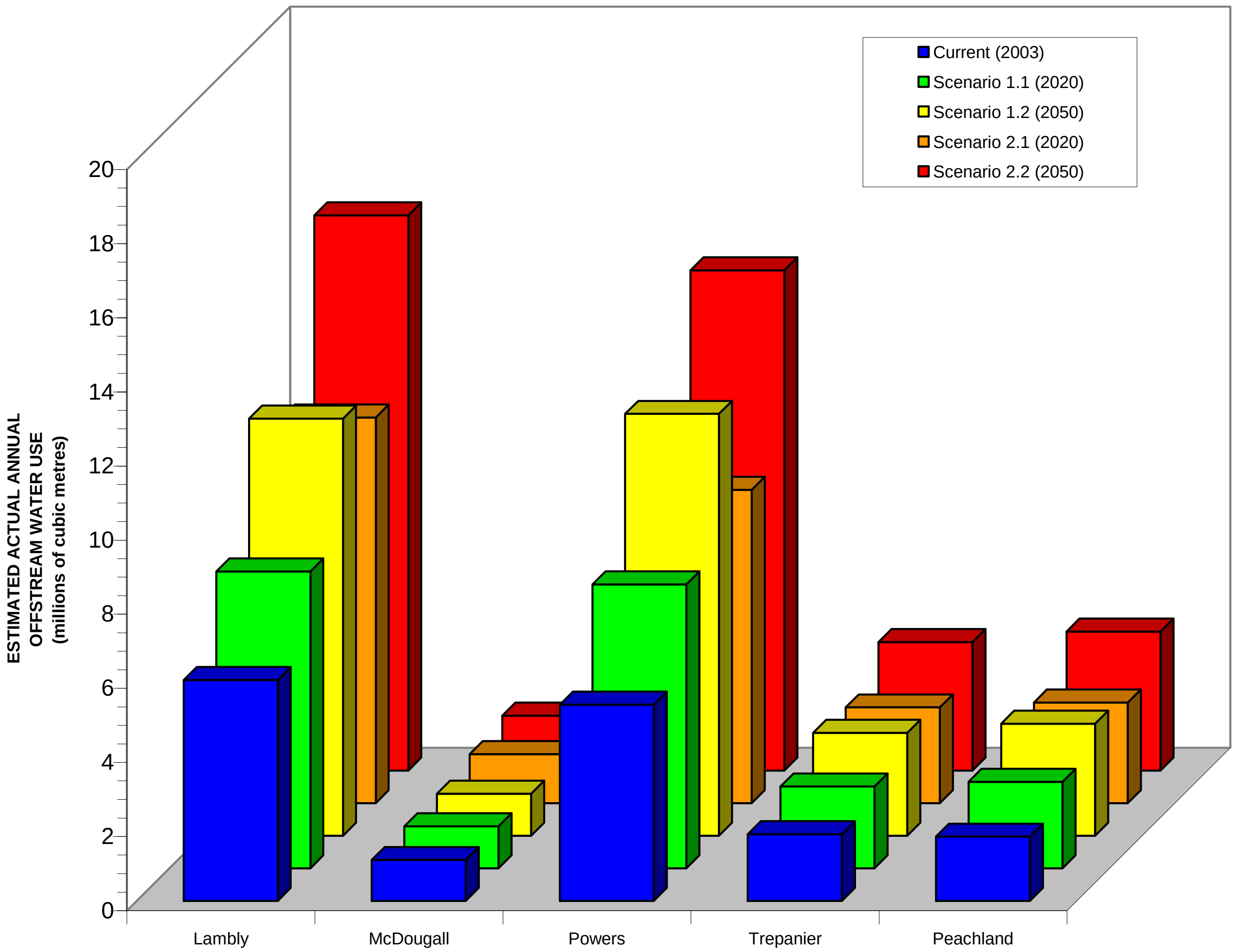

Figure 5 Estimated actual annual offstream water use at the mouths of the five principal streams in the TLU.

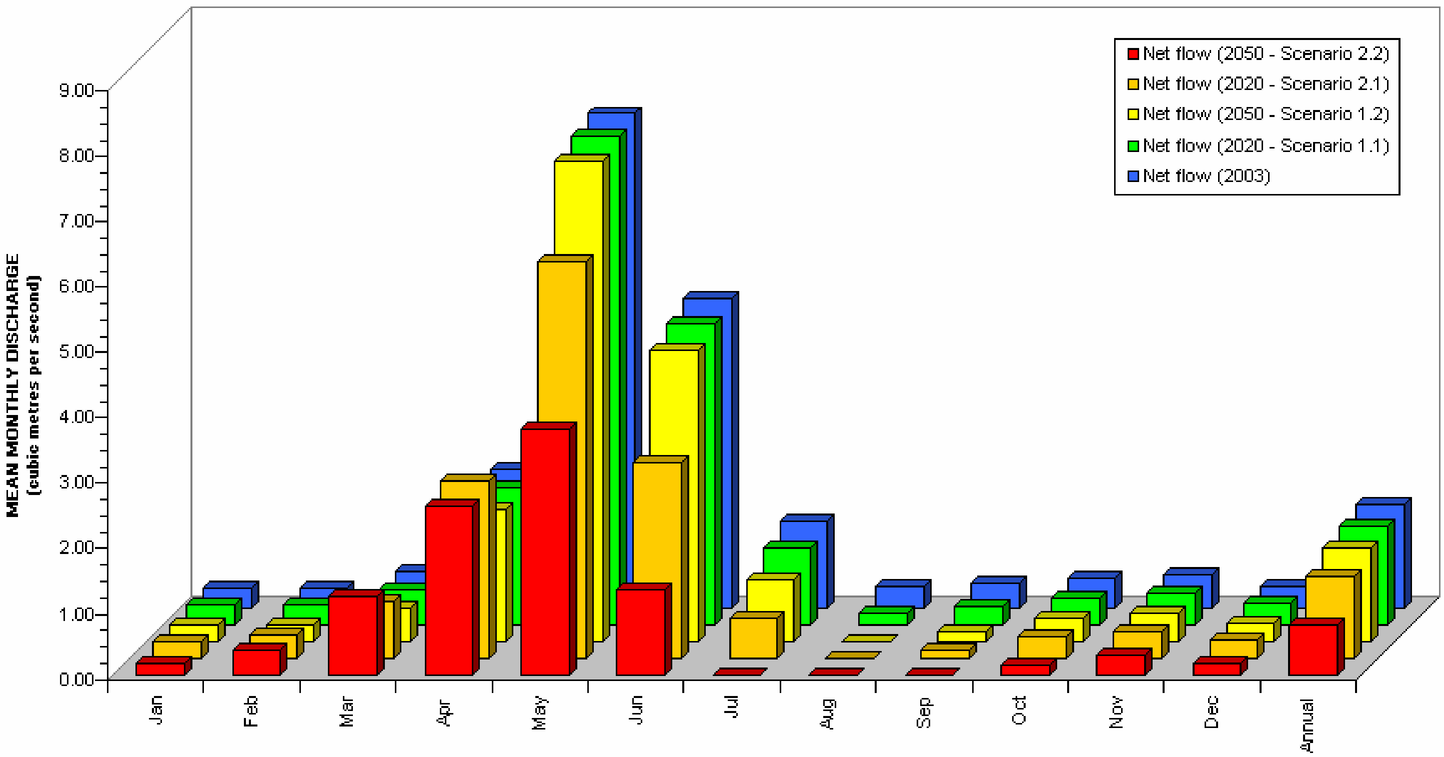

Figure 6 Net flows: Lambly Creek at the mouth.

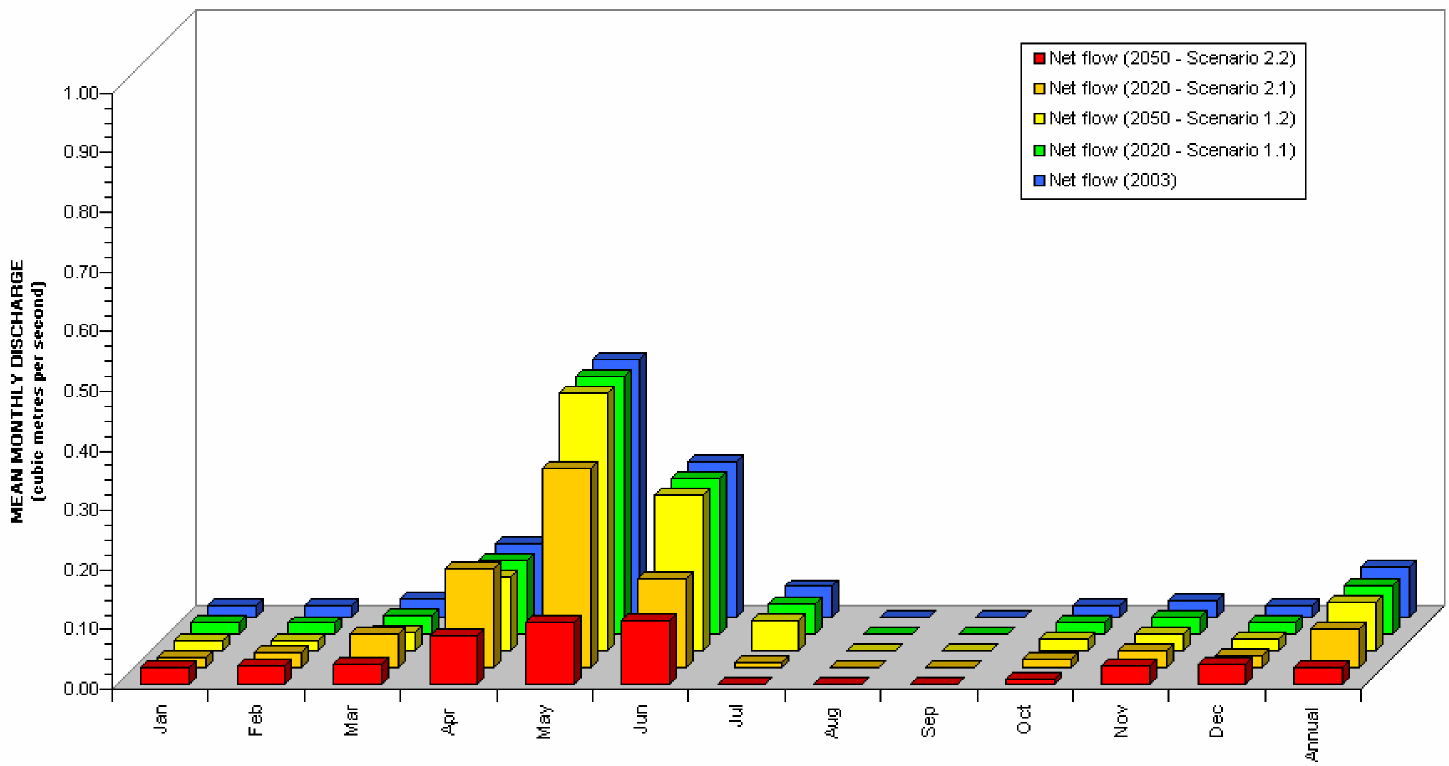

Figure 7 Net flows: McDougall Creek at the mouth.

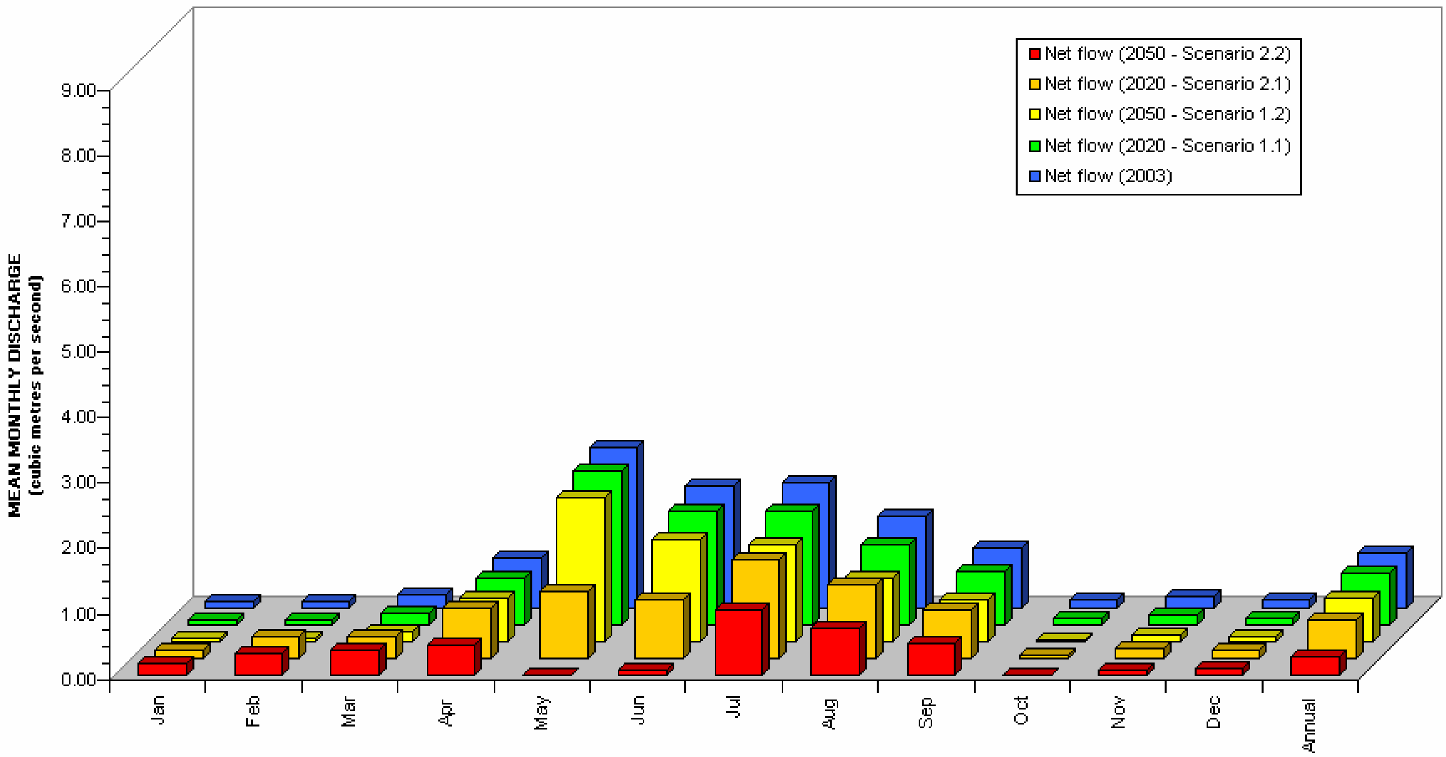

Figure 8 Net flows: Powers Creek at the mouth.

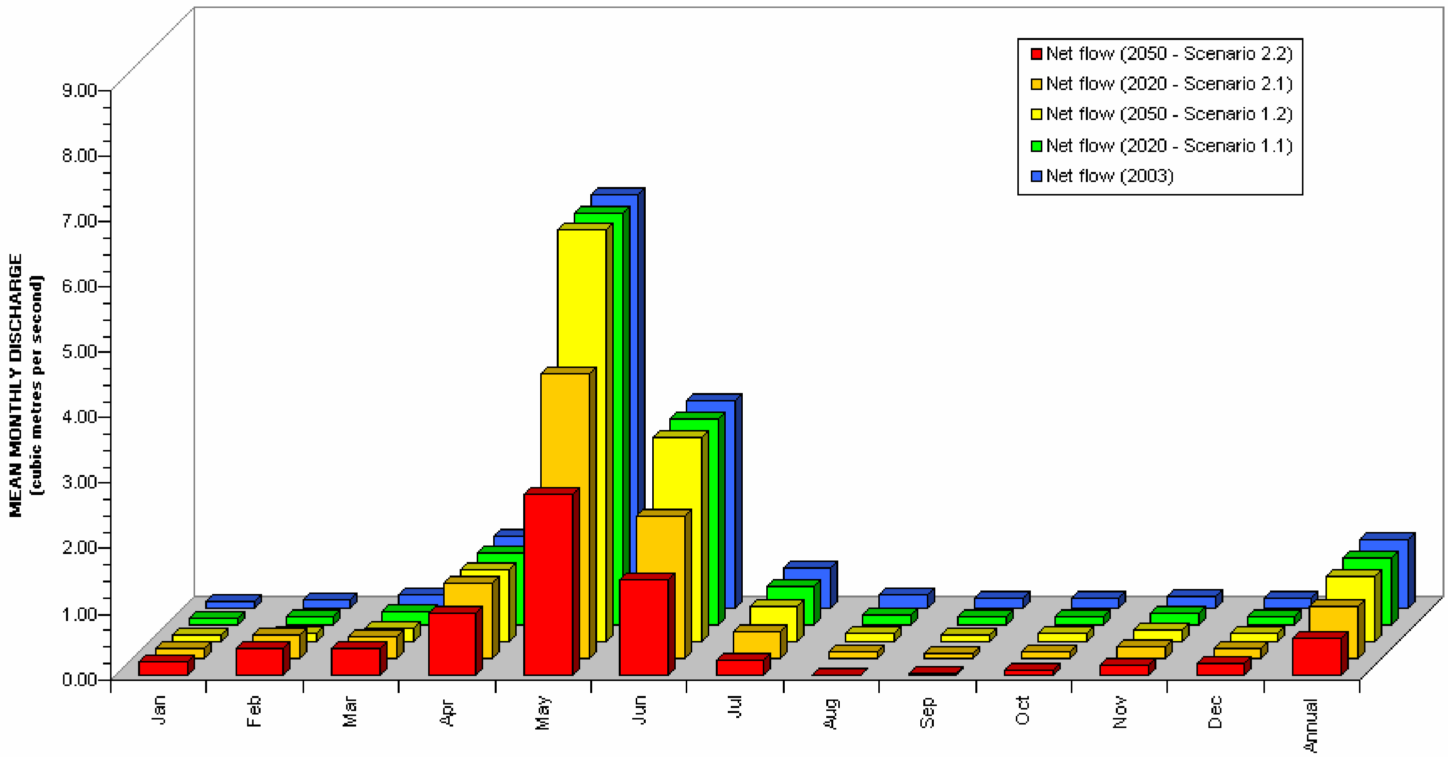

Figure 9 Net flows: Trepanier Creek at the mouth.

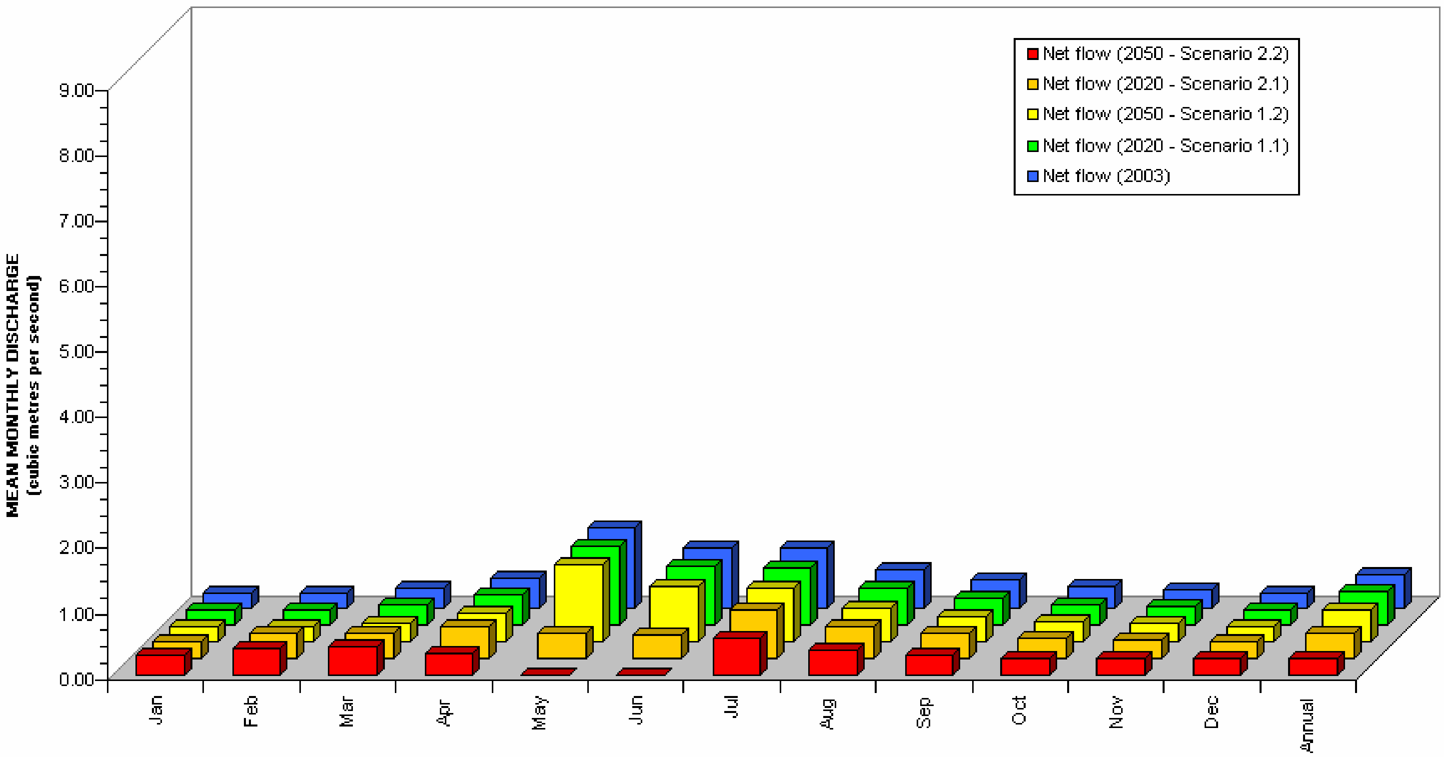

Figure 10 Net flows: Peachland Creek at the mouth.

ACKNOWLEDGEMENTS

This report was written by Summit Environmental Consultants Ltd., Westland Resource Group, Gartner-Lee Ltd., and Sunderman and Associates. The Regional District of Central Okanagan and the B.C. Ministry of Sustainable Resource Management, along with Land and Water BC Inc. and the B.C. Ministry of Water, Land, and Air Protection, provided overall leadership to the study, and assisted with collecting relevant data, maps, reports, and other information. Background information was provided by a wide variety of government and water management agencies operating within the Trepanier Landscape Unit, including the above-noted agencies. A body known as the Trepanier Advisory Working Group (water management stakeholders and government agencies) identified key water management issues and provided technical guidance to the study. Funding for the project was provided by the Regional District of Central Okanagan and the B.C. Ministry of Sustainable Resource Management. Additional funding for considering the impacts of projected climate change and climate change adaptation techniques was provided by the Ministry of Community, Aboriginal and Women's Services.

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1.0 INTRODUCTION

This document is a report of the Trepanier Landscape Unit (TLU) water management plan. Due to its length, it has been divided into two volumes: Volume 1 – Text and Volume 2 – Appendices. The report is summarized in an Executive Summary, which appears at the beginning of Volume 1, and has also been produced as a separate document. Summaries of the technical analyses are found in Volume 1 of the report, and details are found in Volume 2. All the report figures are grouped together and presented at the end of Volume 1. Sections 1 through 12 of Volume 1 present information on current conditions in the TLU. Sections 13 through 16 examine future impacts on water and present recommendations for improving water management in the TLU in order to reduce the impacts of future population growth and climate change.

1.1 PROJECT BACKGROUND

The plan was initiated by the B.C. Ministry of Sustainable Resource Management (MSRM), Land and Water British Columbia Inc. (LWBC), and the Regional District of Central Okanagan (RDCO) in early 2003. The plan is intended to bridge a gap between the more broad scale of the Okanagan-Shuswap Land and Resource Management Plan (LRMP) and the more detailed scale of Official Community Plans.

The Trepanier Landscape Unit (TLU) is located on the west side of the Okanagan valley in south-central British Columbia (Figure 1.1), and covers an area of 990 km^2. It is located in a relatively arid part of B.C., and includes the watersheds of Peachland Creek, Trepanier Creek, Powers Creek, Lambly Creek, and McDougall Creek. The communities of Westbank and Peachland are located in the TLU (Figure 1.2 and Map 1), which also supports a wide range of activities, including forestry, farming, mining, and recreation.

There are four major water purveyors in the project area, each with its own water system and pricing structure. Future development of the tributaries in the TLU is constrained by existing water licences, available water storage, the needs of the aquatic environment, and flood management provisions. Existing pressures on the water resource are expected to increase due to population and economic growth, and climate change.

RDCO, MSRM, LWBC, and the B.C. Ministry of Water, Land and Air Protection (MWLAP) all recognize the importance of the water resource and its relationship with land use planning, and want to promote sustainable economic development in the Okanagan Basin. Numerous studies and plans have been completed for the TLU, including water demand and availability studies (by the provincial government and the Okanagan Basin Water Board), groundwater vulnerability mapping (by the provincial government), climate change research (by Agriculture Canada and Environment Canada), watershed assessments (by forest licensees), flow assessments (by the provincial government), and urban growth projections (by the District of Peachland, Westbank First Nation, and the Regional District of Central Okanagan). Although the sustainable management of instream and offstream surface water and groundwater uses is an objective in the Okanagan-Shuswap Land and Resource Management Plan, there is still no single all-encompassing document that makes use of all the information available to date, and identifies water management issues and solutions for the area.

Therefore, in March 2002, the RDCO Regional Board supported the development of a water resource management plan for the Trepanier Landscape Unit in partnership with MSRM, LWBC, and other potential partners.

1.2 PROJECT INTENT

Understanding and managing the relationship between water and land use planning requires information on surface water and groundwater, water quality and quantity, instream and riparian values, and the economic value of water. Planning and management must also consider the impacts of various land uses on the water resource and the governance of those lands.

The intent of this document is to consider all uses of water, to involve multiple stakeholders in addressing the management of water, to examine management options and potential tradeoffs in terms of their impacts on the water budget, and to provide planning recommendations suitable for consideration and implementation by local and provincial governments.

In particular, the plan is intended to assist land and water managers with:

- developing a process for examining current information relating to water in order to compare several alternative scenarios for managing the resource;
- being proactive with water licence decisions instead of reactive to individual applications;
- addressing and resolving conflicts among instream and off-stream uses, and among other resource users and settlement land uses;
- making decisions based on the current scientific and economic information concerning the water resource; and
- effectively planning for development that is economically, socially, and environmentally sustainable.

This report is intended to form a framework for subsequent water resource plans in the Ministry of Sustainable Resource Management, Southern Interior Region and/or other watersheds in the Province. A summary of the report may form part of the "Water Management" chapter of a future Sustainable Resource Management Plan (SRMP) for this area. Lastly, this project is also intended to demonstrate the linkage between water management (including water allocation) and land use, and to set a standard for partnership development among provincial and local governments and other stakeholders interested in managing development in communities with respect to the water resource.

Finally, this report is intended to provide strategic direction to provincial water managers and to provincial and local government approving agencies. It is anticipated that this strategic direction will assist in developing subsequent operational plans, such as water allocation plans, and updates to Official Community Plans.

1.3 OBJECTIVES

The overall goal of the project is to provide a foundation to develop sound water management policies that are appropriate for the specific conditions of the TLU, and to enable sound water management decisions in the TLU. The objectives of the Trepanier water management plan are to:

- Assess the present state of land and water resources, and water management activities within the Trepanier Landscape Unit, and identify the possible influence of future pressures on the water resources of the TLU;
- Identify the future effects of growth and climate change on water resources in the TLU;
- Provide recommendations for water management in the TLU that will enable:
  - the Regional District of Central Okanagan to amend Official Community Plans and servicing policies, upon which land use decisions are based;
  - Land and Water B.C. to make water licensing decisions;
  - the Ministry of Sustainable Resource Management to implement the objectives and strategies of the Water General Management Zone and Community Watershed Special Resource Management Zone of the Okanagan-Shuswap Land and Resource Management Plan; and
  - the Ministry of Sustainable Resource Management to identify economic opportunities that are environmentally and socially sustainable.

The first objective was met through activities undertaken in Phase 1 of the project. The second and third objectives were met through activities undertaken in Phase 2. Phase 1 and 2 activities are listed here:

Phase 1

- Obtaining and reviewing relevant background information;
- Identifying water management policies, goals, and issues in the TLU;

- Conducting technical analyses of the current state of hydrology, groundwater, water use, fisheries, water quality, groundwater, land use, water economics, and population in the TLU; and
- Identifying future pressures on the water resource in the TLU.

Phase 2

- Determining the likely effects on water supply and demand at14 specific locations in the TLU in 2020 and 2050, under the influences of presently-predicted population change and economic development, and the expected influence of climate change; and
- Developing recommendations for water management in the TLU to minimize these impacts.

2.0 OUTLINE OF PROJECT

Section 2.0 describes the composition and role of the Steering Committee formed to guide the project, and of a larger stakeholder group formed to provide technical advice. The process used to complete the project is also reviewed.

2.1 ORGANIZATION

The project is being guided by a Steering Committee comprised of representatives of the two lead agencies, as well as representatives of the British Columbia Ministry of Water, Land, and Air Protection (MWLAP), and Land and Water BC (LWBC) (Table 2.1).

Table 2.1 Composition of the Steering Committee.

Agency	Representative
RDCO[1]	Leah Hartley (alternates: Ken Arcuri, Hilary Hettinga)
MSRM[2]	Karen Rothe (alternate: Ron Smith)
MWLAP[3]	Brian Symonds
LWBC[4]	Don McKee

1: RDCO = Regional District of Central Okanagan
2: MSRM = Ministry of Sustainable Resource Management
3: MWLAP = Ministry of Water, Land, and Air Protection
4: LWBC = Land and Water BC

The Steering Committee is responsible for providing overall direction and guidance. The Steering Committee selected consultants to complete the water management plan in winter 2003, and has worked closely with the consultants throughout the project.

In order to provide technical advice and input throughout the project, the Steering Committee created a second, larger body referred to as the Trepanier Advisory Working Group (TAWG). This group is comprised of representatives of the major water resource interests in the TLU (Table 2.2), and includes the members of the Steering Committee. Terms of Reference for the Advisory Working Group are presented in Appendix A.

Table 2.2 Members of the Trepanier Advisory Working Group.

Name	Job Title	Company
Brian Jamieson	Manager	Westbank Irrigation District
Ted Jeffery	Administrator	Lakeview Irrigation District
Joe Mocilac	Director of Operations	District of Peachland
Brian Symonds	Section Head, Floodplain Management Section	Ministry of Water, Land and Air Protection
Steve Matthews	Fisheries Section Head	Ministry of Water, Land and Air Protection
Don McKee	Hydrologist/Engineer	Land & Water B.C. Inc.
Hilary Hettinga	Director of Engineering Services	Regional District of Central Okanagan
Leah Hartley	Planner	Regional District of Central Okanagan
Dave Smith	Senior Habitat Biologist	Fisheries and Oceans Canada
Mike Adams	Drinking Water Officer	Interior Health Authority
Ron Smith	Regional Water Planner	Ministry of Sustainable Resource Management
Karen Rothe	Water Planning Team	Ministry of Sustainable Resource Management
Mike Doiron	Forestry Planner	Riverside Forest Products
Kerry Rouck	Project Forester	Gorman Bros. Lumber Ltd.
Michael Patterson	Regional Reclamation Manager	Noranda Mines (Brenda Mine)
Pauline Terbasket	Executive Director	Okanagan Nation Alliance
Rob Richardson	Director of Public Works	Westbank First Nation
Ted McRae	District Planning Officer	Ministry of Forests
Carl Withler	Resource Stewardship Agrologist	Ministry of Agriculture, Food & Fisheries, Interior Region

1: Alternate for Mike Adams: Greg Baytalan
2: Alternates for Rob Richardson: Gary Thompson, Water and Utility Manager

2.2 PROCESS

The Steering Committee and the consultants met in person in late March 2003 to begin the planning process. At that time, the Steering Committee approved a schedule in which Phase 1 was complete by fall 2003, and Phase 2 was complete by spring 2004.

The maps, data, reports, and other relevant information needed to complete the work were assembled, beginning in April 2003. The information assembled consisted of both hard-copy and digital information. The process of information collection, assembly, and review is outlined in Section 3.0.

Members of TAWG and the consultants held a meeting and undertook a field visit to the TLU in May 2003. During the field visit and meeting, Working Group members were asked to help identify major water management issues in the TLU through four methods:

- Several TAWG members made presentations and led discussions at specific stops of interest on the field tour;
- Discussions that took place on the May 8 field trip;
- Verbal input in breakout groups during the May 8 meeting that followed the field trip; and
- Written responses to a questionnaire presented and discussed at the May 8 meeting.

Section 5.0 of this report presents a summary of the water management issues in the TLU, gained primarily through interaction with the TAWG. The results of the questionnaire completed by some of the TAWG members are discussed in Section 5.0.

On the basis of all the information collected, the consultants prepared analyses of current conditions, which were presented in a draft Phase 1 report in September 2003. The draft Phase 1 report was discussed with the TAWG in a meeting on September 25, 2003. On the basis of that meeting and subsequent discussions, the draft Phase 1 report was revised.

Phase 2 work was conducted entirely in the office, and involved detailed simulations of water supply and demand using computer models, followed by analyses of demand and supply management options to mitigate the predicted effects, and development of recommendations for future water management in the TLU. Phase 1 and Phase 2 work has been integrated into this report.

3.0 INFORMATION REVIEW AND GAP ANALYSIS

There is a great deal of relevant technical and planning literature available for the TLU. Section 3.0 summarizes the work done to obtain and review relevant information and identify data gaps and weaknesses. These weaknesses are highlighted in several recommendations in Section 16.0 concerning data management.

3.1 INFORMATION REQUIREMENTS

The map scale that has been chosen for the project is 1:20,000, and the mapping base is the Terrain Resource Inventory Mapping One (TRIM 1) base (streams are taken from the TRIM 2 base). There is a great deal of existing information that is useful in completing a water management plan in the TLU. The following list outlines the major types of information assembled for the project:

- Hydrometric data;
- Climate data;
- Water licence information;
- Water demand and water supply studies undertaken for irrigation districts or other agencies;
- Water use and storage records available from local irrigation districts and water utilities;
- Water supply system infrastructure and operations reports;
- Official Community Plans (Westbank, Peachland, Westside, and Lakeview);
- Physical Development Plan (Westbank First Nation);
- Okanagan-Shuswap Land and Resource Management Plan;
- Present and projected land use information;
- Reports on growth and development strategies and policies of RDCO;
- Economic data on the cost of water in the study area, and on pricing strategies used by water purveyors;
- Groundwater vulnerability mapping;
- Well records;
- MWLAP Water Quality Inventory Program reports and files;

- Crop water use information;
- Reports on water management and climate change in the Okanagan Basin;
- Output of the UBC Watershed Model for the five major creeks in the study area associated with future climate scenarios (provided by the University of B.C. and the Sustainable Development Research Institute);
- Watershed assessments completed for forest licensees in the TLU for Peachland, Trepanier, Powers, Lambly, and McDougall Creek watersheds;
- Geological maps
- Fish habitat assessments and other fisheries studies; and
- Digital orthorphotos (2002) covering the entire study area.

The analysis of water use and supply required the compilation of all water licences in the TLU and determination of their precise location. Licence data, organized by stream hierarchy, was provided by MSRM, however most seepages and springs are omitted from this dataset. This it was necessary to cross-reference digital point-of-diversion files and the online water licence query at Land and Water B.C. to identify missing licences. Given the format of the water licence dataset, it is possible for several points-of-diversion under a single licence to each have a licenced quantity attributed to it. Therefore, in order to avoid counting a licence more than once, it was particularly important that the data was screened for multiple points-of-diversion. To simplify comparison, all water use (provided in various units) was converted to metric units.

Conducting the land use analysis required detailed current[1] land use data and statistical data on typical water use for each type of land use. The analysis also required information that shows where, when, and how much urban, economic, and resource development is expected to occur in the TLU in the next 17 years (to 2020). Land use data were somewhat problematic as some of the required data are not available for the entire study area, or for the time frames required of the analysis (2003 and 2020), or are not available in a convenient

[1] For the purposes of this study, "current" is defined as 2003. In some cases where the only available data is not dated 2003, but is reasonably recent, it has been necessary to assume that data is "current".

format. Information on projected land use beyond 2020 is not available – projections to 2050 were based on assumed continuous growth in urban areas at presently projected rates, but no change in the overall land use distribution. Appendix D provides a list of all the information reviewed for the land use analysis, and Appendix E summarizes the land use data requirements and the data that are actually available for analysis, and provides comments on data adequacy.

In analyzing the issues affecting water in the TLU, we relied heavily on the results of TAWG surveys and workshop discussions. Although TAWG members provided information on a broad range of topics, some interests were not represented in the group. Some TAWG members expressed concern that other water issues may exist that have not been included in this report. The size and diversity of the TLU make it difficult to represent all interests on a working group. Nonetheless, the authors of this report are confident that all of the major issues affecting water in the TLU have been identified.

3.2 SOURCES OF INFORMATION

The two lead members of the Steering Committee (RDCO and MSRM) took the lead in coordinating the information collection process. These agencies requested information from various sources, and passed it to the consultants. The consultants followed up where necessary to ensure that all relevant information was collected. The agencies that provided information that was used in completing Phase 1 of the project were:

- The Regional District of Central Okanagan;
- Provincial agencies - MSRM, MWLAP, and LWBC;
- Federal agencies (Fisheries and Oceans Canada (DFO), Environment Canada, and Agriculture Canada (the Pacific Agri-Food Research Station);
- Major water utilities - Westbank Irrigation District, Lakeview Irrigation District, the District Municipality of Peachland, and Westbank First Nation;
- Several minor water utilities in the TLU; and
- The University of British Columbia (hydrologic modelling results).

The information listed in Section 3.1 was obtained from the agencies listed in Section 3.2. Some of the information was made available electronically and some was made available in hardcopy. Digital spatial information was organized for later analysis and presentation.

3.3 INFORMATION EVALUATION AND GAP ANALYSIS

Information was reviewed and evaluated, and used to prepare the technical analyses presented in Sections 4.0 through 11.0 of this report. In each of those sections of the report, the specific information that was utilized is described. Assumptions required for technical analyses are described and implications of data deficiencies are outlined. Some recommendations are made in these sections of the report, and all recommendations are summarized in Section 16.0.

4.0 DESCRIPTION OF THE TREPANIER LANDSCAPE UNIT

Section 4.0 provides an overview of the biophysical characteristics of the TLU, which sets the stage for analyses of water issues (Section 5.0), and descriptions of land use, water use, water pricing, hydrology, water quality, and fisheries (Sections 6.0 through 11.0).

4.1 LOCATION

The Trepanier Landscape Unit (TLU) covers an area of 990 km^2 along the west side of Okanagan Lake (Figure 1.1). It is located in the Regional District of Central Okanagan, and encompasses:

- the communities of Peachland, and Westbank;
- several other smaller communities;
- rural and agricultural areas; and
- the Westbank First Nation’s Indian Reserves 9 and 10.

The eastern boundary of the TLU includes the shoreline of Okanagan Lake, but not the lake itself. The southern, western, and northern boundaries follow watershed divides.

Five principal watersheds are located in the TLU and include (from north to south): Lambly Creek, McDougall Creek, Powers Creek, Trepanier Creek, and Peachland Creek (Figure 1.2 and Map 1). With the exception of McDougall Creek, all are classified as Community Watersheds. Community Watershed status has also been granted to the watershed above Rose Valley Lake. In addition, there are several residual areas containing streams and seepages that drain the slopes along the west side of Okanagan Lake. For the purposes of this investigation we have identified five residual areas: Westside Road, Lakeview, Westbank North, Peachland North, and Peachland South (Figure 1.2).

Land use in the TLU includes residential, commercial, and agricultural uses near Okanagan Lake, and forestry, water storage, and range uses in the upper elevations. A former copper and molybdenum mine (the Brenda Mine) is located in the headwaters of Peachland and Trepanier Creeks, and several sand and gravel extraction facilities are found throughout the

TLU. The TLU is also heavily used for recreation, and includes Eneas Lake Provincial Park, Trepanier Protected Area, several Regional Parks (including Glen Canyon, Rose Valley, and Mt. Boucherie), Bear Creek Provincial Park, Fintry Provincial Park, Shorts/Chapperon Protected Area, and the McDougall Rim and Powers Creek trail networks.

4.2 PHYSIOGRAPHY AND BEDROCK GEOLOGY

4.2.1 Overview

The TLU is located on the west side of the Okanagan Valley and extends from an elevation of 342 m on the west side of Okanagan Lake to 1,900 m on the Thompson Plateau. The physiography of the Okanagan Valley is largely the result of glacial and fluvial erosion and deposition. Much of the Okanagan Valley bottom is therefore blanketed with glacial till, outwash, and glaciolacustrine sediment. The valley slopes that extend up to the plateau are typically steep with bedrock bluffs and are covered by a thicker mantle of surficial materials (mainly colluvium) than is the valley bottom. The Thompson Plateau is characterized by rolling gentle slopes with a relatively thick fluted surficial veneer composed of till and outwash. Colluvium is also common along incised valleys on the plateau.

The bedrock of the TLU is primarily composed of volcanics. A series of Miocene-aged basalt flows up to 20 m thick cap the bedrock geology of the Thompson Plateau. Underlying the plateau basalts and extending throughout much of the upper to middle elevation terrain of the TLU are plutonic rocks (e.g., granite and granodiorite) mainly from the Nelson and Okanagan Batholiths. Volcanic rocks (namely trachyte, breccia and andesites) are common in the valley bottom areas (e.g., Mount Boucherie). The physiography and bedrock geology of the five principal watersheds in the TLU are described in more detail below. A hypsometric curve for each of the principal watersheds (that indicates the watershed area at or below a given elevation) is provided in Figure 4.1.

4.2.2 Lambly Creek Watershed

Lambly Creek drains an area of 243 km^2 from its headwaters at Tadpole Lake on the Thompson Plateau to Okanagan Lake at Bear Creek Provincial Park. Elevations in the watershed range from 1,860 m at the apex of Whiterocks Mountain to 342 m at Okanagan Lake. The watershed divide crosses Terrace Mountain along the northern boundary of the TLU at about 1,600 m elevation (in the area of the proposed Dunwaters Creek diversion). The median elevation for the watershed is 1,281 m. Lambly Creek and its tributaries have incised into the bedrock in this area, which is almost exclusively Rossland and Nicola Group pyritic slate, phyllite, and argillite with local occurrences of limestone. The lower reaches of the Lambly Creek drainage are underlain by plutonic rocks (Nelson Group granodiorite and granite) and minor amounts of trachyte near the mouth of Lambly Creek (Tempelman-Kluit, 1989).

4.2.3 McDougall Creek Watershed

McDougall Creek drains an area of 53 km^2 from its headwaters at Hayman Lake on the Thompson Plateau to Okanagan Lake 1.5 km north of Westbank. The majority of the McDougall Creek drainage is on the relatively steep and rocky slopes on the west side of the Okanagan Valley, opposed to the gently graded plateau that makes up significant portions of the other principal drainages in the TLU. Elevations in the McDougall Creek watershed range from 1,560 m at the summit of Mount Swite to 342 m at Okanagan Lake. The bedrock that underlies the watershed is dominantly volcanic in origin. Marama and Kitley Lake Formation trachyte and volcanic breccia are the dominant rock types (Tempelman-Kluit, 1989).

4.2.4 Powers Creek Watershed

Powers Creek drains an area of 145 km^2 from its headwaters at Islaht, Dobbin, West, Jackpine, Paynter, Webber, and Lambly Lakes on the Thompson Plateau to Okanagan Lake 2 km south of Westbank. Elevations in the Powers Creek watershed range from 1,864 m at the summit of Whiterocks Mountain to 342 m at Okanagan Lake. The median elevation for the watershed is 1,242 m. Plutonic rocks (granite and granodiorite of the Okanagan Batholith) underlie the western portion of the headwaters around Paynter and Jackpine Lakes. Low-grade metamorphic and sedimentary rocks, namely Nicola and Rossland Group pyritic slate, phyllite, argillite, quartzite and limestone, underlie the eastern headwaters area.

Volcanic rocks, namely, trachyte, breccia, and rhyolite are the dominant bedrock types in the lower reaches of the Powers Creek watershed (Tempelman-Kluit, 1989).

4.2.5 Trepanier Creek Watershed

Trepanier Creek drains an area of 258 km^2 from its headwaters on the Thompson Plateau to Okanagan Lake 3 km north of Peachland. The headwater reaches of Trepanier and Lacoma Creeks are deeply incised relative to the other streams in the TLU. Elevations in the Trepanier Creek watershed range from 1,900 m at the summit of Mount Gottfriedsen to 342 m at Okanagan Lake. The median elevation of the watershed is 1,228 m. The underlying bedrock geology is dominated by Nelson plutonic rocks, including granodiorite, quartz diorite, and granite. Trepanier Rhyolite is also common, particularly in the lower reaches (Tempelman-Kluit, 1989).

4.2.6 Peachland Creek Watershed

Peachland Creek drains an area of 145 km^2 from its headwaters at Peachland Lake on the Thompson Plateau to Okanagan Lake 2 km south of Peachland. Elevations in the Peachland Creek watershed range from 1,900 m at the apex of Mount Gottfriedsen to 342 m at Okanagan Lake. The median elevation in the Peachland Creek watershed is 1,209 m. Bedrock geology in this area largely consists of plutonic rocks (granodiorite, quartz diorite and granite) from the Nelson and Okanagan Batholiths. Nicola and Rossland Group pyritic slate, phyllite, argillite, quartzite and limestone also underlie the region, particularly on the northeast side of the drainage (Tempelman-Kluit, 1989).

4.2.7 Residual Areas in the TLU

The residual areas, which include all of the areas in the TLU that drain directly into Okanagan Lake and are not a part of the five primary watersheds, total approximately 146 km^2. The residual areas include Mt. Boucherie, Mt. Coldham, and Mt. Drought as well as isolated valley-side streams that do not funnel into the primary drainage systems. The majority of streams in this area are ephemeral (i.e., do not flow year round) and not well incised. The area is characterised by a wide range of slopes, from the gently sloped valley bottom of the Okanagan valley to steep rock bluffs. Elevations in the residual areas range from more than 1,400 m at the summit of Mt. Hayman to 342 m at Okanagan Lake. The bedrock geology that underlies this area is dominated by volcanics, in particular trachyte, andesite, volcanic breccia, and Trepanier Rhyolite.

4.3 SURFICIAL GEOLOGY AND SOILS

Surficial materials at higher elevations on the Thompson Plateau consist mostly of patchy veneers of glacial till and colluvium overlying bedrock. The till dates back to the last glacial period when the interior plateau was covered by ice. Glaciofluvial deposits (e.g., sand and gravel) are the primary material at lower elevations and in many of the major stream valleys. Many of the tributary valleys to the Okanagan Valley (e.g., Peachland Creek) were meltwater channels that drained the melting ice from the plateau (Rood, 2001). Also, near the mouths of major streams, modern alluvial fans and raised delta deposits are prominent. These deposits are characterised by interbedded silt, sand and gravel. Near Mount Boucherie, surficial materials also include glaciolacustrine sediments (e.g., clay and silt) that are remnants of Glacial Lake Penticton. Till is also present at lower elevations, however it is rarely exposed outside of gravel pits.

Dark Brown Chernozemic soils are found at elevations below approximately 600 m in the TLU, where the moisture regime is semiarid, the parent materials are lacustrine silts, fluvial sands and gravels and glacial till, and the vegetation is sparse (Valentine et al., 1981). At elevations above approximately 600 m, soils are dominantly classified as Eutric and Dystric Brunisols. Eutric Brunisols are typically associated with fluvioglacial sands and gravels and open forests of ponderosa pine or Douglas fir with bluebunch wheatgrass or lodgepole pine and pine grass (Valentine et al., 1981). Dystric Brunisols are typically associated with till and colluvium on the plateau.

4.4 BIOGEOCLIMATIC ZONES

Five principal biogeoclimatic zones occur in the TLU. At elevations below 600 m, the very dry hot Ponderosa Pine and Bunchgrass (PPxh1 and BGxh1) zones are dominant. At middle-elevations is the Interior Douglas-fir (IDF) zone, the most common zone in the TLU. Between 600 m and 1,000 m the very dry hot Interior Douglas-fir zone (IDFxh1) is dominant, and at slightly higher elevations (between 1,000 m and 1,400 m) the dry cool Interior Douglas-fir zone (IDFdk2) becomes extensive. Higher up the slopes (between 1,400 m and 1,800 m) the dry mild Montane Spruce zone (MSdm2) becomes common. At the highest elevations in the TLU, on the plateau and mountain summits (above 1,800 m), the very dry cold and dry cold Engelmann Spruce-Subalpine Fir zones (ESSFxc and ESSFdc2) occur.

4.5 CLIMATIC AND HYDROLOGIC REGIMES

A total of 11 Environment Canada climate stations have operated in the TLU, of which six are still active [Peachland Greata Ranch (1126078), Peachland Wind (112F080), Peachland (1126070 and 1126070), Kelowna Quail's Gate (1123993), and Kelowna Lakeview (1123990)]. Lower elevations in the TLU are represented well by the Peachland station (elevation 345 m), while the decommissioned station at Brenda Mines (1126077) (elevation 1,520 m) is generally representative of the higher elevations in the TLU. At the Peachland station (1126070) (Figure 4.2), mean daily temperatures range from a high of 21.1°C in July to a low of –1.2°C in December. Total precipitation averages 401 mm, of which 91 mm (water equivalent) falls as snow. At Brenda Mines (Figure 4.3), mean daily temperatures are highest in August, at 14.1°C, and lowest in December, at –7.3°C. Total precipitation at Brenda Mines averages 653 mm, with 389 mm (water equivalent) falling as snow. The above values are all averages based on the period 1971 – 2000, taken from Environment Canada (2003). These statistics show that with increasing elevation in the TLU, temperatures generally become cooler and precipitation is not only greater but also includes a higher proportion falling as snow.

The TLU is located in the Southern Interior hydrologic zone (MELP, 1998). According to Obedkoff (2000), the TLU has annual runoff volumes that vary with elevation, from less than 100 mm near Okanagan Lake to in excess of 200 mm in the headwaters. Roughly 75% of the annual runoff occurs between April and July in response to snowmelt. Runoff typically peaks in May although in low elevation watersheds, peak runoff may occur considerably earlier. Following the spring peak, streamflows steadily decline throughout the summer, fall, and winter. Annual minimum flows occur typically in fall or winter, but may also occur in late summer. Given the ubiquitous nature of withdrawals, storage and diversions in the TLU, the natural hydrologic regimes of most streams have been affected by anthropogenic influences. Offstream water withdrawals tend to reduce runoff volumes, and storage in upland reservoirs (e.g., Peachland Lake, Lambly Lake) affects the shape of the natural hydrograph.

Year to year variability in annual runoff is relatively high in the Okangan (including the TLU). Figure 4.4 presents the total annual runoff (i.e., inflows to) on a per unit area basis for Okanagan Lake. As outlined in Rood (2001), there are consistent patterns of declining annual runoff in the late 1940's and 1950's, above average annual flows in the 1960s and 1970s, and below average flows in the 1980s. Annual inflows to Okanagan Lake average 80,000 m^3/km^2 over the period of record, and have ranged from as low as 13,000 m^3/km^2 to as high as 220,000 m^3/km^2. By comparison, inflows to Harrison Lake, which drain an area comparable in size but in a wetter (coastal) climate, average 500,000 m^3/km^2 and range from 390,000 m^3/km^2 to 650,000 m^3/km^2. While the variability between the two areas is comparable in absolute terms, as a proportion of their respective means the variability is much greater for the Okanagan than near the coast. This is reflected by a coefficient of variation (i.e., standard deviation divided by mean) of 50% for the annual inflows to Okanagan Lake. This contrasts with the coefficient of variation of annual inflows to Harrison Lake of 11%.

4.6 SUMMARY

The Trepanier Landscape Unit covers 990 km^2 on the west side of Okanagan Lake within the boundaries of the Regional District of Central Okanagan. The area includes the watersheds of five major creeks: Lambly, McDougall, Powers, Trepanier, and Peachland. Elevations range from 342 m at Okanagan lake to a maximum of about 1900 m at the highest elevations along the western boundary of the TLU. The bulk of the land base (the mid and upper elevations) is managed by the provincial crown, where land uses include forestry, agriculture (range), recreation, and mining. Lower elevations along the shore of Okanagan Lake include one small municipality (Peachland), a first nation community (Westbank I.R. #9 and I.R. #10), and a large rural unincorporated area, where land uses include urban, commercial, industrial, recreation, and agriculture. There are five biogeoclimatic zones represented in the TLU. Bedrock geology is typically of volcanic origin. Lower elevations are mantled by glaciofluvial and glaciolacustrine deposits, and higher elevations are typically mantled with colluvium and/or glacial till. Annual precipitation in the TLU varies with elevation, and is relatively low, averaging about 600 mm per year. Average annual runoff varies with elevation from about 120 to 230 mm. Inter-annual variation in annual runoff is significant in the Okanagan and accounts for a large portion (50%) of the mean annual runoff. Streamflows rise to a peak in spring in response to snowmelt, then decline through the summer to baseflow levels by late summer. These baseflows are maintained through the winter.

5.0 WATER MANAGEMENT ISSUES, GOALS, AND POLICIES

Section 5.0 presents a discussion of the Acts, regulations policies, objectives, and guidelines that relate to water management in the TLU. Information obtained from the TAWG on water-related issues, barriers to more effective water management, and rates of compliance with existing policies is also presented. Finally, water management goals relevant to the TLU are highlighted. The information provides the framework for the technical discussions that follow in subsequent sections of the report.

5.1 INTRODUCTION

The natural characteristics of the hydrologic regime, the requirements of the varied water users, and increasing urbanization and resource development create a variety of issues for water management in the TLU (Figure 5.1). Ideally, a sufficient supply of clean water would be available and affordable to meet the needs of all users at all times, and to maintain the ecological functions of watersheds. In most places, including the TLU, land use practices, associated water demands, and environmental conditions affect the ability to achieve the ideal balance of supply and demand.

5.2 KEY ISSUES FOR WATER MANAGEMENT IN THE TLU

5.2.1 Issues Identified by Water Managers

The TAWG identified the following issues in the TLU through a survey and discussions at a May 8, 2003 workshop:

- Unregulated groundwater use;
- Unlicensed water use;
- Over-recorded streams;
- Protection of current water uses in the face of future development;
- Increasing competition for water, for example increasing residential needs versus orchard irrigation requirements;
- Forestry practices that impact timing of flows;
- Low flows, particularly in September, that harm fish and fish habitat;

- Increasing development and associated impervious surfaces affect the timing of flows;
- Forestry road development impacts on water quality and fish habitat;
- Range operations, particularly the impacts of cattle watering on streams;
- Unregulated recreation use, specifically motocross riders, that increases erosion and sedimentation in streams;
- Mining impacts on water quality;
- Urban development occurring along watercourses; and
- Tenure conflicts on private, Crown, and First Nations land.

These issues do not occur uniformly throughout the TLU. For instance, flow reductions that affect fish spawning or rearing will be more important on reaches of streams that have high fisheries values than in areas with low fisheries values. (All five major streams in the TLU have high fisheries values.) Forestry roads are more common in the higher elevation portions of the TLU, and urban development occurs in lower elevations. Mines are found in a few specific locations, and their effects are concentrated in downstream areas.

It is notable that flooding is *not* considered a major issue in the TLU. The alluvial fans of the major streams in the TLU are all subject to flooding and erosion. However, the only flood protection works (other than localized bank works on most of the streams in developed areas) is some diking done by the Municipality of Peachland along the lower reaches of Trepanier Creek upstream of Hwy 97. The water supply reservoirs in the headwaters of each of the major TLU streams provide incidental mitigation of floods, although this is not their primary function.

There have been specific concerns associated with flooding in the following areas:

- The upper reaches of Trepanier Creek (above Highway 97C) where the flows have exceeded channel capacity;
- The fan of Trepanier Creek in the vicinity of Highway 97;

- The lower reaches of McDougall, Powers, and Peachland Creeks on their floodplains within approximately a kilometre of Okanagan Lake. Along these reaches, the channel capacity has been exceeded in part due to high flows and in some instances channel erosion and infilling;
- Drainage problems due to limited channel capacity, infilling, and development along smaller streams (e.g., Smith Creek) and drainages in areas like West Kelowna Estates, Glen Rosa subdivision, and some of the smaller pockets of development north of Westbank along west side of Okanagan Lake; and
- Flooding from Okanagan Lake of low-lying lakefront properties (e.g., Green Bay and Fintry).

There have also been localized debris flows in some of the steeper portions of the watersheds such as McDonald Creek (near Brenda Mine) and some other smaller drainages (e.g., a small creek near the Highway 97C and Drought Hill in Peachland experienced a debris flow about 4 years ago which blocked Highway 97.

Potential impacts on water resources in the TLU are summarized as follows:

- Water utilities divert water from natural channels;
- Mines may release metals and sediments into watercourses. (Brenda is presently the only major mine in the TLU, and it has been closed since 1990). The potential exists for other mines to operate, and gravel pits are scattered throughout the TLU;
- Dams (for water supply retention, tailings ponds, or other purposes) interrupt natural stream flows, change hydrology, interrupt migration corridors for aquatic animals, and affect downstream ecology and alluvial fan dynamics;
- Logging may result in increased sedimentation, drainage effects and sedimentation from roads, altered hydrology, and changes in water temperature;
- Irrigated agriculture removes water from streams, changes stream hydrology and drainage patterns, can introduce fertilizers and pesticides into ground and surface water, and can generate increased nutrients that may reach streams and groundwater;
- Land cultivation for agriculture increases erosion and sedimentation;

- Gravel operations may remove water from streams for washing aggregate, modify stream hydrology, and increase sedimentation;
- Manufacturing operations use water, and can contaminate stormwater and sewage water;
- Housing increases impervious surface area, increases water use, and may result in contamination of stormwater and groundwater (mainly from metals, fertilizers, and pesticides);
- Transportation systems may result in changes in drainage, increased imperviousness, modification of streamflows and streambeds, and contamination of runoff due to emissions of hydrocarbons, metals, and other chemicals from motor vehicles and the use of de-icing chemicals on roadways;
- Sewage treatment can result in the release of metals and other contaminants; and
- Outdoor recreation can increase sedimentation (e.g., from off-road vehicles), alter shorelines (from cabins, docks, and boat launches), and introduce fertilizers and pesticides into the environment (particularly golf courses).

Water in the TLU is typically affected by more than one of these factors, so maintaining adequate supplies of clean water for human use and to maintain ecosystems requires management of a broad spectrum of land use, water use, and contamination issues.

5.2.2 Cumulative Effects

In a watershed, human activities can combine to result in cumulative effects that are greater than anticipated individual effects. For instance, the introduction of organic matter into a stream might not be a problem under normal flows and volumes. If flows and volumes are reduced by human use or natural conditions, then the concentrations of organic matter can increase, biological oxygen demand may go up, and stream dependent organisms may be harmed. The quality of the remaining water in the stream may decline, affecting downstream users and ecosystems, and requiring increased levels of treatment prior to human use. The analyses of Sections 8.0 and 14.0 in this report indicate that streamflows have already been reduced by human activity and that flow reductions will become more severe in future.

5.3 Existing Management Policies and Guidelines (LRMP and OCPs)

Water in the TLU is managed by large number of agencies operating under a large number of Acts and regulations, as indicated in the following table:

Legislation	Legislation
Water Act	Water Utility Act
Fisheries Act	Environmental Management Act
Forest & Range Practices Act	Environmental Assessment Act
Drinking Water Protection Act	Mines Act
Drainage Ditch and Dyke Act	Range Act
Health Act • Safe Drinking Water Regulation • Sanitary Regulation • Sewage Disposal Regulation	Local Government Act
Waste Management Act	Fish Protection Act† • Streamside Protection Regulation
Water Protection Act	Land Act

† not yet enacted

Water managers in the TLU are already familiar with many of the water management issues described in this report. Water management planning has occurred at many levels during the past 30 years in the Okanagan Basin. During the 1970s, the federal and provincial governments sponsored a study of water in the Okanagan. The study recognized the importance of coordinated planning—for land use as well as water—and recommended a unified institutional structure for planning throughout the Okanagan basin. The Okanagan Basin Water Board (OBWB) was created following release of the federal-provincial report to coordinate implementation of the report's recommendations. However, to this date the OBWB has not yet been able to galvanize sufficient valley-wide support to effectively implement this mandate. Recent efforts to create water management partnerships using administrative services of the OBWB have proved unsuccessful, primarily due to lack of municipal support.

Land and resource users in the TLU (as in most parts of British Columbia) have historically developed plans specific to their tenures or activities that were approved by associated regulators. For instance, forest management plans are prepared by forest licensees and approved by the Ministry of Forests. Land use plans are developed by local governments and approved by Municipal Councils and Regional District Boards. Water licences are approved by Land and Water B.C., and applications to remove land from the Agricultural Land Reserve are reviewed by the Land Reserve Commission.

As a response to uncoordinated and often conflicting resource uses, the provincial government instituted the preparation of Land and Resource Management Plans (LRMPs) in British Columbia. The Okanagan-Shuswap Land and Resource Management Plan (OSLRMP), completed in 2002, contains extensive description, analysis, and policy guidance for the use of land, water, and other resources in the plan area. The TLU covers a relatively small portion of the OSLRMP area. The goals of the Okanagan-Shuswap LRMP that are relevant to water management are outlined in Section 5.6. The present report provides recommendations for a water management plan, which will provide assistance to water users and managers in the area as they implement the goals of the OSLRMP.

Another important document that provides context for the TLU Water Management Plan is the *Water Resources Discussion Paper* (2000) prepared by the Regional District of Central Okanagan as part of their Regional Growth Strategy process. The Discussion Paper contains a description of agencies involved in water management, the Growth Strategy elements that apply to water (and associated land use), and suggests policy directions for streams and for water delivery. Among the items listed as potentials for consideration in the region are:

- apply provincial guidelines as a baseline for protecting aquatic habitat in all land development and public sector investments;
- reduce per capita water use;
- apply wastewater best management practices from Okanagan Basin Water Board and Ministry of Health;
- consider full or partial closure of community watersheds on an “as needed” basis (although this option is also declared infeasible in another part of the document);

- build an Okanagan Basin partnership for water management;
- link land use decisions to water use planning; and
- support stewardship and restoration of individual streams.

The Official Community Plans (OCPs) prepared by local governments in the TLU directly affect land use and associated water use and water quality. OCPs have been prepared for Peachland, Westbank, Lakeview, and Westside. OCP goals and objectives are outlined in Section 5.6.

5.4 IMPLEMENTATION OF OSLRMP AND OCP POLICIES

TAWG members were asked to report on their implementation of applicable OSLRMP and OCP policies, and on the effects of implementation on their agencies. A summary of results is presented in this section. In total, 74 policies in six categories (see Table 5.1) were evaluated for implementation by, and effect on, various agencies in the TLU (See Table 1.3 for a list of TAWG members).

Table 5.1 Water management policy categories.

Category	Number of Policies Evaluated	Description
Allocation	10	Policies regarding water licences, complying with water licences, water withdrawals, and protection of licensed users.
Flow Regime	8	Policies about activities that affect the timing and volume of flows in streams, natural drainage patterns, and flooding.
Water Quality	13	Policies stating water quality standards or concerning water quality characteristics.
Land Use – Urban Areas	11	Policies affecting urban and commercial development, septic tanks, and storm water drainage.
Land Use – Resource Areas	10	Policies on resource activities such as forestry, agriculture, mining, and recreation in rural and resource extraction areas (primarily non-urban areas).
Land Use – Riparian Areas	22	Policies specific to activities in riparian areas adjacent to streams.

There are two clear trends in the responses – policy implementation rates are relatively low; and very few respondents identified negative effects of the policies on their agencies. On average, 33 percent of all responses indicated that the specified policies had been implemented.[2] Only five percent of total responses indicated that negative effects occurred or might occur by implementing the policies.

Responses varied slightly among categories. Water quality and flow regime policies have the lowest implementation rates at 25 and 28 percent respectively (Figure 5.2). Implementation rates for all other categories range between 35 and 38 percent. In all categories, the percentage of responses recording negative effects of policy implementation is 10 percent or lower (Figure 5.3). In other words, 90 percent or more of the respondents see implementation of the policies in all categories as having either no effect or a positive effect on their agencies.

In each policy category, there are exceptions to the trends, as described in the following synopses. Some inconsistencies in survey responses have been noted and are likely due to different responses from representatives of the same agencies to the same question, or potentially to differing interpretations among respondents. The survey results are presented as submitted, without revision, because reinterpreting survey responses could not be done reliably.

5.4.1 Allocation

Of the ten water allocation policies reviewed, none have been implemented by all who regarded them as applicable, although four show implementation rates of 50 percent or higher[3] (Table 5.2). The Ministry of Agriculture, Fisheries, and Food (MAFF) (Kelowna branch) reported it would not implement the OSLRMP policy requiring all water users to keep and submit records of water use and water quantity held in reservoirs. The Ministry of Forests (MOF) (Range branch) and the Lakeview Irrigation District identified negative

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[2] For each group of related policies, the percent implementation is defined as the percentage of positive responses as a proportion of the total responses. For example, if a policy category contains five policies that apply to six agencies, the total possible score is 30 (six agencies X five policies). If only ten positive responses were received, this would be interpreted as 33 percent implementation (10 / 30).

[3] For each policy, the percent implementation is defined as the percentage of positive responses as a proportion of the total responses received. Agencies did have an option to choose 'not applicable" and these responses have not been included in the calculation.

impacts on their agencies of the OSLRMP policy of restricting the issuance of larger or new water licences until water management plans are in place. MOF (Range branch) also suggested it would be affected negatively by the implementation of the OSLRMP policy to encourage voluntary reductions in allocated quantities and to promote conservation strategies.

Table 5.2 Water allocation policy implementation.

Policy	**Implementation (%)**
Where feasible, utilize water from large lakes or reservoirs instead of from smaller streams.	75
***Water extraction rates and licensing should address the impacts of present or potential water shortages on fisheries, particularly with respect to Peachland Creek and Trepanier Creek.	66
Encourage or require all water users to keep records of water use and water quantity held in storage reservoirs, and submit these records, as requested, to the appropriate authority.	50
Encourage voluntary reductions in allocated quantities and promote conservation strategies that reduce the about of water required for irrigation, commercial, and domestic use.	50
Restrict the issuance of larger or new water licenses in priority watershed until management plans are in place.	33
Conserve instream flows by cancelling unused license quantities.	33
***Existing water supplies, including agricultural and residential water supplies, are to be sustained when developing new areas.	33
MWLAP will identify groundwater sources that provide important contributions to instream flows so interruption or interception of these sources can be avoided.	25
Encourage diversions for consumptive use from mainstream lakes and rivers rather than upland tributaries.	0
Include clauses in new water licence to make consumptive use under licence subject to instream flow requirements during specified low flow periods.	0

***** OCP policies - all others are OSLRMP policies.

5.4.2 Flow Regime

Eight policies from the OSLRMP regarding flow regime were reviewed (Table 5.3). Implementation rates are generally low, with all but two policies showing implementation rates of 33 percent or lower. Two policies have not been implemented by any agency. MAFF (Kelowna branch) and MOF (Range branch) both suggested they would be negatively affected by the implementation of the policy to manage water for instream uses (and provide adequate flows in all seasons). MOF (Range branch) also identified possible negative impacts of the policy to encourage water licensees to create flow management plans (making it a condition of new licences). Westbank Irrigation District has a licensed diversion in operation, and so they reported they could not implement the policy to maintain natural drainage patterns and flows.

Table 5.3 Flow regime policy implementation.

Policy	Implementation (%)
Use both structural and non-structural measures to prevent damage from flooding events and mitigate impacts on downstream resource values.	66
Manage water for instream uses, including fisheries, to provide adequate flows during all seasons.	50
Manage forest harvesting so that cut block placement and harvesting techniques support the properly functioning condition, including the timing and magnitude of flows (LWAP and FPC).	33
Identify and establish floodways and greenways in settlement areas to reduce risk and impact of flooding and erosion.	33
Encourage water licensees to create flow management plans for water storage reservoirs that recognize instream and consumptive uses. A requirement for flow management plans should be included as a condition for new licences.	28
Maintain natural drainage patterns, maintain hydrograph, and maintain low flows in range of current licensed demand.	25
Streamflow: No change in natural variability of timing, duration or magnitude of peak flows, low flows; no change in the natural variability of stream peak flows as a result of road densities in any sub-basin.	0
Maintain natural drainage patterns in both planning and operational phases of developments.	0

5.4.3 Water Quality

Implementation rates in this category are low, with eleven out of thirteen policies showing implementation rates of 33 percent or lower (Table 5.4). This result is somewhat surprising, as many of the policies are well defined with measurable parameters, and because of all policy categories, water quality policies were identified by the fewest responses as having negative effects. Only MOF (Range branch) identified possible negative impacts of the OSLRMP policy to control non-point sources of water pollution and sedimentation through best land management practices.

5.4.4 Land Use - Urban Areas

Of the eleven policies reviewed, three showed an implementation rate of 50 percent or higher (Table 5.5). Most of the policies in this category come from OCPs, and it is interesting to note that implementation rates for OCP policies vary greatly, and seem to be similar to implementation rates for OSLRMP land use policies.

MOF (Range branch) reported possible negative impacts on their agency of the OSLRMP policy to avoid degrading water quality and quantity where proposed developments have the potential to impact domestic water supplies outside of community watersheds.

Table 5.4 Water quality policy implementation.

Water Quality	**Implementation (%)**
Ensure that sewage treatment plants, recreational users, etc. are not contributing harmful levels of parasites or bacteria to streams at any time.	60
Coliforms: No detectable increase in fecal coliforms at intakes.	40
Pesticides: Not detectable at the intake.	33
Avoid activities that could result in increases to stream temperature.	33
Algae: Less than 2ug/L in lakes, less than 50 mg/m^2 chlorophyll-a in streams.	25
Nitrate-N: Less than 10mg/L at the intake.	25
Temperature: Within range and duration of natural variability of the undisturbed watershed.	25
Utilize best management practices for disposal of storm water and wastewater.	25
Control non-point sources of pollution and sedimentation via best land management practices.	25
Road deactivation or other measures should be prescribed to reduce impacts to water quality.	25
A 30 metre wide band on each side of a stream, for a distance of one kilometre above the intake, should be managed to prevent contamination from livestock.	20
Turbidity and suspended sediment: within range and duration of natural variability of the undisturbed watershed; no long-term change in turbidity measured at intakes as a result of road and stream crossings.	0
*****Powers Creek: storm water discharge to Powers Creek, if determined to be injurious to the viability of the spawning areas, shall be diverted or treated prior to discharge into the creek.	0

***** OCP policies - all others are OSLRMP policies.

5.4.5 Land use - Resource areas

Ten policies regarding land uses and activities in resource areas were reviewed (Table 5.6). MOF (Okanagan-Shuswap Forest District) reported that negative impacts could occur to their agency if the implementation of the OSLRMP policy regarding aggregate tenuring and mining permitting processes resulted in increased distances to aggregate sources (and therefore increased costs). The federal Department of Fisheries and Oceans (DFO) noted that, with regard to the OSLRMP policy that the "Ministry of Energy and Mines, in consultation with regulatory agencies, will consider potential impacts to water quality and fish habitat when reviewing applications for new designated placer areas," placer mining is not compatible with fish and fish habitat. DFO also noted that the OSLRMP policy to operate water storage facilities to maximize safety might cause either positive or negative effects downstream.

Table 5.5 Land use: urban areas policy implementation.

Land Use: Urban Areas	**Implementation (%)**
***Cluster housing options will be encouraged.	66
***Septic tanks should not be constructed within 30 metres of the natural boundary of any stream or waterbody.	66
When alienating Crown land prone to flooding, minimize risk to life and property by applying appropriate restrictions on development or use.	50
Avoid degrading water quality and quantity where proposed developments have the potential to impact domestic water supplies outside of community watersheds.	40
Protect the quantity and quality of water in vulnerable aquifer areas. Provide for infiltration over a dispersed area, limit increase in impermeable areas, direct groundwater polluting activities away from recharge areas of community wells	40
***Development will be not permitted or restricted where slopes are greater than 30%.	33
***New development must provide storm water management to mitigate environmental impacts from runoff, erosion, and sedimentation. In some cases, a specific plan must be developed.	33
***Impervious surfaces should be minimized to aid in storm water infiltration. Storm water can be collected in reinforced natural swales or new drainage channels made with natural materials, and then conveyed to a stormwater pond or site drainage system of sufficient capacity.	25
***Hillside development must preserve or protect natural water and drainage courses.	20
***Ensure that storm drainage planning within individual developments considers the Drainage Studies and the cumulative basin-wide effects of all future uses on the water basin.	0
***Encourage the Approving Officer to ensure that all new septic fields would not contaminate existing wells or contribute to any contamination of the Rose Valley drainage area.	0

***** OCP policies - all others are OSLRMP policies.

5.4.6 Land Use - Riparian Areas

The OSLRMP and OCPs contain 22 policies applying to land use activities in riparian areas, of which only three show no implementation (Table 5.7). MOF (Range Branch) identified potential negative effects of the OSLRMP policy on ensuring minimal risk of livestock contributing to harmful levels of parasites or bacteria in streams. MAFF (Kelowna Branch) reported negative effects of the OCP policy to implement a leave strip along streams and banks as set out in the Ministry of Water, Air, and Land Protection (MWALP) Guidelines for

Protection of Aquatic Habitat. DFO noted that a minimum leave strip of 15 metres is required for new urban development, and 30 to 50 metres may be adopted for new rural development, rather than the optional 10 metre and 15 metre setbacks allowed in the OCP policies included in the Land Use: Urban Areas category in this report.

Table 5.6 Land use: resource areas policy implementation.

Policy	**Implementation (%)**
In the course of their licensed uses, water storage reservoirs must be operated and maintained with a primary consideration for safety in the case of structural failure.	100
Amend aggregate tenuring and mine permitting processes to incorporate the following issues and concerns: land and resource values; compatible and incompatible land uses; adjacent land uses; impacts to roads; and impacts to neighbouring communities.	66
*****Development will not be permitted on adjacent lands if there are negative impacts.	50
Prior to receiving authority for a new tenure or use agreement from the statutory decision-maker (SDM), new recreation or tourism uses must show how they can co-exist with existing or established recreation or tourism uses.	40
All roads, trails, and other construction activity must be undertaken under appropriate regulations and standards.	33
Encourage water purveyors to prevent unauthorized access to dams on facility roads.	33
Limit access to the lakeshore and drawdown zone by motor vehicles and other mechanized means of transportation (applies only to lakes that are direct storage reservoirs) – locate new roads at least 210 metres from the lakeshore unless there is no practical alternative.	33
Reduce number of non-status roads in community watersheds that result in harmful impacts on water quality.	25
Ministry of Energy and Mines, in consultation with regulatory agencies, will consider potential impacts to water quality and fish habitat when reviewing applications for new designated placer areas.	0
*****Buffers should be established on non-farm property adjacent to agricultural land that conform to the Landscape Buffer Specification standards (Agricultural Land Commission) and may include roads, topographic features, and watercourses.	0

***** OCP policies - all others are OSLRMP policies.

Table 5.7 Land use: riparian area policy implementation.

Land Use: Riparian Areas	Implementation (%)
Development activities are not to disrupt movement opportunities (i.e., stream crossings that do not obstruct fish passage), or spawning areas.	100
All levels of government that work with private landowners should encourage the use of stream riparian buffers where riparian integrity is compromised.	62
Manage livestock away from riparian areas.	60
Manage development activities to protect sensitive and critical fish habitats such as side channels, off channel habitats, wetlands, small rearing tributaries that are critical habitats.	50
Utilize grazing regimes that minimize impacts to riparian areas.	50
Ensure that range use plans address the sensitivity of riparian areas and minimize livestock impacts on these areas.	50
To maintain the integrity of riparian areas during forestry operations skidder crossings should not occur at a greater density than one per 150 metres of stream.	50
10,000 hectares of “enhanced riparian reserves” will be allocated within the plan area within five years.	40
For a larger S6 stream establish either a 10-metre reserve or retain approximately the equivalent in basal area within the riparian management zone (RMZ) by cutblock.	40
For W3 wetlands, manage for approximately 50% of the perimeter to be in a 30-metre management zone where there will be approximately 50% retention.	40
*****Development will not be permitted in significant ravine, valley, river, or stream corridors (in some areas, development will be permitted only if there is no negative impact).	40
Reduce access to and fording of streams that result in harmful impacts on water quality.	33
*****A leave strip of at least 10, 15, or 30 m from streams or tops of banks should be preserved, as set out in the MELP Development Guidelines for the Protection of Aquatic Habitat.	33
Plan development activities along streams such that stream water temperatures should not increase to the point that they would be detrimental to fish and fish habitat.	25
*****All new development in applicable ESAs should conform to the Land Development Guidelines for the Protection of Aquatic Habitat (MELP).	25
For S1 streams with a stream width greater than 20 metres and less than 100 metres, establish a riparian reserve zone (RRZ) 50 metres wide, and a riparian management zone (RMZ) 20 metres wide on each side, with an average 50% basal area retention.	20
For S2 streams (i.e., stream width greater than 5 metres and less than 20 metres), establish a riparian reserve zone (RRZ) 30 metres wide, and a riparian management zone (RMZ) 20 metres wide on each side, with an average 50% basal area retention.	20
For S3 streams (i.e., stream width from 1.5 to 5 metres), establish a riparian reserve zone (RRZ) 20 metres wide, and a riparian management zone (RMZ) 20 metres wide on each side, with an average 50% basal area retention target	20
For S4 streams with no fish present and S6 streams: a) Establish a machine free buffer of 5 metres adjacent to the stream; and b) Within each sub-basin (as determined in the Interior Watershed Assessment Procedure), no more than 25% of the stream length total of that category of these streams on the Crown land portion is to be in a non-greened-up state.	20
Implement management practices that ensure minimal risk of livestock contributing harmful levels of parasites or bacteria to streams.	0
Ensure that mining activities that occur in riparian management areas minimize, where practical, disturbance to vegetation, and reduce the potential for erosion and sediment delivery	0
*****Development will not be permitted in significant ravine corridors or stream corridors including, but not limited to, the corridors along Law Creek, Powers Creek, Smith Creek, and McDougall Creek.	0

***** OCP policies - all others are OSLRMP policies.

5.5 CHALLENGES FOR WATER MANAGEMENT

Water management has been a key concern in the Okanagan Basin for decades, and many of the issues noted in this report have been identified in previous studies. The lack of action in some areas indicates that plan implementation is not always successful. As part of the survey conducted for this project, selected water managers were asked about barriers to implementation, or "why have the water policies not been more completely implemented?" The following summaries present the views of the survey respondents.

Ineffective management tools. Water management tools are not always effective or geared to integrated watershed management. For instance, solutions for one water management problem (e.g., installing a pipeline for delivering water to domestic users) may negatively affect other watershed components (e.g., fisheries and riparian habitat). Enforcement of existing regulations is problematic, especially where there is a lack of resources for adequate agency participation. Land ownership further complicates water management as jurisdictions, authority, permitting processes, and regulations differ among private, Crown, and First Nations lands.

Groundwater completely escapes regulation in the TLU (as elsewhere in British Columbia). The provincial government requests well drillers to provide drill log information on wells. Otherwise, there are virtually no regulations regarding quantity of water extracted from wells, or assurance or protection of quality.

Lack of data. Timely and accurate data are required to inform water management decisions. Currently, important data elements are held by a variety of agencies and organizations, and there is no established means of sharing data effectively and efficiently. This challenge for water management was identified as long ago as 1974 in the federal-provincial study of water in the Okanagan Basin, which recommended establishing a central data clearing house, potentially administered by the Okanagan Basin Water Board. Summit (2000) made a similar recommendation. Little progress has been made on this initiative to date, although it is understood that the B.C. Freshwater Institute has recently begun work to develop such a product.

Even if data are shared in a timely manner, there may be a fundamental lack of data to support management decisions, for example, data are very scarce on groundwater. Many factors contribute to data gaps, including inadequate long term funding for scientific and routine monitoring, changing priorities of issues requiring study, or the identification of new issues for which data collection methods have not been established.

Limited education on water value and use. Some water users have a good understanding of watershed-wide issues and objectives, and have established processes for undertaking water management activities. Water users with a more limited understanding of the issues may not be using 'best practices,' thereby negatively affecting the watershed. Similarly, public and corporate attitudes to water and its use differ. The supply of clean water may be viewed as a 'right' rather than as a commodity that must be paid for or as a natural asset with intrinsic value, and application of water conservation practices vary widely. Education programs accompanied by consistent regulations and pricing are necessary if the level of awareness of water management issues and best management practices is to be raised.

Organizational barriers. In principle, staff of most agencies agree that a coordinated and integrated approach to water management in the TLU is desirable. In practice, organizational characteristics may create barriers to integrating water management, at both the delivery and political levels. Those responsible for water management sometimes operate independently (in what are sometimes called "jurisdictional silos") without consistent consultation and communication with other managers, leading to land use decisions and allocation of resource rights that inadequately recognize the interests and rights of tenure holders, or the ecological effects of decisions. Some agencies may approach water management from an administrative rather than a watershed perspective, or may function under a legally-mandated narrow focus that precludes consideration of the entire watershed and the associated issues. Budgets also limit the kinds of activities and efforts an agency can undertake, so that even if a particular water management action is deemed desirable, funding may not be available. In the case where money must be spent to mitigate impacts, means for collecting funds from parties responsible for the impact may not be in place.

There are many interests in TLU water; some are water users, others are managers and distributors of water. No single party has overall responsibility for maintaining water supply or water quality in the TLU. These responsibilities fall to water purveyors, companies, various regulatory authorities, and to individuals. The existing model of governance is characterized by periodic communication but limited interaction among government, water purveyors, and other interests in water. This model is not effective for achieving sustainability goals. The narrow focus of individuals and institutions, and the potential for mistrust among the various interests affects the ability to make necessary trade-offs to balance social, economic, and ecological needs. Alternative governance models exist, but there are few examples of success. According to UBC (1997), implementation problems in other areas have included:

- difficulty in establishing and maintaining leadership;
- challenges in reaching consensus among groups; and
- weak legal support for such new models.

Trepanier Advisory Working Group (TAWG) members identified institutional issues as important in the TLU. Institutional inertia is great in matters of water management, particularly because some groups are organized around historic legislative and resource management models and structures, and see little benefit in change. Today's understanding of ecological impacts of water use and of better models of land use and social organization may be powerless to affect distribution and tenure patterns established decades ago.

Differing institutional priorities and conflicting objectives. Water users and managers have diverse and sometimes conflicting requirements, making integrated water management difficult. Some means of setting priorities or evaluating tradeoffs among management decisions must be established if conflicts cannot be directly resolved. For instance:

- How do we decide about trade-offs? What are people's values and how can they be prioritized? Is human health more important than water access for cattle, fish, or recreation? How do we set priorities?
- Will there be new "higher value" water uses in the future, and how will these be accommodated?
- An agency may have a mandate that is inconsistent with the mandates of other water management agencies. How can this inconsistency be overcome?
- How can agencies be motivated to work together when society also has diverse values on many water and land use issues?

Although the various institutions involved in the management and use of water agree on certain principles of water management, their perception of the importance of issues vary and sometimes conflict. Although not all TAWG members responded to the question about water management priorities, the results shown in Table 5.8 reveal that perceptions differ according to the agency's mandate. For example, the following pattern emerges:

- water quality is more important to water purveyors than it is to agriculture, forestry, or fisheries managers;
- low flows are more important to fisheries managers (presumably to leave water in streams for fish) and irrigators (presumably to remove water from the stream for irrigation) than to others;
- protection of riparian areas was rated as a high priority by most agencies;
- DFO has the most consistently high ratings for water management issues; and,
- The Regional District of Central Okanagan (RDCO) and MOF expressed the fewest concerns about water management, although they both had several highly-rated items.

Table 5.8 Perceived importance of water management issues, by agency.

Issue		MAFF	DFO	LID	WID	MOF	RDCO
1.	Low summer flows	H	H	M	M	L	
2.	Fluctuating annual flows	H	M	L	M	H	
3.	Water taste and colour	L	L	H	H	N/A	H
4.	Coliforms and other organisms in water	L	L	H	H	H	H
5.	Clearcutting of forest areas	L	M	M	M	H	
6.	Grazing animals near water bodies	L	H	H	H	H	
7.	Runoff from farms, orchards, livestock	M	H	N/A	L	N/A	
8.	Urban development (housing, commercial)	H	H	N/A	M	N/A	
9.	Increased impervious surfaces	M	H	N/A	L	M	M
10.	Water conservation by residential users	H	H	M	H	N/A	H
11.	Water conservation by commercial users	H	H	M	H	L	H
12.	Water conservation by agriculture		H	M	H	N/A	
13.	Fully recorded streams (water licences)	M	H	H	H	H	
14.	Lack of groundwater management	L	H	N/A	H		M
15.	Riparian protection in urban and forest areas	M	H	H	H	H	
16.	Demand for water outstrips supply	H	H	L	M	L	
17.	Water is priced too low	M	H	H	H	N/A	L
18.	Water is priced too high	M	L	N/A	N	N/A	
19.	Potential mining activity	H					

Agencies:
MAFF = Ministry of Agriculture, Food, and Fisheries
DFO = Fisheries and Oceans Canada
LID = Lakeview Irrigation District
WID = Westbank Irrigation District
MOF = Ministry of Forests
RDCO = Regional District of Central Okanagan

Perceived importance:
H = High
M = Moderate
L = Low
N/A = Not applicable

For water management to be truly successful in the TLU, interests of the agencies will need to be more closely aligned, and each will have to understand and respond to the interests of others. Such collaboration will not imply that the values of all agencies are equally important or consistent with sustainable water management, but rather that the various perspectives will need to be articulated and considered as actions to manage or use water are made. A crucial step in moving toward more sustainable water management is for all agencies operating in the TLU to agree on a single set of water management goals. Recommendations to address these barriers to effective water management are provided in Section 16.0 of this report.

5.6 GOALS AND POLICY ISSUES FOR A TLU WATER MANAGEMENT PLAN

This planning study is being undertaken in the context of a variety of Acts, regulations, plans, policies, and guidelines. This section of the report highlights some of the water management goals that are particularly relevant to the TLU.

5.6.1 LRMP Goals

The Okanagan-Shuswap LRMP contains the following goals pertaining to water management. Although not distinguished in the LRMP, the goals clearly fall into two categories: those that deal with the *process* of water management decisions, and those that describe a desirable *state* of the hydrologic system.

Goals of the water management process:

- Manage consumptive and instream uses of the surface and groundwater resource on a sustainable basis;
- Ensure instream flows for fish, fish habitat, and aquatic ecosystems are considered when making water allocations; and
- Maintain the integrity of the hydrometric inventory system.

Goals for the hydrologic system:

- Achieve and maintain properly functioning conditions of streams including the timing and magnitude of flows;
- Manage for good water quality as indicated by levels of turbidity, temperature, sediments, and contaminants;
- Minimize risk to life and property from floods, erosion, mass wasting, and debris torrents; and
- Maintain the quality and quantity of ground water.

5.6.2 Official Community Plan Goals and Objectives

Four Official Community Plans (OCPs) have been prepared in the TLU: Westside, Westbank, Lakeview, and Peachland. The plans express local perspectives and priorities, and set directions for future development in their jurisdictions. The OCPs also contain Regional Context Statements, describing how the plan complies with the RDCO Regional Growth Strategy.

This section provides a brief summary of some of the goals, objectives, or vision statement elements contained in the OCPs of TLU jurisdictions that are relevant to water management.

Westside OCP

<u>Vision</u>

- Improve Westside Road while retaining the rural character of the community.
- Service certain subdivisions with community water, sewer, and storm drains, consistent with rural character.

<u>Objectives</u>

- Provide a framework to identify, manage, and protect Environmental Sensitive Areas (ESAs) and significant watercourses.
- Incorporate the *Land Development Guidelines for Protection of the Aquatic Habitat* in the Westside OCP.
- Maintain high water quality in surface water, ground water, and aquifers.
- Regulate, through provincial agencies, the siting and environmental design of development near flood plains, the waterfront, and along streams or creeks.
- Apply RDCO's water quality objectives in Westside, including using water quality as the prime determinant of land use in watersheds.

Lakeview OCP

<u>Objectives</u>

- Provide a framework to identify and manage ESAs.
- Protect the quality and integrity of ecosystems, including air, water, land and biota.
- Ensure valley-wide cooperation and coordination to protect water quality of lakes, rivers, and streams in the Okanagan Basin.
- Use water quality as the prime determinant of land use in watersheds.
- RDCO should liaise with various water purveyors to ensure an overall coordinated water management strategy for adequate water supply and quality as the community expands.
- An Okanagan-wide water conservation strategy and program should be pursued.
- Existing water supplies, including agricultural and residential water supplies, are to be sustained when developing new areas.

- Prepare strategies for overall storm water management.

Peachland OCP

Objectives

- Protect ESAs from impacts of development.
- Maintain water quality in our streams and along Okanagan Lake.
- Control storm run off from development in order to minimize impacts on streams and Okanagan Lake.
- Preserve and enhance fish habitat through implementation of Streamside protection regulations.
- Recognize and protect the rural character of Peachland by directing new development to established neighbourhoods in the municipality.

Westbank OCP

Vision

- A strong rural character through the protection of agricultural lands and open spaces where appropriate.
- Single family neighbourhoods, protected from encroaching higher density.
- A fully serviced community, where water supply and a storm water drainage plan is expected to address any concern of low quality or insufficient municipal services in all urban areas of Westbank.
- Managed growth, using sewer and water utility extensions and road access to avoid sprawl or premature developments.
- A network of open space, parks, and ESAs, linking neighbourhoods and providing recreational amenities.

Goal statements

- Protect the quality and integrity of the ecosystem, including air, water, land, plants, and animals. Require a system of water, sewer and storm drainage infrastructure that promotes health and safety in an environmentally and financially sustainable manner.
- Ensure a phased approach to water, sewer and drainage service extensions and improvements that support this Land Use Plan.

The OCPs contain a variety of more specific policies and implementation actions associated with these broad vision, goal, and objective statements.

With regard to water, the OCPs emphasize protecting quality and providing adequate supply and delivery to existing and future development. Most plans include statements reflecting the importance of protecting the ecological character of the hydrologic system (streams, vegetation, wildlife). The OCPs pay more attention to the form and servicing of new development than to the tradeoffs between use of water for human activity and for the needs of fish and riparian ecosystems.

Only in Lakeview's plan does water conservation receive mention, and there only in the context of an Okanagan Basin-wide initiative. The plans reflect little in the way of local responsibility for water conservation; supply-side solutions seem to be preferred.

Most of the plans recognize the need for collaborative action among jurisdictions in managing water. The TLU is a logical geographic unit to further such collaboration on water management goals and actions.

5.7 SUMMARY

Major water stakeholders in the TLU identified several water-related issues that affect the TLU, including unregulated groundwater use, over-licensed streams, reductions in flow that affect fish, urban development along watercourses, increasing competition for water, and water quality impacts associated with range, forestry, mining and urban land use.

The Okanagan-Shuswap Land and Resource Management Plan (LRMP) and four Official Community Plans (OCPs) provide goals and objectives, as well as policies for water management in the TLU. Water-related LRMP policies can be categorized into 6 groups (allocation, flow regime, water quality, land use in urban areas, and use in resource areas, and land use in riparian areas). Agencies with responsibility for water management, however, reported that their rates of implementation of LRMP and OCP policies was relatively low, even though the policies were not in general perceived to have a negative effect on them.

Stakeholders identified several challenges to effective water management, including ineffective management tools, lack of data, limited education on water value and use, organizational barriers, and differing institutional priorities and conflicting objectives.

Although there is good cooperation among the agencies responsible for water management in the TLU, and they agree on some principles of water management, there is little coordinated management. To ensure long-term economic and environmental sustainability in the TLU, it is important that agencies operating in the TLU agree on water management goals, and work together to implement improved water management.

6.0 LAND USE IN THE TLU

6.1 INTRODUCTION

The TLU supports a wide range of land uses, from densely developed urban areas to large areas of forest cover, each with unique effects on water demand and quality. These land uses are described in this section and their implications for water resources are introduced. Detailed estimates of water use are provided in Section 7.0.

Analysis of land tenure and use indicates that the TLU can be subdivided into an upper zone of Crown Land, and a lower zone of largely private land. Most of the agricultural and urban development in the TLU has occurred within the lower zone. In addition, water licence information indicates that most of the water use within the TLU occurs in the lower zone. Therefore, for the purposes of a description of land use, we have conveniently subdivided the TLU into an upper "resource" zone, and a lower "urban" zone (Figure 6.1).

In addition, for the purposes of a detailed analysis of water use in Section 7.0, the TLU has been sub-divided into 14 areas for which population and water use information has been compiled (Figure 6.2).

6.2 RESOURCE LAND

Resource lands are primarily Crown-owned with little urbanized development. Major land uses include extensive agriculture (generally restricted to grazing operations), forestry, mining, and tourism and recreation (Figure 6.3).

Extensive Agriculture

Agricultural operations on resource land consist of cattle grazing on non-irrigated grasslands and forest, and watering at streams. Currently, all available Crown range tenures have been allocated, due to the shortage of privately-owned land suitable for spring and fall grazing (J. Paul et. al., 1998). The Ministry of Forests administers range tenure and regulates the number of animals using each tenure area. Approximately 880 cow-calf pairs range in the TLU (MAFF, 2003), using an estimated 5.4 m^3 of water per day (equivalent to 1,960 m^3 of water annually, or less than 0.01 percent of the total annual water use in the TLU). Much of this water is returned to the ground near the point of consumption.

Approximately 6,200 hectares of resource land in the TLU is designated as Agricultural Land Reserve (ALR). Aerial photography from 1999 shows no signs of intensive agricultural activity, so the ALR land is assumed to be used only for range operations.

Forestry

Commercial forestry has been ongoing in the TLU for many decades. Currently, Riverside Forest Products, Gorman Brothers Lumber, and MOF operate in the TLU. Silvicultural systems include clearcutting and selective logging, but practices have changed over time as provincial regulations have developed. Infestations of mountain pine beetle have been an issue in the TLU, and past logging has sometimes concentrated on infested areas rather than on older growth stands (J. Paul et. al., 1998). Watershed assessment reports provide the following general descriptions of logging activities in the five major sub-basins included in this project:

- In the Lambly Creek watershed, early harvesting centred on infested areas and clearcutting has been the commonly used method (Dobson, 2001a).
- Logging in the Peachland Creek watershed has taken place near the main tributaries and more recently in the Peachland Lake area (Dobson, 1999).
- The Powers Creek watershed has supported forestry since the mid 1940s, although the majority of harvesting in the upper portion of the watershed occurred in the 1980s and 1990s (Dobson, 2001b).
- Logging has occurred in the McDougall Creek watershed, with harvesting in the upper watershed beginning in 1995 under a small business licence (Summit, 1996).
- Logging has occurred throughout the Trepanier Creek watershed. Much of the recent harvesting has been concentrated in the Lacoma and McDonald sub-basins (Dobson, 1998).

The watershed assessment reports also include a number of indicators of logging activity. For each sub-basin (Figure 6.4), total harvested area, equivalent clearcut area (ECA), and number of stream crossings, among others, are reported (Table 6.1).

Table 6.1 Logging Activity Indicators for Interior Watershed Assessment Report Sub-basins.

Sub-basin		**Area (ha)**	**Harvested (%)**	**ECA (%)**	**Number of stream crossings**
Trepanier Creek	Jack	4,025	38.5	11	26
	Lacoma	4,787	18.5	15	13
	Upper Trepanier	3,589	15	7.5	5
	MacDonald	3,568	5.5	23	29
Peachland Creek	Sub-basin P1	3,322	42	9	34
	Sub-basin P2	6,359	29	19	102
	Sub-basin P3	4,483	24	10	55
Lambly Creek	North Fork	4,183	50	41	163
	Terrace	7,920	51	35	158
	Bald Range	4,072	25	18	59
McDougall Creek	McDougall	4,510	Unknown	11	26
Powers Creek	North Powers	3,356	35	29	54
	West Powers	6,170	26	22	62

Adapted from Dobson (1998), Dobson (1999), Dobson (2001a and b), Summit (1996).

The Lambly Creek watershed has been the most heavily logged, with three-quarters of the watershed reported to be 50 percent logged (Figure 6.5). Portions of the Trepanier Creek, Peachland Creek, and Powers Creek watersheds also show high percentages of harvest. ECAs exceed 30% only in the upper sub-basins of Lambly Creek.

Watershed assessment reports are meant to assess the potential impacts of proposed forestry plans on the watershed, specifically on peak flows in watercourses, channel stability, riparian function, surface erosion (associated with forestry roads), landslides, and water quality. Based on the watershed assessment reports for the watersheds in the TLU, completed between 1996 and 2001, some historic impacts on riparian areas and peak flows are noted as having likely occurred prior to existing regulations. Although the reports do not indicate a significant concern with respect to potential future impacts on water supply or quality due to future harvesting in the study area, they do provide recommendations to minimize future impacts.

Energy and Mining

Potential for energy production and mining exists in the TLU, with known mineral occurrences of precious metals (gold, silver), base metals (lead, zinc, copper, molybdenum), industrial minerals (limestone, clay, gypsum, graphite, sand, gravel), gemstones (opal, agate), and uranium. However; exploration activity has lagged behind other areas of the province (J. Paul et. al., 1998). Although numerous mineral tenures exist, Brenda Mine (now owned by Noranda) is the only major mine in the TLU. It has been closed since 1990 and reclamation activities continue to the present time.

Aggregate extraction is conducted in the TLU to support local construction and infrastructure maintenance demand. Currently, 35.5 million tonnes of aggregate supply are under permit to industry and 3.5 million tonnes are under permit to the Ministry of Transportation (MOT). Figure 6.6 shows locations of operating sand and gravel pits in the TLU. Most pits are in urbanized areas; only six of the sites identified are on resource land, and all six are licensed to MOT (EBA, 2000).

Tourism and Recreation

Tourism and recreation on resource lands includes a variety of activities, such as fishing, canoeing, boating, hiking, hunting, trail riding, wildlife viewing, downhill skiing, cross-country skiing, and snowmobiling. Figure 6.7 shows some of the variety of tourism and recreation features in the TLU. Figure 6.8 indicates the tourism and recreation management zones from the OSLRMP. On Crown land in particular, key activities noted in J. Paul et. al. (1998) include:

- Hunting – both guide outfitting and recreational hunting (key species include deer, black bear, mountain goat, mountain sheep, and cougar);
- Camping and recreation activities in provincial parks and forest recreation sites;
- Motorized activities (such as ATVs and snowmobiles); and
- Sportfishing, with small lakes forming the backbone of the Okanagan sport fishery.

Tourism and recreation activities, as practiced at tourism and recreation sites, trails, and in general recreation areas, generally have little impact on water supply and demand on resource land. Facilities and resorts that provide food and accommodation require domestic water and produce wastewater. Only five such facilities are located in the TLU (Figure 6.7). Crystal Mountain Resort is the only facility of sufficient size to potentially affect water demand.

The Jackpine Lake Resort, Telemark Cross Country Ski Club, and the Silver Lake Forest Education Centre are small, seasonally-used facilities that are unlikely to cause any water related impacts.

6.3 URBAN LAND

In the "urban" zone of the TLU, land use includes residential, commercial/industrial, and intensive agriculture. This section includes an introduction to the land uses. Water use associated with each type of land use is presented in Section 7.0.

Residential development in the TLU is focussed in the District Municipality of Peachland, the town of Westbank, Westbank First Nation reserves #9 and #10, and in several other subdivisions or developments. Most of the population lives within sub-areas C through N (Figure 6.2). The present population of the TLU is 36,336 [Appendix F, based on RDCO (2003b)]. This figure was actually correct in 2001, and although there may have been some change to this figure between 2001 and the present, we have assumed that 36,336 is the present population.

Commercial and industrial activities include a range of activities, including aggregate production (described more fully in Section 6.2), three golf courses, retail malls, an industrial park, a nursery, and two wineries.

Areas of intensive agriculture in the TLU include orchard crops and vineyards. Approximately 982 hectares of land are currently used for intensive agriculture. Most of the irrigated agriculture in the study area occurs on the benchlands near Okanagan Lake, sometimes in close proximity to urban areas, as shown in Figure 6.9.

6.4 SUMMARY

Land uses in the TLU include forestry, mining, range and recreational activities in the mid and upper elevation "resource" areas, and residential, agricultural, commercial and industrial activities in low elevation "urban" areas close to Okanagan Lake. These land use activities require water and thus affect water quantity, and also have the potential to affect water quality and aquatic resource values.

Except for the water storage reservoirs, water use by activities occurring on the mid and upper elevation "resource" lands is relatively minor, compared with water use on the "urban" lands, where most of the population of 36,336 live. Residential development is concentrated in the District Municipality of Peachland, the town of Westbank, Westbank First Nation reserves #9 and #10, and several other subdivisions. Commercial and industrial operations include a nursery, two wineries, retail malls, an industrial park, and several aggregate operations. There are 982 ha of intensive agriculture in the TLU, much of which is irrigated.

7.0 WATER USE

7.1 INTRODUCTION

This section analyses water use in the TLU according to source (surface water, groundwater, Okanagan Lake), purveyor, location (14 communities), and sector (residential, commercial, industrial, and agricultural).

Two principal approaches were used to estimate water use in the TLU. The first approach involved organizing and estimating water use by source and purveyor (i.e., supply-side). The second approach involved organizing water use by land use (i.e., demand-side). Both approaches necessarily involve assumptions (that are documented in their respective sections below), however, in order to increase confidence in the underlying assumptions and ultimately the final estimates, an iterative procedure was employed whereby the results of the two approaches were compared and assumptions (i.e., per capita residential water use) were adjusted until the results of the two approaches were reconciled.

Section 7.2 summarizes the estimates of water use by source (i.e., surface water, Okanagan Lake, and groundwater) and by purveyor. For the main water purveyors, details are provided on their water systems, licensed quantities and actual water use records. For the smaller purveyors and other water licensees, all available details on water use are provided. In Section 7.3 the estimates of water use by land use (i.e., residential, commercial/industrial, and agricultural) organized by community[4] are summarized. Section 7.4 presents an overall summary of the water use analysis.

7.2 ESTIMATES OF WATER USE BY SOURCE AND PURVEYOR

To assist the reader, it is recommended that Sections 7.2.1 through 7.2.4 be read in conjunction with the chart provided in Appendix C.

[4] Distribution system losses (e.g., leakage) were also included in this analysis.

7.2.1 Surface Streams

Water licences have been issued on 184 streams or waterbodies in or adjacent to the TLU (including Okanagan Lake). The licences total 53.674 million m^3 for offstream uses and 12.595 million m^3 for instream uses. These figures do not include storage licences, which total 36.098 million m^3 in the TLU (although only 28.950 million m^3 of the licensed storage volume is actually utilized). A list of all licensed water users in the TLU is provided in Appendix B. The list was compiled from Water Rights Information System Demand Reports (MSRM, 2003a) (as of June 6, 2003) for the five principal watersheds, and online water licence reports from Land and Water B.C. To ensure all streams and springs were accounted for throughout the TLU, the data set was cross-referenced with digital map files containing all licensed points-of-diversion (PODs) supplied by the Information Management Group of the Ministry of Sustainable Resource Management.

The analysis of actual water withdrawals from surface sources in the TLU is organized by the 10 areas of the TLU identified on Figure 1.2 and Map 1. The analysis is based on several data sources, and involved a number of assumptions when data on actual water use was not available.

In total, water withdrawn from surface streams in the TLU is estimated to be **16.107 million m^3 per year**. An estimated 14.476 million m^3 or 90% of all surface water use in the TLU is obtained from the five principal watersheds (Lambly, McDougall, Powers, Trepanier, and Peachland Creeks). The remaining 1.631 million m^3 or 10% is distributed among the water users in residual areas 6 through 10. The details behind these estimates are provided below.

Lambly Creek (Area #1)

The total estimated offstream water use from Lambly Creek is **4.521 million m^3 per year**. Approximately 94% of the water used in the Lambly Creek watershed is by the Lakeview Irrigation District (LID), with the remaining 6% used by other water licensees.

Lakeview Irrigation District (LID)

The LID is located directly across Okanagan Lake from the City of Kelowna and services an area of 9.30 km^2 of which 1.58 km^2 (17%) is agricultural land (Figure 7.1). The agricultural land served by the LID is distributed as follows: 55% orchards (using overhead sprinklers), 23% vineyards (using drip irrigation), and 22% vacant land (old orchards) (Jeffery, pers. comm., 2003b). In 2002, the LID supplied water entirely from the Lambly Creek watershed to approximately 3,060 domestic connections (approximately 11,200 people). Currently, the LID holds water licences for a total of 9.683 million m^3 of water per year (5.242 million m^3 for waterworks, and 4.440 million m^3 for irrigation). However, the actual annual average water withdrawal is estimated to be **4.237 million m^3** (or 44% of its licensed volume). Table 7.1 presents the monthly water use by the LID from 2000-2002.

Table 7.1 Monthly water use by Lakeview Irrigation District for 2000 to 2002 (Jeffery, 2003a).

MONTH	YEAR			
	2000	**2001**	**2002**	**AVERAGE**
	m^3	m^3	m^3	m^3
Jan	110,721	129,476	93,773	111,323
Feb	106,080	112,100	116,120	111,433
Mar	122,080	135,454	118,590	125,375
Apr	218,433	233,745	250,996	234,392
May	436,366	495,727	436,672	456,255
Jun	594,359	538,908	719,017	617,428
Jul	752,996	809,505	969,054	843,852
Aug	794,330	751,615	799,136	781,693
Sep	322,985	491,137	566,207	460,110
Oct	229,460	245,785	254,827	243,357
Nov	119,763	141,137	134,211	131,704
Dec	112,229	121,550	127,193	120,324
Total	3,919,807	4,206,144	4,585,802.1	**4,237,251**

Water storage reservoirs, reservoir capacities and locations, and drainage diversions used by the LID (see Map 1) are described below:

Rose Valley Lake reservoir (live storage 2.880 million m^3) is the primary storage reservoir for the LID water supply. The natural drainage area for this reservoir is 3.26 km^2, however, water from Lambly Creek (downstream from the Esperon Lake and Big Horn reservoirs) is diverted to the Rose Valley Lake reservoir greatly increasing the drainage area. The Lambly Creek diversion consists of a low diversion weir and a 6,400 m long 800 mm diameter pipeline. The Rose Valley Lake reservoir is dammed by a 25 m by 100 m earth fill dam.

Big Horn reservoir (live storage 2.300 million m^3) is a secondary storage reservoir and is primarily used to store surplus water during spring freshet for release during the late summer, fall, and winter. The watershed area draining into the Big Horn reservoir is 34.7 km^2. This area would be increased by 7.84 km^2 with the future construction of the Dunwaters Creek diversion. Water flows from the reservoir down Terrace Creek to Lambly Creek. It is then diverted to the Rose Valley Lake reservoir.

Esperon Lake reservoir (live storage 0.190 million m^3) is also a secondary reservoir located in the upper reaches of the Lambly Creek watershed. The watershed area draining into Esperon Lake is 1.0 km^2. The only drainage diversion is a manually operated 26-inch square slide gate that is used to regulate flow. Drainage from the reservoir flows to the Rose Valley Lake reservoir via Lambly Creek.

System Management: According to LID documents, the typical LID annual operating strategy consists of:

- filling the reservoirs at Esperon Lake, Big Horn Dam, and Rose Valley Lake during spring freshet (April 1 to June 30);
- utilizing unregulated flow from Lambly Creek from April to June while discharge is great enough to meet the consumption requirements;
- withdrawing water from storage when Lambly Creek can no longer meet the service area water demands; and

- after spring freshet, fisheries releases of water are maintained at 300,000 m^3 per month between March and November and 200,000 m^3 per month between December and February.

The LID water supply is distributed directly from the outlet of the Rose Valley Lake reservoir. Chlorination and metering take place directly downstream of the dam. Large diameter (600 mm and 900 mm) steel pipe conveys the treated water to consumers. With the exception of two small pumps, the entire system is supplied by gravity.

Other Water Users

Individual water licences within the Lambly Creek watershed other than the Lakeview Irrigation District total **0.284 million cubic metres per year** (MSRM, 2003a) and are listed in Appendix B. Since no information is available on actual water use by these licensees, for the purposes of this analysis we have assumed that actual water use is equal to the licensed quantity.

McDougall Creek (Area #2)

The total estimated offstream water use from McDougall Creek is **1.118 million m^3 per year**. Approximately 28% of the water used in the McDougall Creek watershed is by the Westbank First Nation, with the remaining 72% used by individual water licensees.

Westbank First Nation

Water use by the Westbank First Nation from McDougall Creek is assumed to be equal to the total licensed quantity of **0.312 million m^3 per year** (MSRM, 2003a).

Other Water Users

Since no actual water use information was available, water use from the remaining licensees in the McDougall Creek watershed is assumed to be equal to the total licensed quantity of **0.806 million m^3 per year** (MSRM, 2003a).

Powers Creek (Area #3)

The total estimated offstream water use from Powers Creek is **5.303 million m^3 per year**. Approximately 93% of the water used in the Powers Creek watershed is by the Westbank Irrigation District (WID), with the remaining 7% used by individual water licensees.

Westbank Irrigation District

The Westbank Irrigation District (WID) services an area of 12.5 km^2 around the community of Westbank (Knight and Piesold, 1981; Figure 7.1). In 2002, the WID supplied irrigation water to 144 agricultural users that irrigate a total of 3.88 km^2, domestic water to approximately 4,156 residential homes (population of 11,886), 204 commercial services, and 41 industrial customers. The water supply for the WID is obtained primarily from the Powers Creek watershed[5]. Currently, the WID holds water licences for 11.142 million m^3 of water per year (62% for irrigation and 38% for waterworks). However, actual use of water averages 44% (4.957 million m^3) of its licensed annual volume. Table 7.2 presents the monthly and annual water use by the Westbank Irrigation District for 2000 and 2001.

[5] The WID diverts water from a portion of the Lambly Creek watershed via Sandberg Ditch, Whiterocks Ditch, Tadpole Lake, and Alocin Creek.

Table 7.2 Monthly water use by Westbank Irrigation District for 2000 and 2001 (NHC, 2003c).

MONTH	YEAR		
	2000	2001	AVERAGE
	m^3	m^3	m^3
Jan	132,405	132,710	132,558
Feb	134,068	116,383	125,226
Mar	147,210	139,497	143,353
Apr	270,851	253,539	262,195
May	553,116	636,950	595,033
Jun	601,034	674,723	637,879
Jul	953,074	973,777	963,426
Aug	1,030,405	926,192	978,299
Sep	477,516	690,111	583,814
Oct	273,443	234,437	253,940
Nov	152,453	141,365	146,909
Dec	134,366	135,189	134,777
Total	4,859,942	5,054,874	**4,957,408**

Water storage reservoirs for the WID, reservoir capacities and locations, and drainage diversions based on WID (2002) and Dobson (2002) are summarized below (see Map 1):

Lambly (Bear) Lake Reservoir (live storage 6,170,000 m^3) is the closest reservoir to the WID intake. It is located on the divide between the North Powers Creek and the Lambly Creek watersheds. Prior to development of the lake as a reservoir, Lambly Lake drained at its north end into Lambly Creek. Following the construction of a saddle dam at the north end and a dam at the south end (with low level outlet and spillway), all inflows to Lambly Lake have been routed to North Powers Creek. Paddle Creek has been diverted to supplement runoff.

Tadpole Lake Reservoir (live storage ~6,000,000 m^3) is situated near the divide between the Lambly Creek and Powers Creek drainages. The north end of Tadpole Lake is dammed (across the natural drainage path into North Lambly Creek) and drainage is routed south into Powers Creek via Alocin Creek. Two interceptor ditches have also been constructed to divert runoff from Whiterocks and Sandberg Mountains to the drainage area of Tadpole Lake.

Jackpine Lake reservoir (live storage 1,220,000 m^3) is located along the divide between Powers Creek and Trepanier Creek at a similar elevation as Lambly Lake. Infrastructure at the Jackpine reservoir is limited to an earth fill dam and spillway across the natural outlet of the lake into Powers Creek.

Dobbin Lake reservoir (live storage 692,000 m^3) is situated on the upper reaches of Powers Creek on the drainage divide between the Powers Creek watershed (Okanagan Watershed) and the Alocin Creek watershed (Nicola Watershed). Runoff into Dobbin Lake is heavily dependent on the diversion of Alocin Creek and Tadpole Lake, via the Nicola Ditch. Similar to the Jackpine reservoir, an earth fill dam regulates drainage of the reservoir into Dobbin Creek on its way to Powers Creek.

Horseshoe (Islaht) Lake reservoir (live storage 995,000 m^3) is located approximately 500 m east of Dobbin Lake. Horseshoe Lake consists of three arms. The west arm is connected to the main lake by an excavated channel. Each arm is dammed and drainage is directed down its natural course into Powers Creek. Flow from Bit Creek has been diverted into Horseshoe Lake increasing the catchment area.

Paynter Lake reservoir (live storage 431,000 m^3) is situated on the western edge of the Powers Creek watershed at an elevation of 1,360 m. Paynter Lake has been dammed at three locations. The northern most dam is the Control Dam with a 400 mm corrugated metal pipe outlet. The Middle Dam and South Dam are cut-off dams.

System Management: According to (Dobson, 2002) the typical WID annual operating strategy consists of:

- if possible, carrying over storage capacity from one year to the next in the Jackpine (~60%), Lambly (~30%), and Tadpole Lake (~20%) reservoirs to ensure adequate water supply for the following year;
- if there are significant amounts of carry over storage and a normal to above normal spring runoff is expected, diversion paths (e.g. Paddle Creek and Bit Creek) will be regulated or closed and reservoir water may be released prior to spring freshet, in order to minimize peak discharges through dam spillways;
- during drought conditions all diversions are opened to maximize the input to reservoirs; and
- all releases from the reservoir are determined and authorized by the Manager of WID based on the runoff conditions during freshet and irrigation demands during the period April 1 - September 30.

The intake for the WID's water supply consists of a concrete dam, debris filter, and spillway located on Powers Creek approximately 3 km upstream from the mouth. From the intake, water is piped 2,135 m to the head of the distribution system. At this point, the water is chlorinated and distributed through two sub-systems, east and west of Powers Creek (Knight and Piesold, 1981).

<u>Other Water Users</u>

Offstream water use by the remaining licensees in the Powers Creek watershed is assumed to be equal to the total licensed quantity of **0.346 million m^3 per year** (MSRM, 2003a). This value excludes the total licensed quantity for instream (conservation) use of 2.679 million m^3 per year (MSRM, 2003a).

Trepanier Creek (Area #4)

The total estimated offstream water use from Trepanier Creek is **1.785 million m^3 per year**. Approximately 53% of the water used in the Trepanier Creek watershed is by the District of Peachland, with the remaining water use distributed between the Star Place Water System (approximately 1%), Dietrich Water System (approximately 1%), and other individual water licensees (45%).

District of Peachland

The District of Peachland provides water for approximately 1,900 domestic services (approximate population of 4,600) and several agricultural and commercial services. Three systems are operated by the District of Peachland to obtain, store, and distribute water:

- Water System #1 - Source: Trepanier Creek and Okanagan Lake;
- Water System #2 - Source: groundwater wells;
- Water System #3 - Source: Peachland Creek.

On Trepanier Creek, the District of Peachland currently holds water licences for 3.482 million m^3 of water per year (51% for waterworks and 49% for irrigation). However, on average only 27% (**0.950 million m^3**) of its licensed annual volume is actually used (NHC, 2003c; Table 7.3). The following outlines Water System #1 for which Trepanier Creek is the primary source:

> **Water System #1 (WS#1)** supplies water to approximately 800 agricultural, residential, and commercial services along the Peachland shoreline, downtown (below an elevation of 400 m), along Desert Pines Avenue, along Clarence Road and vicinities (between 400 m and 470 m elevation), and to the region bounded by Cousins, MacKinnon, and Dryden Roads (above 450 m elevation). There are two water sources for WS#1: Trepanier Creek and Okanagan Lake. Generally, water is diverted from Trepanier Creek via a 400 mm diameter pipe to a small settling pond and chlorine injector and then is pumped out for use. If the water quality of Trepanier Creek becomes impaired, water is pumped from Okanagan Lake to the Cousins Reservoir (Urban Systems, 2001).

Table 7.3 Monthly water use from Trepanier Creek by District of Peachland for 1999 to 2001 (NHC, 2003c).

MONTH	YEAR			
	1999	**2000**	**2001**	**AVERAGE**
	m^3	m^3	m^3	m^3
Jan	29,159	31,540	31,012	30,570
Feb	26,908	28,754	27,765	27,809
Mar	29,466	31,451	29,514	30,144
Apr	45,086	57,479	54,488	52,351
May	0	54,792	60,939	38,577
Jun	95,612	128,372	117,908	113,964
Jul	192,144	188,905	191,029	190,693
Aug	196,130	216,479	176,600	196,403
Sep	114,086	102,761	127,575	114,807
Oct	70,208	76,330	69,927	72,155
Nov	31,712	27,828	67,733	42,424
Dec	29,208	27,033	65,473	40,571
Total	859,721	971,724	1,019,962	**950,469**

Star Place Water System

Star Place Water System is located on the Trepanier Bench and services 8 residential lots with approximately 11,000 m^3 of water per year (RDCO, 2003a).

Dietrich Water System

Since no actual water use data was available, we have assumed that actual water use is equivalent to the total quantity of licences, i.e. for 10,000 m^3 of water per year (MSRM, 2003a).

Other Water Users

Individual licences for other water users in the Trepanier Creek watershed total 0.814 million m^3 per year (MSRM, 2003a). We have assumed that actual use equals the total licensed quantity.

Peachland Creek (Area #5)

<u>District of Peachland</u>

For Peachland Creek, the District of Peachland currently holds water licences for 7.436 million m^3 of water per year (64% for waterworks and 36% for irrigation). However, on average only 19% (**1.416 million m^3**) of its licensed annual volume is actually used (NHC, 2003d; Table 7.4). The following outlines Water System #3 for which Peachland Creek is the primary source:

> **Water System #3 (WS#3)** supplies water to approximately 910 agricultural, residential, and commercial services in the Princeton and Sanderson Avenue area. In the upper reaches of Peachland Creek, Peachland Lake reservoir has been created. An earthfill dam was constructed at the natural outlet of Peachland Lake to enhance water storage for Brenda Mine. Since the closure of the mine in 1990, the District of Peachland has utilised the lake as a reservoir. Water flows from the reservoir via Peachland Creek to a screened intake (5.6 km upstream from Okanagan Lake) and treatment facility. From the treatment facility water is distributed through a main 600 mm pipe, which supplies progressively smaller water mains (Urban System, 2001).

Table 7.4 Monthly water use from Peachland Creek by District of Peachland for 1999 to 2001 (NHC, 2003d).

MONTH	YEAR			
	1999	**2000**	**2001**	**AVERAGE**
	m^3	m^3	m^3	m^3
Jan	32,867	32,420	36,052	33,779
Feb	28,973	27,554	32,603	29,710
Mar	34,668	38,145	36,638	36,484
Apr	96,535	99,159	77,912	91,202
May	168,451	164,537	200,372	177,787
Jun	221,840	205,209	173,442	200,164
Jul	273,039	266,821	273,337	271,066
Aug	272,730	317,866	232,132	274,243
Sep	165,061	121,820	196,754	161,212
Oct	83,775	84,362	67,202	78,446
Nov	31,733	33,897	30,247	31,959
Dec	29,149	32,006	28,676	29,944
Total	1,438,821	1,423,796	1,385,367	**1,415,995**

<u>Other Water Users</u>

Offstream water use from the remaining licensees in the Powers Creek watershed is assumed to be equal to the total licensed quantity of **0.333 million m^3 per year** (MSRM, 2003a). This value, however, excludes the total licensed quantity for instream (conservation) use of 9.823 million m^3 per year (MSRM, 2003a).

Residual Areas (Areas 6-10)

Total annual water use in the residual areas of the TLU (i.e., those not drained by one of the five principal streams) is estimated to be **1.631 million cubic metres per year**[6], and is broken down as follows:

- Area #6: 0.033 million m^3 per year (all individual licensees);
- Area #7: 0.179 million m^3 per year (69% by Westbank First Nation, 31% other licensees);

[6] The presented estimate of total annual water use in the residual area does not include one licence for "land improvement" at Camp Hewitt Spring in Area #10 totaling 2.679 million m^3. Water under this licence is diverted to a pond for "beautification" purposes and released back to the stream (Bender, pers. comm., 2004).

- Area #8: 1.111 million m^3 per year (30% by Westbank First Nation, 70% by other licensees);
- Area #9: 0.061 million m^3 per year (all individual licensees); and
- Area #10: 0.247 million m^3 per year (all individual licensees).

These estimates assume that actual water use is equivalent to the licensed quantities for offstream use.

7.2.2 Okanagan Lake

Roughly 157 water licences have been issued on Okanagan Lake in the TLU (Appendix B). In total, water use from Okanagan Lake is estimated to be **7.304 million m^3 per year**[7], with 28% by local water purveyors, 23% by the Westbank First Nation, 1% by the District of Peachland, and 48% by other licensees. The details behind these estimates are provided below.

Local Water Purveyors

Knight and Piesold (1981) suggests that most private water utilities pump water primarily from Okanagan Lake and/or from local wells and typically store it in underground or above ground reservoirs. Distribution systems typically consist of multiple pump systems conveying water from a reservoir tank through PVC or cement piping to the users. The primary use is domestic, although there is some commercial (e.g. Casa Loma Resort) and seasonal irrigation use (e.g. Casa Loma area; Casa Loma, pers. comm., 2003). The following outlines the estimated water use by each of the local water purveyors that use water from Okanagan Lake:

- Casa Loma Utilities services 173 users (2 seasonal irrigation, 1 commercial – Casa Loma Resort, and 170 single family homes. Water use averages 115 m^3 per day in

[7] The presented estimate of total annual water use from Okanagan Lake does not include one licence for “land improvement” by the Green Bay Property Owners Association totaling 3.572 million m^3. Water under this licence is diverted to a canal for “beautification” purposes and released back to Okanagan Lake (Bender, pers. comm., 2004).

the winter and 1,325 m^3 per day in the summer (Casa Loma, 2003). Total annual water use is therefore estimated to be **0.190 million m^3**;

- Fintry Utilities is licensed to use **0.083 million m^3** of water per year (MSRM, 2003a), which we have assumed approximates actual use;
- Green Bay Resort – Mortier is licensed to use **0.085 million m^3** of water per year (MSRM, 2003a), which we have assumed approximates actual use;
- Green Bay Waterworks services a minimum of 59 residential lots (Knight and Piesold, 1981) and is licensed to use **0.017 million m^3** of water per year (MSRM, 2003a). We have assumed the licensed quantity approximates actual use;
- Jennens Road Water Co-op services a minimum of 20 residential lots (Knight and Piesold, 1981). Assuming 3 persons per lot and an average annual per capita daily water use of 789 litres per day (L/day) (see Section 7.3), total annual water use is estimated to be **0.017 million m^3;**
- Pritchard Water System services the entire Pritchard area and includes the Shanboolard system (Harley, pers. comm., 2003). Water is provided to 138 residential lots and one 125-unit commercial campground along the lakeshore in Westbank (RDCO, 2003a). Based on the average of 2001 and 2002 meter readings, the campground uses an average of 8,060 m^3 of water per year. Residential water use is estimated by assuming 3 persons per lot each with an average annual per capita water use of 789 L/day. Therefore, total annual water use by the Pritchard Water System is estimated to be **0.137 million m^3**;
- Sunnyside Utilities services approximately 600 households (approximate population of 2,100) in the Mt. Boucherie area (Jamieson, pers. comm., 2003a). Assuming an average annual per capita water use of 789 L/day, approximately **0.605 million m^3** of water is used per year;
- Traders Cove Waterworks is licensed to use **0.166 million m^3** of water per year (MSRM, 2003a), which we have assumed approximates actual use;
- West Kelowna Estates Water System services 750 residential lots plus approximately 100 vacant lots that are not yet developed, and 200 additional lots that will be joining

the system in the next 1 to 2 years. Annual water use in 2002 was reported at **0.724 million m^3** (RDCO, 2003a); and

- Wilson's Landing Utility is licensed to use **0.014 million m^3** of water per year (MSRM, 2003a), which we have assumed approximates actual use.

Westbank First Nation

The Westbank First Nation serviced a population of approximately 5,878 (RDCO, 2003b) with **1.654 million m^3** of water in 2002 (WFN, 2003).

District of Peachland

As part of Water System #1, if the water quality of Trepanier Creek becomes impaired, water is pumped from Okanagan Lake to Cousins Reservoir (Urban Systems, 2001). Currently, the District of Peachland is licensed to use 0.083 million m3. For the purposes of this report we have assumed that this quantity is approximately equal to actual water use from Okanagan Lake.

Other Water Users

Other water licences from Okanagan Lake within the TLU total **3.529 million m^3** per year. For the purposes of this report we have assumed that this quantity is approximately equal to actual water use from Okanagan Lake.

7.2.3 Groundwater

The potential rates of groundwater use and extraction are difficult to determine, as groundwater users in British Columbia are not required to record pumping rates or pumping duration. In addition, pumping tests to ascertain potential well yields are not required. Accordingly, well yields reported at the time of drilling were used to estimate potential extraction rates.

The total of all the reported extraction rates for the wells registered with MWLAP, and available in other reports, is roughly 400 L/s (equivalent to 6,340 gallons per minute, or 12.6

million m^3 per year, Appendix G). This estimate is based on drillers' estimates, and not on pumping test or flow test data. Drillers' estimates usually refer to maximum well yields, as opposed to long-term pumping rates. Thus, the actual use of groundwater is likely to be much lower. However, since there is no requirement for reporting the drilling of wells, or of groundwater use within BC, it is difficult to accurately assess actual groundwater use in the TLU.

Our best estimate of actual groundwater use is **1.100 million m^3** per year, which is divided between the District of Peachland (70%), Shannon Lake Estates (13%) and others (17%). The details behind these estimates are provided below.

District of Peachland

Water System #2, which is entirely supplied by groundwater, supplies water to approximately 190 residential and commercial (golf course) services in the Peachland area. According to Urban Systems (2001) water is pumped from wells to two reservoirs: (1) on Ponderosa Drive (capacity 418,000 litres) and (2) above the Ponderosa Pines Golf Course (capacity 182,000 litres). Assuming that actual water use is equivalent to the total capacity of the wells [reported as 24.32 L/s (Urban Systems, 2001)], total annual groundwater use by the District of Peachland is estimated to be **0.767 million m^3**.

Shannon Lake Estates

Shannon Lake Estates services a minimum of 169 residential lots (Knight and Piesold, 1981) using groundwater. Assuming that 3 people occupy each lot, and each person uses an average of 789 L/day (on an annual basis), it is estimated that **0.146 million m^3** per year is used by Shannon Lake Estates.

Other Water Users

If it is assumed that each of the 217 wells listed in Appendix G is used for domestic purposes (a single residence with 3 persons each), the annual water use (assuming an average annual per capita water use of 789 L/day) from groundwater would be **0.187 million m^3**. Since this represents less than 2% of the maximum extraction rate of 12.6 million m^3, it is possible that agricultural and industrial users account for most of the groundwater used in the TLU.

7.2.4 Total Water Use

The estimated total annual offstream water use in the Trepanier Landscape Unit is **24.511 million m^3**. This is distributed as follows:

- 16.107 million m3 (66%) from streams (i.e., surface water);
- 7.304 million m^3 (30%) from Okanagan Lake; and
- 1.100 million m^3 (4%) from groundwater sources.

Section 7.3 outlines how these quantities are distributed among the types of land use in the TLU and by community.

7.3 ESTIMATES OF WATER USE BASED ON LAND USE ANALYSIS

7.3.1 Introduction

A second method to estimate water use in the TLU, which was used in this report, is based on land use information. The principal land use categories adopted for this report include residential (considering both indoor and outdoor use), commercial/industrial and agricultural[8]. Although not a land use, distribution systems losses (i.e., leakage) have also been taken into account in estimating total water use in the TLU.

Water use on “resource” land is relatively small relative to water use on “urban” land. In this section of the report, the areas are considered together. As indicated in Section 6.0, water by extensive agriculture is minimal. Historic forestry operations have been determined to have a minimal impact on the hydrologic regime. Water use by other activities on “resource land” (including Brenda Mine, aggregate operations, and tourism operations) is accounted for in this section of the report.

[8] Golf course water use has also been considered, and is summarized under agricultural use.

On "urban" land, several key data sets form the basis for the water use analysis:

- Community build-out projections, prepared by RDCO staff, showing current and future (2020) population and number of dwellings in the TLU;
- Population and employment projections for urbanized areas of the TLU, prepared by Urban Systems (1999), showing current and future (2018) employment in selected economic sectors and providing conversion factors from number of persons employed to square footage of development in each sector;
- Water use adjustment factors for selected land uses, prepared by Urban Systems (2002) for RDCO, allowing for estimates of water use by various urban land uses; and
- Current and future agricultural development and associated water use, developed by Agriculture and Agri-Food Canada (Agriculture and Agri-Food Canada, 2003 and 2003b).

Sections 7.3.2 through 7.3.5 summarize water use for each of the principal land use categories by community. All data that these summaries are based on are provided in Appendix H.

7.3.2 Residential Water Use

Estimates of the residential demand for water are available for the District of Peachland, Lakeview Irrigation District (LID), and Westbank Irrigation District (WID). Urban Systems (2001) reported a per person annual average demand for water (including both personal and outdoor use) in the District of Peachland of 900 L/day, which they noted as being among the highest rates of domestic water use in British Columbia, if not the world. In the Lakeview Irrigation District, Reid Crowther (2000) estimated average annual residential water use at 865 L/day. During drought years, per capita water usage is expected to increase considerably. UMA (1992) estimated per capita domestic use for a <u>drought year</u> in the Lakeview Irrigation District (LID) at roughly 1,370 L/day (consisting of 370 L/day for indoor use and 1,000 L/day for outdoor use), which includes distribution losses. Although not directly comparable, per person “domestic” water use reported for the Westbank Irrigation District (which includes both residential and commercial purposes) is estimated at 1,239 litres per day (consisting of 375 L/day for indoor use, and 864 L/day for outdoor use) (Jamieson, pers. comm., 2003b).

To put these domestic water use estimates into context, average per person domestic water use in communities in the southern interior of British Columbia similar to the TLU includes the following:

- Kamloops (unmetered): 820 litres/day;
- Kelowna (prior to metering): 775 litres/day; and
- Vernon (prior to metering): 700 litres/day (Urban Systems, 2001).

The average of the annual domestic water use in Peachland, Kamloops, Kelowna (prior to metering), Vernon (prior to metering), and the LID is 812 L/day. This average was used as an reasonable initial assumption for the annual water use in the TLU for both the supply-side estimates (outlined in Section 7.2) and the demand-side estimates outlined below. However, during the process of reconciling the supply-side with the demand-side estimates, the initially assumed per capita residential water use was varied until the two estimates (i.e., supply and demand-side) of total water use in the TLU were more or less equivalent. At that point, the best estimate of average annual per capita residential water use in the TLU was determined to be **789 L/day**. This per capita estimate (which reconciles the supply-side with the demand-side estimates) is only slightly below the average water use in similar communities to that of the TLU noted above, and is therefore considered a reasonable value.

Assuming an average annual per capita water use of 789 L/day, and a current population of approximately 36,336, current residential water use is estimated to be on the order of 28.669 million L/day or **10.206 million m^3 per year.** Average annual residential water use for the TLU by community is presented in Table 7.5.

Table 7.5 Current population and residential water use in the TLU.

Community		Population	Average Annual Residential Water Use	
			(L/day)	(m^3/year)
A	Rural Westside Road	1,336	1,054,104	375,261
B	Crystal Mtn & Brenda Mines	205	161,745	57,581
C	Westlake Road & West Kelowna Estates	3,033	2,393,037	851,921
D	Westbank I.R. #10	856	675,384	240,437
E	Shannon Lake	2,660	2,098,740	747,151
F	Lakeview	6,948	5,481,972	1,951,582
G	Smith Creek	1,334	1,052,526	374,699
H	Upper Glenrosa	977	770,459	274,283
I	Westbank I.R. #9	5,022	3,962,358	1,410,599
J	Lower Glenrosa	4,976	3,926,064	1,397,679
K	Westbank North	2,025	1,597,725	568,790
L	Trepanier	109	85,607	30,476
M	Goats Peak & Gellatly	2,202	1,737,378	618,507
N	Peachland	4,654	3,672,006	1,307,234
Total		**36,336**	**28,669,104**	**10,206,201**

Note: Community refers to a geographic area (Figure 6.2)

7.3.3 Commercial and Industrial Water Use

Commercial and industrial water use in all community areas except Peachland was calculated based on UMA (1999) estimates of the number of people employed in a variety of sectors in 1998[9], and on the conversion factors from commercial and industrial use to single family dwellings used in Urban Systems (2002). Data for Peachland were developed from Economic Development Commission (2002) figures for current employment by sector. Appendix H shows the conversion from the number of people employed within each sector to the average annual water use.

Current water use by commercial and industrial development on urban land is estimated to be on the order of 13.498 million L/day or **4.926 million m^3 per year**. Average annual commercial/industrial water use for the TLU by community is presented in Table 7.6.

[9] UMA (1999) analysis boundaries were aggregated to correspond with RDCO population estimate community boundaries.

Table 7.6 Current estimate of commercial/industrial water use in the TLU.

Community		Average Annual Water Use: Finance, Insurance, Real Estate		Average Annual Water Use: Institutional		Average Annual Water Use: Retail Wholesale		Average Annual Water Use: Resource, Manufacturing, Construction, Utilities		TOTAL	
		(L/day)	(m^3/year)	(L/day)	(m^3/year)	(L/day)	(m^3/year)	(L/day)	(m^3/year)	(L/day)	(m^3/year)
A	Rural Westside Road	0	0	0	0	0	0	0	0	0	0
B	Crystal Mtn & Brenda Mines	0	0	0	0	0	0	0	0	0	0
C	Westlake Road & West Kelowna Estates	39,896	14,562	6,613	2,414	323,957	118,244	2,127,105	776,393	2,497,571	911,614
D	Westbank I.R. #10	0	0	0	0	9,541	3,482	0	0	9,541	3,482
E	Shannon Lake	2,769	1,011	24,452	8,925	184,604	67,380	451,027	164,625	662,852	241,941
F	Lakeview	16,473	6,013	31,369	11,450	387,487	141,433	41,815	15,262	477,144	174,158
G	Smith Creek	0	0	0	0	0	0	0	0	0	0
H	Upper Glenrosa	0	0	3,948	1,441	0	0	2,846,021	1,038,798	2,849,969	1,040,239
I	Westbank I.R. #9	11,863	4,330	10,516	3,838	276,280	100,842	113,319	41,361	411,978	150,372
J	Lower Glenrosa	0	0	32,809	11,975	6,493	2,370	0	0	39,301	14,345
K	Westbank North	49,317	18,001	37,741	13,775	407,075	148,583	0	0	494,134	180,359
L	Trepanier	0	0	0	0	0	0	0	0	0	0
M	Goats Peak & Gellatly	22,620	8,256	4,690	1,712	27,418	10,008	175,447	64,038	230,175	84,014
N	Peachland	0	0	193,856	70,758	364,490	133,039	5,267,283	1,922,558	5,825,630	2,126,355
Total		142,937	52,172	345,995	126,288	1,987,346	725,381	11,022,016	4,023,036	13,498,294	**4,926,878**

Note: Water use by golf courses is summarized under agricultural water use (Section 7.3.4)

7.3.4 Agricultural Water Use

Intensive Agriculture

Water use for intensive agriculture was calculated based on information provided by Agriculture and Agri-Food Canada (2003a, 2003b). Areas under intensive agriculture by crop type[10] were first determined by superimposing digital coverages of crop type (Agriculture and Agri-Food Canada, 2003a) with TLU community boundaries provided by RDCO and calculating the areas of each crop type by community using ArcView (version 8.3). The areas of each of the nine crop types were then multiplied by the average annual demand per unit area (i.e., m^3/ha) based on Agriculture and Agri-Food Canada (2003b) data[11]

[10] Nine crop types were distinguished: apple, apricot, cherry, peach, pear, plum, cropland, pasture, and vineyard.

[11] The demand per unit area based on data from Agriculture and Agri-Food Canada was used rather than total reported demands because there appeared to be some discrepancy between Agriculture and Agri-Food Canada and this study on crop areas, TLU boundaries and/or sub-boundaries.

for the TLU. Table 7.7 presents the current estimated annual agricultural water demand in the TLU by community and crop type. In total, intensive agriculture covers 982 ha of the TLU and requires an estimated **7.250 million m^3 of water per year**.

Table 7.7 Current estimated annual agricultural water demand in the TLU by community and crop type.

	Crop Type:	**APPLE**	**APRICOT**	**CHERRY**	**PEACH**	**PEAR**	**PLUM**	**CROP-LAND**	**PASTURE**	**VINE-YARD**	**TOTAL**	**TOTAL**
	Annual Water Demand[1] (m^3/ha):	7,284	8,421	7,421	7,883	7,775	7,719	7,743	7,897	5,078	**Agricultural**	**Water**
											Area	**Demand**
		Area[2]	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**		
	Community	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(m^3/year)
A	Westside Road – Rural							29.8	1.5		31.2	241,968
B	Crystal Mountain & Brenda Mine	9.6						9.2			18.8	141,045
C	Westlake Road & West Kelowna Estates	6.7		27.2	1.7			24.5		0.7	60.9	458,175
D	Westbank I.R. #10				0.3						0.3	2,387
E	Shannon Lake							103.0	78.4		181.5	1,417,053
F	Lakeview	114.2		8.1	5.2	21.0	1.5	13.8		71.0	234.8	1,575,308
G	Smith Creek	36.2		1.1	1.0	1.6		10.1			50.0	370,417
H	Upper Glenrosa							65.0	16.0		81.0	629,560
I	Westbank I.R. #9							7.0	79.2		86.2	679,956
J	Lower Glenrosa	0.6						18.4	0.0		19.0	147,185
K	Westbank North	48.5	0.2	4.3	3.8	3.1	1.2	5.0	0.9	12.9	80.0	562,247
L	Trepanier							21.5			21.5	166,106
M	Goats Peak & Gellatly	55.7		2.4	1.0	5.1		25.6			89.8	668,970
N	Peachland	18.7		1.6	0.8	1.7	1.0	0.0		2.7	26.5	189,237
	Total:	290	0.2	44.7	13.7	32.6	3.7	333	176	87.4	**982**	**7,249,613**

Notes:
1. Annual water demand estimates for each crop type are based on data from the Okanagan Crop Water Demand Model provided by Agriculture and Agri-Food Canada (2003b).
2. Areas for each crop type are based on agricultural land use data provided by Agriculture and Agri-Food Canada (2003a).

Golf Courses

Water use by golf courses was estimated by determining the irrigated areas (e.g., fairways, greens, landscaped areas) based on an ArcView analysis of recent orthophotos of the TLU. Under current conditions, it was assumed that on an annual basis 10,000 m^3/ha of water is applied at each of the golf courses in the TLU. This is roughly 33% greater than the average water use per unit area for intensive agriculture and is roughly equivalent or slightly less than reported rates of irrigation in warm climate golf courses of North America. The estimated total annual water use by golf courses is **1.044 million m^3** (Table 7.8).

Table 7.8 Current estimated annual water use by golf courses in the TLU.

Golf Course	Community	Estimated Irrigated Area (ha)	Estimated average annual water use (m^3)
Shannon Lake	Shannon Lake	39.0	390,000
Vintage Hills	Westbank I.R. #9	40.4	404,000
Ponderosa	Peachland	25.0	250,000
Total:		**104**	**1,044,000**

7.3.5 Distribution System Losses

Distribution system losses (i.e., leakage) throughout the TLU are not known precisely, however EarthTech (2003) has reported that it could possibly range from 5 to 10%. We have assumed the value 5%. This means that on average distribution system losses account for **1.171 million m^3 per year**. A breakdown of distribution losses is provided in Appendix H.

7.3.6 Total Water Use

Based on the analysis of land use, annual water demand in the TLU is estimated to be **24.598 million m^3** (Table 7.9). This total is distributed as follows:

- Residential 10.206 million m^3 (41%);
- commercial/industrial 4.926 million m^3 (20%);
- intensive agriculture 7.250 million m^3 (30%);
- golf courses 1.044 million m^3 (4%); and
- distribution system losses 1.171 million m^3 (5%).

Table 7.9 Total water use in the TLU by land use.

		Estimated Average Annual Water Use					
		Residential	**Commercial / Industrial**	**Agricultural**	**Golf Courses**	**Distribution Losses**	**TOTAL**
		(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
A	Rural Westside Road	375,261	0	241,968	0	30,861	648,091
B	Crystal Mtn & Brenda Mines	57,581	0	141,045	0	9,931	208,557
C	Westlake Road & West Kelowna Estates	851,921	911,614	458,175	0	111,085	2,332,795
D	Westbank I.R. #10	240,437	3,482	2,387	0	12,315	258,621
E	Shannon Lake	747,151	241,941	1,417,053	390,000	139,807	2,935,953
F	Lakeview	1,951,582	174,158	1,575,308	0	185,052	3,886,100
G	Smith Creek	374,699	0	370,417	0	37,256	782,372
H	Upper Glenrosa	274,283	1,040,239	629,560	0	97,204	2,041,286
I	Westbank I.R. #9	1,410,599	150,372	679,956	404,000	132,246	2,777,174
J	Lower Glenrosa	1,397,679	14,345	147,185	0	77,960	1,637,170
K	Westbank North	568,790	180,359	562,247	0	65,570	1,376,965
L	Trepanier	30,476	0	166,106	0	9,829	206,411
M	Goats Peak & Gellatly	618,507	84,014	668,970	0	68,575	1,440,065
N	Peachland	1,307,234	2,126,355	189,237	250,000	193,641	4,066,468
TOTAL		10,206,201	4,926,878	7,249,613	1,044,000	1,171,335	**24,598,026**

7.4 SUMMARY OF WATER USE

The following summarizes water use in the TLU:

- Water licences have been issued for 66.269 million m^3 per year (53.674 million m^3 for offstream uses and 12.595 million m^3 for instream uses) on approximately 184 streams and waterbodies in or adjacent to the TLU (including Okanagan Lake);
- In addition, storage licences total 36.098 million m^3, of which 28.950 million m^3 is actually utilized at present;
- Based on the average of two methods (supply-side and demand-side), total annual offstream water use in the TLU is estimated to be 24.554 million m^3, which is 46% of the total amount licensed for offstream use for the TLU;
- Approximately 66% of the total water used in the TLU (on an annual basis) is obtained from surface sources, of which 90% is obtained from the five principal streams in the TLU (Lambly, McDougall, Powers, Trepanier, and Peachland Creeks). Approximately

30% of the total water used is pumped from Okanagan Lake, and the remaining 4% is obtained from groundwater sources;

- The estimated annual average per capita residential water use rate in the TLU is 789 L/day; and
- Approximately 41% of the total water used in the TLU (on an annual basis) is used for residential purposes, while 20% is used for commercial/industrial purposes, and 34% is used for agriculture (including golf courses). Distribution system losses account for approximately 5% of the TLU water demand.

8.0 HYDROLOGY

This section presents a detailed analysis of the hydrology of the TLU. Current monthly flows and "naturalized" flows at the mouths of the five principal streams in the TLU, as well as at 9 other locations within the watersheds of these streams are presented and discussed. Details are presented in Appendices I through M. Groundwater conditions in the TLU are also presented.

8.1 SURFACE WATER

8.1.1 Background Information

Hydrometric data has been collected by the Water Survey of Canada (WSC) at 28 stations in the TLU for various years since 1919 (Table 8.1). Of these stations only two are active: Greata Creek near the Mouth (08NM173) and Trepanier Creek near Peachland (08NM041). In addition, since 1999 the Water Management Branch of the Ministry of Water, Land and Air Protection has conducted stream gauging/monitoring on 10 streams in the central Okanagan including Lambly (NHC, 2003a), Powers (NHC, 2003b), Trepanier (NHC, 2003c), and Peachland Creeks (NHC, 2003d).

Since water is stored and diverted for human use in all major watersheds in the TLU, estimation of the natural flow regime requires that streamflows be adjusted by accounting for the effects of water storage and withdrawal. Estimates of natural flows obtained by adjusting measurements of managed flows are referred to as *naturalized*. Such *naturalized flows* have recently been estimated at the mouths of each of the principal watersheds in the TLU by Rood (2001) and are presented in stream summaries prepared by NHC (2003a, 2003b, 2003c, 2003d). Rood (2001) estimated naturalized mean annual flows using several techniques including:

- regression equations that relate natural runoff to watershed characteristics (e.g., drainage area, median elevation);
- graphical relationships between median elevation and annual runoff based on Obedkoff (1998); and

- naturalizing gauging records at the mouths of the tributaries with total licensed water use.

Since average annual streamflows in B.C. have not been constant over the available period of record (Figure 4.4), all naturalized flow estimates were standardized by Rood (2001) to the period 1961 to 1995 (based on long-term inflows to Okanagan Lake) in order to identify the variation between watersheds rather than differences in the period of record. This period also is consistent with Coulson and Obedkoff's (1998) inventory of natural streamflows in B.C.

Table 8.1 Water Survey of Canada hydrometric stations located in the Trepanier Landscape Unit

Watershed	Water Survey of Canada Station Name	Station ID	Drainage Area (km^2)	Period of Record
Peachland Creek	Peachland Creek at the mouth	08NM159	150	1969-82
	Peachland Creek near Peachland	08NM029	122	1919-22
	Peachland Creek municipal irrigation diversion	08NM030	--	1919-23
	Peachland Creek above diversions	08NM140	--	1966-82
	Peachland Creek below diversion to Peachland Lake reservoir	08NM201	74.6	1973
	Peachland Lake reservoir outflow	08NM202	80.3	1973-82
	Peachland Creek diversion to Peachland Lake	08NM219	--	1973-79
	Peachland Lake near Peachland	08NM220	--	1973-79, 1983-84
	Greata Creek near the mouth	08NM173	40.7	1970-present
	McDonald Creek diversion to Peachland Creek	08NM218	--	1973-79
Trepanier Creek	Trepanier Creek near Peachland	08NM041	179	1919-27, 1960-present
	Trepanier Creek at the mouth	08NM155	254	1969-81
	Jack Creek at the mouth	08NM013	40.4	1919
Powers Creek	Powers Creek at the mouth	08NM157	144	1969-82
	Powers Creek above Westbank diversion	08NM033	128	1920-22, 1965, 1967-74
	Powers Creek below Westbank diversion	08NM059	139	1924-27, 1965-87
	Powers Creek Westbank diversion	08NM034	--	1920-31
	Lambly Lake diversion to Powers Creek	08NM136	--	1965-72
McDougall Creek	McDougall Creek near Westbank	08NM014	38.9	1920-26
	Westbank Creek at the mouth	08NM198	14	1972-75
Lambly Creek	Lambly Creek near the mouth	08NM033	272	1919-21, 1965-75
	Lambly Creek near Kelowna	08NM058	246	1924, 1925, 1927
	Terrace Creek near Kelowna	08NM138	31.3	1965-94
	Esperon Creek near Kelowna	08NM139	13	1965-81
	Lambly Creek below Terrace Creek	08NM141	235	1967-71
	Lambly Creek above Terrace Creek	08NM165	76.1	1970-96
	Lambly Creek below Bald Range Creek	08NM166	229	1970-82
	Lambly Creek diversion to Rose Valley Lake	08NM167	--	1970-78

The monthly distribution of naturalized flows was then predicted based on the ratio of the mean monthly flows to the mean annual flows observed at regional stations with natural or naturalized flow records.

A summary of the naturalized mean annual flows, mean annual peak daily flows, and mean 7-day low flows for summer and winter at the mouths of the five principal streams in the TLU as estimated by Rood (2001) is provided in Table 8.2. A summary of the naturalized mean monthly flows is provided in Appendices I through M.

Table 8.2 Summary of estimated naturalized flow statistics at the mouths of the five principal streams in the TLU.

Location (mouth of)	Mean Annual Flow		Mean Annual Peak Daily Flow		Mean 7-day Low Flow (summer)		Mean 7-day Low Flow (winter)	
	(m^3/s)	($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	($L/s/km^2$)	(m^3/s)	($L/s/km^2$)
Lambly Creek	1.77	7.31	22.0	90.9	0.100	0.410	0.120	0.490
McDougall Creek	0.119	2.26	4.50	84.9	0.020	0.380	0.010	0.190
Powers Creek	0.920	6.34	8.90	61.4	0.210	1.45	0.130	0.900
Trepanier Creek	1.09	4.22	13.0	50.5	0.130	0.510	0.120	0.470
Peachland Creek	0.570	3.82	2.70	18.1	0.150	1.00	0.080	0.540

Based on Rood (2001) and NHC (2003a, 2003b, 2003c, 2003d).

As shown in Table 8.2, naturalized mean annual flows at the mouths of the principal streams in the TLU range from 0.119 m^3/s in McDougall Creek to 1.77 m^3/s in Lambly Creek. Mean annual peak daily flows range from 4.50 m^3/s in McDougall Creek to 22.0 m^3/s in Lambly Creek. Mean 7-day low flows in summer range from 0.020 m^3/s in McDougall Creek to 0.210 m^3/s in Powers Creek, while in winter the range is from 0.010 m^3/s in McDougall Creek to 0.130 m^3/s in Powers Creek.

On a per unit area basis ($L/s/km^2$), the average of the mean annual naturalized flows of the five principal watershed is 4.84 $L/s/km^2$. However, among the five watersheds, it ranges from 2.26 $L/s/km^2$ in McDougall Creek to 7.31 $L/s/km^2$ in Lambly Creek. In addition, on a per unit area basis, mean annual peak daily flows range from 18.1 $L/s/km^2$ in Peachland

Creek to 90.9 L/s/km^2 in Lambly Creek. Some of this difference can be attributed to the effect of natural storage in the Peachland Creek watershed and lack of natural storage in the Lambly Creek watershed. In all but Lambly Creek, mean naturalized 7-day low flows are lower in winter than in summer. In the winter, 7-day low flows range from 0.19 L/s/km^2 in McDougall Creek to 0.90 L/s/km^2 in Powers Creek. In the summer, the 7-day low flows range from 0.38 L/s/km^2 in McDougall Creek to 1.00 L/s/km^2 in Peachland Creek.

8.1.2 Streamflow Model Framework

Naturalized mean annual and mean monthly flows presented by Rood (2001) and NHC (2003a, 2003b, 2003c, 2003d) were used in the present analysis to provide the baseline conditions at each of the mouths of the five principal watersheds: Lambly Creek, McDougall Creek, Powers Creek, Trepanier Creek, and Peachland Creek.

In order to provide streamflow estimates for locations in the TLU other than the mouths of the 5 principal streams, a relation presented in Obedkoff (2000) was used to scale normal annual runoff (or unit discharge) according to the median elevation of the drainage area of interest.

For the purposes of this investigation, 14 points-of-interest (POIs) with respect to streamflows were defined in the five principal watersheds (Figure 8.1). The points-of-interest were chosen to isolate as much as possible the effects of storage (primarily on the high elevation plateau) from the effects of withdrawals (primarily in lower elevations near the Okanagan valley bottom). The 14 points-of-interest are:

- Lambly Creek at the mouth;
- Lambly Creek above PD59106 (Lakeview Irrigation District diversion weir)("middle POI");
- Lambly Creek below the confluence with Terrace Creek ("upper POI");
- McDougall Creek at the mouth;
- McDougall Creek below PD 59093 ("upper POI");
- Powers Creek at the mouth;

- Powers Creek above PD58825 (Westbank Irrigation District intake) ("middle POI");
- Powers Creek below the confluence with North Powers Creek ("upper POI");
- Trepanier Creek at the mouth;
- Trepanier Creek above PD58726 (District of Peachland intake) ("middle POI");
- Trepanier Creek below confluence with MacDonald Creek ("upper POI");
- Peachland Creek at the mouth;
- Peachland Creek above PD58648 (District of Peachland intake) ("middle POI"); and
- Peachland Creek below confluence with Greata Creek ("upper POI").

The area and median elevation of the drainage above each of the points-of-interest is provided in Table 8.3.

Table 8.3 Drainage area and median elevation of the drainage above each of the points-of-interest and for the residual areas in the TLU.

Area	Point-of-interest	Drainage area (km^2)	Median elevation (m)
1	**Lambly Creek at the mouth**	**243**	**1,281**
1	Lambly Creek above PD59106 (Lakeview Irrigation District diversion weir)	230	1,306
1	Lambly Creek below the confluence with Terrace Creek	159	1,404
2	**McDougall Creek at the mouth**	**52.9**	**1,070**
2	McDougall Creek below PD 59093	38.5	1,228
3	**Powers Creek at the mouth**	**145**	**1,242**
3	Powers Creek above PD58825 (Westbank Irrigation District intake)	128	1,316
3	Powers Creek below the confluence with North Powers Creek	97.2	1,365
4	**Trepanier Creek at the mouth**	**258**	**1,228**
4	Trepanier Creek above PD58726 (District of Peachland intake)	185	1,311
4	Trepanier Creek below confluence with MacDonald Creek	121	1,423
5	**Peachland Creek at the mouth**	**145**	**1,209**
5	Peachland Creek above PD58648 (District of Peachland intake)	125	1,267
5	Peachland Creek below confluence with Greata Creek	110	1,319
6	Westside Road	56.3*	762
7	Lakeview	37.0*	605
8	Westbank North	25.1*	708
9	Peachland North	13.4*	615
10	Peachland South	16.3*	674

*Areas 6-10 are residual areas directly draining to Okanagan Lake.

Actual monthly streamflows at each of the points-of-interest were estimated by subtracting all upstream licensed or actual withdrawals (where information is available) from the naturalized flows [based on Rood (2001) and NHC (2003a, 2003b, 2003c, 2003d)]. In order to determine upstream withdrawals from each point-of-interest all licensed quantities or estimates of actual water use were compiled and organized for each of the principal watersheds (and residual areas) and converted to metric units (i.e., m^3)(Appendix B).

Given that the monthly distribution of withdrawals is typically not indicated in water licence data, several assumptions were necessary in order to distribute the total annual licensed quantities throughout the year. These assumptions are as follows:

- the total licensed volume is evenly distributed throughout the year for the following purposes: “stockwatering”, “cooling”, “conservation”, “ponds”, “camps” (that are confirmed to be open all year), “processing”, “land improvement”, “kennel”, “public facilities”, and “enterprise”;
- for “domestic” purposes, total annual licensed quantities were distributed based on the distribution of actual domestic (indoor and outdoor) water use obtained from the Westbank Irrigation District (Jamieson, 2003), which is presented below:
  - January: 3.6%;
  - February: 3.6%;
  - March: 3.9%;
  - April: 5.9%;
  - May: 11.4%;
  - June: 12.1%;
  - July: 17.6%;
  - August: 17.8%;
  - September: 11.2%;
  - October: 5.7%;
  - November: 3.6%; and
  - December: 3.6%.

- for “irrigation” and “watering” purposes the annual licensed quantities were distributed based on the distribution of actual irrigation water use obtained from the Westbank Irrigation District (Jamieson, 2003), which is presented below:
    - January: 0.0%;
    - February: 0.0%;
    - March: 0.5%;
    - April: 4.0%;
    - May: 13.7%;
    - June: 15.0%;
    - July: 24.6%;
    - August: 25.0%;
    - September: 13.4%;
    - October: 3.8%;
    - November: 0.0%; and
    - December: 0.0%.
- for licences for “waterworks”, the total annual licensed quantity was distributed according to the distribution of actual monthly use that was available for the three principal utilities (Westbank Irrigation District, Lakeview Irrigation District, and the District of Peachland) (see Section 7.2.1); and
- for “dust control”, the licensed volume is distributed evenly between the stated dates of the licence.

Records of monthly actual water use were obtained for the major water purveyors in the TLU (Section 7.2.1). These values (which are averages based on recent years records) were used in place of the licensed amounts in the estimation of net flows to provide the most accurate estimate of monthly withdrawals from each stream.

Storage and streamflow diversions are ubiquitous in the TLU and can strongly affect the timing and magnitude of streamflows at the points-of-interest. Lambly Lake, for example, previously flowed into Lambly Creek but is now regulated and flows entirely into Powers

Creek. For this report, all areas contributing flow to Lambly Lake are considered to be within the Powers Creek watershed.

In order to account for storage and diversions, all licences were compiled for each watershed and annual licensed quantities were distributed based on their general operating guidelines for each of the major utilities. An exception is that storage was assumed in this report to be not carried over from year to year. This assumption was made because estimated net flows in this report are intended to represent average hydrologic conditions. Additional assumptions made with respect to storage include the following:

- water is withdrawn into storage between April 1 and June 30 (or according to licensed dates) based on the distribution of naturalized monthly streamflows for the stream of interest; and
- water is released from storage based on the distribution of actual water use (available for each of the three main water utilities).

8.1.3 Naturalized and Net Flows

Mean Monthly and Annual Flows

Summary tables and plots of the mean monthly flows at the 14 points-of-interest (POIs) are provided in Appendices I through M. For each POI, the summary provides the estimated mean annual and monthly values of the following:

- net flow (i.e. current average streamflow);
- naturalized flow (i.e. estimated natural flow that would exist without management);
- total licensed quantity for both offstream and instream use;
- licensed quantity for offstream use;
- licensed quantity for instream use;
- estimated actual offstream use (and actual offstream use assuming 10%, 20%, and 30% reductions);
- storage (either withdrawal into storage or release from storage); and
- conservation flows.

For residual areas 6 through 10, hydrographs of mean monthly unit discharge were estimated based on naturalized flows of Powers Creek and were scaled according to the median elevation of each residual area. Actual monthly streamflows can be estimated using Figure 8.2 for any point in the residual areas, if the drainage area contributing to that point is known.

Monthly and Annual Flows for Wet and Dry Years

The year-to-year variability in monthly flows was estimated by scaling naturalized monthly and annual flows according to a regional frequency curve of total annual runoff prepared for the west side of the Okanagan Valley (Letvak, 1980). Tables 8.4 and 8.5 present the wet and dry runoff as percentages of the mean annual runoff for selected return periods. Based on Table 8.4, a wet year with a 5-year return period runoff, for example, would have an annual runoff equal to 130% of the naturalized mean annual runoff. In this example, assuming the distribution of monthly flows is constant, each 5-year return period wet monthly flow would also be 130% of the mean monthly flow. For the purposes of assessing conservation flows (Section 9.0), the 1 in 5 year dry net and naturalized flows are summarized in tables and plots for all 14 POIs in Appendix N.

Table 8.4 Scaling factors used to determine mean annual and monthly runoff during wet years.

Return period of exceedance of annual runoff (years)	Probability of exceedance of annual runoff (%)	Percentage of mean annual runoff (%)
5	0.2	**130**
10	0.1	**150**
20	0.05	**170**
50	0.02	**190**

Source: Letvak (1980).

Table 8.5 Scaling factors used to determine mean annual and monthly runoff during dry years.

Return period of non-exceedance of annual runoff (years)	Probability of non-exceedance of annual runoff (%)	Percentage of mean annual runoff (%)
5	0.2	**67**
10	0.1	**54**
20	0.05	**44**
50	0.02	**33**

Source: Letvak (1980).

Water Balance

An approximate annual water balance in each of the principal watersheds, based on the available climate data and naturalized flow estimates is provided in Table 8.6.

Table 8.6 Water balance of drainages above the 14 points-of-interest in the TLU.

Point-of-interest	Precipitation[1] (mm)	Evapotranspiration & Groundwater[2] recharge (mm)	Annual Naturalized Runoff (mm)
Lambly Creek:			
At the mouth	602	372	230
Above PD59106 (LID diversion weir)	607	367	240
Below the confluence with Terrace Creek	628	329	299
McDougall Creek:			
At the mouth	557	486	71
Below PD 59093	590	495	95
Powers Creek:			
At the mouth	593	393	200
Above PD58825 (WID intake)	609	389	220
Below the confluence with North Powers Creek	620	390	230
Trepanier Creek:			
At the mouth	590	457	133
Above PD58726 (District of Peachland intake)	608	427	181
Below confluence with MacDonald Creek	632	407	225
Peachland Creek:			
At the mouth	586	462	124
Above PD58648 (District of Peachland intake)	599	469	130
Below confluence with Greata Creek	610	470	140

Notes:
1. Precipitation is estimated based on a linear relation between elevation and precipitation for nearby stations.
2. Evapotranspiration and groundwater recharge is calculated as the difference between the estimated precipitation and runoff.

8.1.4 Effects of Water Use on Surface Flow

The discussion below summarizes the current hydrologic conditions at the 14 POIs (refer to Appendices I through M for detailed tabular summaries). A summary of the annual naturalized flow, total annual licensed quantity (converted to m^3/s), estimated actual annual offstream use (converted to m^3/s), and annual net flow under current average hydrologic conditions are presented in Table 8.7.

Table 8.7 Annual naturalized flow, total licences, actual offstream use, and net flow at the 14 points-of-interest in the Trepanier Landscape Unit under current average hydrologic conditions.

Point-of-interest	**Annual naturalized flow**	**Total annual licences for offstream use**	**Estimated actual annual offstream use**	**Annual net flow**
	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)
Lambly Creek:				
At the mouth	1.77	0.414	0.189	**1.58**
Above PD59106 (LID diversion weir)	1.75	0.099	0.048	**1.70**
Below the confluence with Terrace Creek	1.51	0.098	0.046	**1.47**
McDougall Creek:				
At the mouth	0.119	0.035	0.035	**0.084**
Below PD 59093	0.116	0.019	0.019	**0.097**
Powers Creek:				
At the mouth	0.920	0.351	0.168	**0.849**
Above PD58825 (WID intake)	0.893	0.186	0.001	**0.989**
Below the confluence with North Powers Creek	0.709	0.162	0.000	**0.806**
Trepanier Creek:				
At the mouth	1.09	0.137	0.057	**1.03**
Above PD58726 (District of Peachland intake)	1.06	0.020	0.001	**1.06**
Below confluence with MacDonald Creek	0.863	0.020	0.000	**0.863**
Peachland Creek:				
At the mouth	0.570	0.588	0.055	**0.515**
Above PD58648 (District of Peachland intake)	0.515	0.221	0.000	**0.515**
Below confluence with Greata Creek	0.488	0.221	0.000	**0.488**

Notes: Refer to Appendices I through M for additional information.

Lambly Creek

<u>Lambly Creek below confluence with Terrace Creek</u> (Figure 8.3)

- Currently, net flows range from 0.308 m^3/s in January to 6.55 m^3/s in May. The annual net flow is estimated to be 1.47 m^3/s;

- On an annual basis, net flow is 3% less than naturalized flow. On a monthly basis, net flows are less than naturalized flows from April to June (by up to 8.7%);
- On an annual basis there is a maximum of 1.42 m^3/s of additional flow that is not currently licensed. On a monthly basis, this ranges from 0.216 m^3/s in February to 6.97 m^3/s in May;
- On an annual basis, 6% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 2% to 44% of the naturalized flow;
- On an annual basis, 3% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use varies from 1% to 20% of the naturalized flow; and
- On an annual basis, there is 0.052 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.016 m^3/s in December and January to 0.120 m^3/s in August.

<u>Lambly Creek above PD59106 (Lakeview Irrigation District weir)</u> (Figure 8.4)

- Currently, net flows range from 0.347 m^3/s in January to 7.65 m^3/s in May. The annual net flow is estimated to be 1.70 m^3/s;
- On an annual basis, net flow is 3% less than naturalized flow. Net monthly flows are less than naturalized flows from April to June (by up to 7.6%);
- On an annual basis there is a maximum of 1.65 m^3/s that is not currently licensed. On a monthly basis, this ranges from 0.255 m^3/s in January and February to 8.09 m^3/s in May;
- On an annual basis, 6% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 2% to 38% of naturalized flow;
- On an annual basis, 3% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use accounts for 1% to 18% of the naturalized flow; and
- On an annual basis, there is 0.052 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.016 m^3/s in December and January to 0.120 m^3/s in August.

Lambly Creek at the mouth (Figure 8.5)

- Currently, net flows range from 0.308 m^3/s in January to 7.56 m^3/s in May. The annual net flow is estimated to be 1.58 m^3/s;
- On an annual basis, net flow is 11% less than naturalized flow. Net monthly flows are less than naturalized flows between April to October (by up to 48% in August) and greater between November and March (by as much as 12%);
- On an annual basis, there is a maximum of 1.36 m^3/s that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 23% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 7% to 168% of naturalized flow;
- On an annual basis, 11% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use accounts for 3% to 69% of the naturalized flow;
- On an annual basis, 44% of the actual offstream use is supported by actual storage, while 37% of the licences for offstream use, and 37% of the licences for both offstream and instream use are supported by licensed storage; and
- On an annual basis, there is 0.225 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.026 m^3/s in January to 0.604 m^3/s in August.

McDougall Creek

McDougall Creek below PD59093 (Figure 8.6)

- Currently, net flows range from 0.019 m^3/s in January and February to 0.446 m^3/s in May. The annual net flow is estimated to be 0.097 m^3/s;
- On an annual basis, net flow is 16% less than naturalized flow. Net monthly flows are less than naturalized flows all year (by up to 24% in August);
- On an annual basis, there is a maximum of 0.097 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license in August as offstream licences already exceed naturalized flows in these months;

- On an annual basis, 16% of the naturalized flow is licensed for offstream use, all of which is assumed to be used. On a monthly basis, offstream licences account for 1% to 137% of naturalized flow;
- On an annual and monthly basis, there is no flow available for use without further licensing.

McDougall Creek at the mouth (Figure 8.7)

- Currently, net flows range from 0.000 m^3/s in August to 0.434 m^3/s in May. The annual net flow is estimated to be 0.084 m^3/s;
- On an annual basis, net flow is 30% less than naturalized flow. Net monthly flows are less than naturalized flows for all months (by up to 141% in August);
- On an annual basis, there is 0.084 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 30% of the naturalized flow is licensed for offstream use, all of which is assumed to be used. On a monthly basis, offstream licences account for 1% to 251% of naturalized flow;
- On an annual basis, 43% of the actual offstream use (as well as licensed offstream and instream use) is supported by licensed storage; and
- On an annual and monthly basis, there is no flow available for use without further licensing.

Powers Creek

Powers Creek below confluence with North Powers Creek (Figure 8.8)

- Currently, net flows range from 0.116 m^3/s in January and February to 2.11 m^3/s in July. The annual net flow is estimated to be 0.806 m^3/s;
- On an annual basis, net flow is 14% more than naturalized flow due to flow diversion from the Lambly Creek watershed. However, net monthly flows are less than naturalized flows between April and June (by up to 49% in May);

- On an annual basis, there is a maximum of 0.547 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 23% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 8% to 184% of naturalized flow;
- On an annual basis, none of the naturalized flow is actually used offstream upstream of this POI; and
- On an annual basis, there is 0.162 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.012 m^3/s in December to February to 0.454 m^3/s in August.

<u>Powers Creek above PD58825 (Westbank Irrigation District intake)</u> (Figure 8.9)

- Currently, net flows range from 0.146 m^3/s in January and February to 2.56 m^3/s in May. The annual net flow is estimated to be 0.989 m^3/s;
- On an annual basis, net flow is 11% more than naturalized flow due to flow diversion from the Lambly Creek watershed. However, net monthly flows are less than naturalized flows between April and June and in October (by up to 39% in May);
- On an annual basis, there is up to 0.707 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 21% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 6% to 169% of naturalized flow;
- On an annual basis, less than 1% of the naturalized flow is actually used offstream; and
- On an annual basis, there is 0.185 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.012 m^3/s in December to February to 0.522 m^3/s in August.

<u>Powers Creek at the mouth</u> (Figure 8.10)

- Currently, net flows range from 0.097 m^3/s in February to 2.45 m^3/s in May. The annual net flow is estimated to be 0.849 m^3/s;
- On an annual basis, net flow is 8% less than naturalized flow. Net monthly flows are less than naturalized flows for all months except between July and September (by up to 43.5% in October);
- On an annual basis, there is up to 0.569 m^3/s that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 29% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 6% to 238% of naturalized flow;
- On an annual basis, 9% of the naturalized flow is licensed for instream use. On a monthly basis, instream licences account for 2% to 62% of naturalized flow;
- On an annual basis, 18% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use accounts for 6% to 124% of the naturalized flow;
- On an annual basis, all actual offstream use is supported by actual storage, while all of the licences for offstream use, and all of the licences for both offstream and instream use are supported by licensed storage; and
- On an annual basis, there is 0.098 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from no available flow between November and March to 0.483 m^3/s in August.

Trepanier Creek

<u>Trepanier Creek below confluence with McDonald Creek</u> (Figure 8.11)

- Currently, net flows range from 0.095 m^3/s in January to 5.13 m^3/s in May. The annual net flow is estimated to be 0.863 m^3/s;
- On an annual basis, net flow is equivalent to naturalized flow. However, net monthly flows are less than naturalized flows between April and June (by up to 0.6% in May);

- On an annual basis, up to 0.844 m^3/s of flow that is not currently licensed. On a monthly basis, available flows range from 0.095 m^3/s in January to 5.124 m^3/s in May;
- On an annual basis, 2% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 0% to 28% of naturalized flow.
- On an annual and monthly basis, none of the naturalized flow is actually used offstream; and
- On an annual basis, there is 0.020 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0 m^3/s in November to February to 0.058 m^3/s in August.

<u>Trepanier Creek above PD58726 (District of Peachland intake)</u> (Figure 8.12)

- Currently, net flows range from 0.116 m^3/s in January to 6.18 m^3/s in May. The annual net flow is estimated to be 1.06 m^3/s;
- On an annual basis, net flow is 0.1% less than naturalized flow. Net monthly flows are less than naturalized flows between November and February and April and June (by up to 2.0% in May);
- On an annual basis, there is a maximum of 1.04 m^3/s that is not currently licensed. On a monthly basis, available flows range from 0.116 m^3/s in January to 6.27 m^3/s in May;
- On an annual basis, 2% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 0% to 24% of naturalized flow;
- On an annual and monthly basis, less than 1% of naturalized flow is actually used offstream; and
- On an annual basis, there is 0.020 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from zero between November and February to 0.058 m^3/s in August.

Trepanier Creek at the mouth (Figure 8.13)

- Currently, net flows range from 0.105 m^3/s in January to 6.31 m^3/s in May. The annual net flow is estimated to be 1.03 m^3/s;
- On an annual basis, net flow is 5% less than naturalized flow. Net monthly flows are less than naturalized flows for all months (by up to 27% in August);
- On an annual basis, there is a maximum of 0.953 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license in August and September as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 13% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 2% to 142% of naturalized flow;
- On an annual basis, 5% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use accounts for 1% to 57% of the naturalized flow;
- On an annual basis, 46% of the actual offstream use is supported by actual storage, while 19% of the licences for offstream use, and 19% of the licences for both offstream and instream use are supported by licensed storage; and
- On an annual basis, there is 0.080 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.012 in January and February to 0.222 m^3/s in August.

Peachland Creek

Peachland Creek below confluence with Greata Creek (Figure 8.14)

- Currently, net flows range from 0.225 m^3/s in January to 0.933 m^3/s in May. The annual net flow is estimated to be 0.488 m^3/s;
- On an annual basis, net flow is equivalent to naturalized flow. However, net monthly flows are less than naturalized flows from April to June (by up to 59% in May);
- Monthly instream licenses are met or exceeded all year;
- On an annual basis, there is a maximum of 0.267 m^3/s that is not currently licensed. However, no additional surface water is available to license between August and February as offstream licences already exceed naturalized flows in these months;

- On an annual basis, 28% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 9% to 184% of naturalized flow;
- On an annual basis, 17% of the naturalized flow is licensed for instream use. On a monthly basis, instream licences account for 0% to 120% of naturalized flow;
- On an annual and monthly basis, none of the naturalized flow is actually used offstream upstream of this POI; and
- On an annual basis, there is 0.136 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.032 m^3/s in December to 0.315 m^3/s in August.

Peachland Creek above PD58648 (District of Peachland intake) (Figure 8.15)

- Currently, net flows range from 0.229 m^3/s in January to 1.06 m^3/s in May. The annual net flow is estimated to be 0.515 m^3/s;
- On an annual basis, net flow is equivalent to naturalized flow. However, net monthly flows are less than naturalized flows from April to June (by up to 56% in May);
- Monthly instream licenses are exceeded all year;
- On an annual basis, there is a maximum of 0.294 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license between August and February as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 26% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 8% to 174% of naturalized flow;
- On an annual basis, 16% of the naturalized flow is licensed for instream use. On a monthly basis, instream licences account for 0% to 113% of naturalized flow;
- On an annual and monthly basis, none of the naturalized flow is actually used offstream upstream of this POI; and
- On an annual basis, there is 0.136 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.032 m^3/s in December to 0.315 m^3/s in August.

Peachland Creek at the mouth (Figure 8.16)

- Currently, net flows range from 0.225 m^3/s in January to 1.23 m^3/s in May. The annual net flow is estimated to be 0.515 m^3/s;
- On an annual basis, net flow is 10% less than naturalized flow. Net monthly flows are less than naturalized flows from April to June (by up to 54% in May);
- Monthly instream licenses are not met between November and March;
- On an annual basis, there is a maximum of 0.012 m^3/s of flow that is not currently licensed. However, no additional surface water is available to license between July and March as offstream licences already exceed naturalized flows in these months;
- On an annual basis, 43% of the naturalized flow is licensed for offstream use. On a monthly basis, offstream licences account for 14% to 228% of naturalized flow;
- On an annual basis, 55% of the naturalized flow is licensed for instream use. On a monthly basis, instream licences account for 0% to 376% of naturalized flow;
- On an annual basis, 10% of the naturalized flow is actually used offstream. On a monthly basis, actual offstream use accounts for 3% to 67% of the naturalized flow;
- On an annual basis, all of the actual offstream use is supported by actual storage. Licenced storage supports all of the licences for offstream use, but supports only 51% of the licences for both offstream and instream use; and
- On an annual basis, there is 0.191 m^3/s not being utilized under existing licences. On a monthly basis, flow available for use without further licensing ranges from 0.026 m^3/s in December to 0.492 m^3/s in August.

8.1.5 Summary

The following summarizes the current hydrology of the principal streams in the TLU:

- Flows in all major streams in the TLU are regulated. Therefore, naturalized flows have been estimated (at 14 points-of-interest) on the basis of site-specific and regional flow information, and licensed and actual water use information;
- On an annual basis, net flows are 13% less than naturalized flows in the five principal streams of the TLU. The estimated naturalized and net annual flows at the mouths of the five principal streams in the TLU under average conditions are:

	Naturalized	Net
o Lambly Creek:	1.77 m^3/s	1.58 m^3/s
o McDougall Creek:	0.119 m^3/s	0.084 m^3/s
o Powers Creek:	0.920 m^3/s	0.849 m^3/s
o Trepanier Creek:	1.09 m^3/s	1.03 m^3/s
o Peachland Creek:	0.570 m^3/s	0.515 m^3/s

- Under 1 in 5 year drought conditions, the naturalized and net annual flows are expected to be roughly 67% of the above-noted estimates;
- In all but McDougall Creek, streamflows should persist year-round in principal streams of the TLU under average hydrologic conditions;
- On average, offstream water licences account for 28% of the naturalized annual flow in the principal streams of the TLU. Actual offstream use in the TLU averages 15% of the naturalized annual flow. The percentage of naturalized flow represented by water licences for offstream use and actual use for the five principal streams are:

	Licences	Actual
o Lambly Creek:	23%	11%
o McDougall Creek:	30%	30%
o Powers Creek:	29%	18%
o Trepanier Creek:	13%	5%
o Peachland Creek:	43%	10%

- On an annual basis, actual storage supports between 44% and 516% (i.e. all)of the water use in the principal streams of the TLU, while 19% to 191% (i.e., all) of licensed offstream use is supported by licensed storage and 19% to 51% of licensed offstream and instream use is supported by storage. The breakdown of these percentages by principal stream is as follows:

	Actual storage as a percentage of actual water use	Licensed storage as a percentage of licensed offstream use	Licensed storage as a percentage of offstream & instream use
o Lambly Creek:	44%	37%	37%
o McDougall Creek:	37%	43%	43%
o Powers Creek:	303%	191%	145%
o Trepanier Creek:	46%	19%	19%
o Peachland Creek:	516%	115%	51%

- On an annual basis, the flow which is not presently licensed for offstream or instream use is as follows:

	Annual flow that is not currently licensed
o Lambly Creek:	1.36 m^3/s
o McDougall Creek:	0.084 m^3/s
o Powers Creek:	0.569 m^3/s
o Trepanier Creek:	0.953 m^3/s
o Peachland Creek:	0.012 m^3/s.

8.2 GROUNDWATER

8.2.1 Introduction

The use and development of groundwater in the Okanagan Valley has mirrored trends in the remainder of the province. Given the abundance of surface water resources, which are easier to access and develop than groundwater, there has been little historical interest in using the groundwater resource in the TLU. However, although groundwater has not been heavily utilised, it remains a vital resource and may prove key in supporting continued development and growth in the study area.

8.2.2 Aquifers

As shown on Figure 8.17, six large aquifers have been identified in the TLU by MWLAP. These six aquifers are located along the periphery of Okanagan Lake, in the immediate vicinity of Westbank. This portion of the TLU also supports urban development, agricultural operations and local industries, all of which require a source of water. Accordingly, groundwater usage is concentrated in this area of the TLU.

In contrast, no significant aquifers have been identified in the upland areas of the TLU. Although anecdotal evidence suggests the presence of small, local aquifers, no well logs were available that confirmed their presence. As the upland area of the TLU has not been subjected to the same level of development as the area near the lake, the demand on the groundwater resources is much lower.

The aquifer have been delineated and mapped by MWLAP staff from water well logs that were voluntarily submitted to the Groundwater Section. There are several limiting factors that must be considered. Firstly the aquifers were mapped from existing water well log database. Water wells are drilled in areas of human development and not, as a rule, in unpopulated or undeveloped regions. Thus there are numerous water wells within three or four kilometres of the lake, and none in the upland area of the TLU. However, there are no requirements for well logs to be submitted to the Groundwater Section, so there may large areas where no well log data is available and thus no aquifers are documented. Second, there are presently no standards for logging water wells, which may compromise the quality of the information that is contained in the database.

The delineated aquifers are listed in Table 8.8, which also shows the aquifer location and type of deposit that hosts the aquifer. As shown there are two main types of aquifers, those hosted in bedrock and those in coarse granular material (glacial outwash sediments). Wells in bedrock aquifers tend to have low yields, unless fractures are intercepted. If this occurs, well yields can be significantly increased. On the other hand, wells in surficial material tend to have higher yields, especially if coarse granular material is encountered (such as sand and gravel). Aquifers in surficial material near Okanagan Lake are likely in direct hydraulic connection with the lake and wells drilled in these sediments will have very high yields.

Table 8.8 Aquifers in the Trepanier Landscape Unit

Aquifer Number	Name	Location	Area (km^2)	Type
301	Shannon Lake	Shannon Lake	1.1	Sand and Gravel
302	South of Westbank	Near Gellatly at mouth of Powers Creek	1.6	Sand
303	Southeast of Westbank	Southeast of Westbank, along west side of lake	2.1	Sand
304	Westbank	West side of Okanagan Lake	19.4	Bedrock
305	Westbank North	West side Okanagan Lake	18.6	Bedrock
306	East of Westbank	Parallel along north side of Mt Boucherie, extending northeast	3.6	Sand and Gravel

8.2.3 Aquifer Classification

Designed primarily for use within a Water Management Program of MWLAP, the aquifers in B.C. are classified based on a two part ranking system. This classification system was developed to support groundwater management within the province, with a view to priorizing efforts towards highly developed/highly vulnerable aquifers with high ranking points.

The first part of the classification system is based on the current level of aquifer development and vulnerability to contamination. The classification sub-class is based on the level of development, based on a three point system. A ranking of I, therefore, indicates a highly developed aquifer, a ranking of II indicates a moderately developed aquifer and a ranking of III indicates an aquifer with low development. The vulnerability sub-classes are based on a three point system, where A is high vulnerability, B is moderate vulnerability and C is a low vulnerability. The vulnerability assessment is based on type, thickness and extent of geologic material overlying the aquifer, depth to the top of water and type of aquifer material. There is no consideration of land use or surface activities in the vulnerability assessment. The component of the classification system accords a measure of the relative development and vulnerability of each aquifer, to assist with priorizing aquifers for protection and management.

Aquifer ranking points are applied in seven categories, including aquifer productivity, vulnerability, size, groundwater demand, type of use, quality concerns, and quantity concerns. Provincial hydrogeologists, using drillers' logs and groundwater reports, completed for the area assessed these parameters. The maximum points available for aquifer ranking are 21. The higher the point total (to a maximum of 21 points), the high priority an aquifer is accorded.

The ranking component points for the six aquifers in the TLU range from 8 to 10. These point totals infer that historically the aquifers have not ranked high in terms of requiring protection and management. This was primarily due to the facts that the aquifers were not highly developed, have moderate vulnerability and productivity, and relatively low demand. There were little quality or quantity concerns in the TLU aquifers.

The levels of productivity and demand are relative assessments, based on the level of groundwater extraction balanced against an estimation of the groundwater water available. As shown in Table 8.9, the aquifers in the TLU were mapped as moderately to lightly developed. The levels of vulnerability for the six aquifers were moderate or low. As discussed above, the vulnerability rankings, which relate to the potential for contamination from the surface, were based on the hydrogeologic properties of the aquifer and the overlying sediments, if present. Thus, a fine-grained surficial deposit would lower the vulnerability ranking of an aquifer, in comparison to a coarse grained deposit. Aquifer vulnerability rankings do not consider the land uses or human activities that occur above the aquifers.

Considering the coarse grained nature of four of the six aquifers, their locations and the land use activities above the aquifers, their vulnerability rating is likely higher than moderate. However, a detailed assessment of land use activities, zoning and urban density and development would be required to investigate the vulnerability in more detail. The two bedrock aquifers, by virtue of being deeper in the sub-surface and since groundwater flow is primarily fracture controlled, are likely moderately vulnerable, as mapped by MWLAP.

Table 8.9 Rankings applied to TLU aquifers

Aquifer Number	Name	Ranking	Productivity	Demand	Vulnerability	Aquifer Classification
301	Shannon Lake	10	Moderate	Moderate	Moderate	IIB
302	South of Westbank	10	High	Moderate	Moderate	IIB
303	Southeast of Westbank	8	Moderate	Low	Moderate	IIIB
304	Westbank	9	Low	Moderate	Moderate	IIB
305	Westbank North	9	Moderate	Moderate	Moderate	IIB
306	East of Westbank	8	Moderate	Low	Low	IIC

As shown in Table 8.9, five aquifers in the TLU are classified as II (moderately developed) and one as III (lightly developed). Five aquifers have a vulnerability designation of moderate and one is designated as having low vulnerability. The ranking points range from 8 to 10. Thus, the aquifers within the TLU are designated as moderately developed, moderately vulnerable, and as having low ranking points. In terms of management within the provincial system, these aquifers are deemed moderate to low priority.

8.2.4 Groundwater Recharge

Groundwater recharge to the regional bedrock aquifers occurs in topographically elevated areas (Figure 8.18). Recharge is via vertical infiltration from precipitation through the thin soil horizon, which mostly occurs during spring freshet. Groundwater flows through the bedrock mass under the influence of gravity and discharges in topographically low areas.

Recharge into the local surficial deposits is likely via two main mechanisms, through streambed discharge and through exfiltration from bedrock aquifers. As the surficial aquifers are located at lower elevations the contribution from precipitation is likely insignificant in comparison to the infiltration at higher elevations, due to the negligible water surplus at low elevations. The recharge from streams occurs as the streams flow off the predominantly bedrock highlands and onto the surficial sediments or alluvial fans at lower elevations. Likely the streams lose flow over the initial reaches as they flow off the bedrock and onto the surficial deposits and may gain flow again at lower elevations before flowing into the lake. The majority of recharge to the surficial aquifers likely occurs as groundwater exfiltrates from the bedrock aquifers into the surficial aquifers.

A report on drainage in the Glenrosa area of Westbank (Golder, 1992), examined groundwater elevations in 43 water wells at the time of drilling and concluded that groundwater recharge occurred primarily at elevations greater than approximately 650 – 700 m.

An estimate of the maximum and potential average annual rate of recharge to TLU aquifers was obtained using an approximate water balance approach. Areas of the TLU below 1,200 m elevation are considered to have a negligible water surplus and therefore do not generally contribute to groundwater recharge. Assuming that recharge occurs only in the upland area of the TLU, the water balance for the four points-of-interest representing plateau portions of the TLU generally above 1,200 m (Lambly Creek below the confluence with Terrace Creek, Powers Creek below the confluence with North Powers Creek, Trepanier Creek below the confluence with MacDonald Creek, and Peachland Creek below the confluence with Greata Creek) was analysed (Table 8.6). Based on these four points-of-interest, the annual precipitation and annual runoff average 623 mm and 399 mm, respectively. The difference between precipitation and runoff is 224 mm, and represents the surplus amount of water that is available for both evaportranspiration and groundwater recharge.

An estimate of the maximum volume of potential groundwater recharge can be estimated assuming that none of the surplus water goes into evapotranspiration (an assumption that is necessary in lieu of data on actual evapotranspiration rates), and that groundwater recharge generally occurs on the plateau above 1,200 m. Although both assumptions are not strictly valid since some percentage of the surplus water is certainly lost through evapotranspiration and since groundwater recharge may occur nearly everywhere in the TLU at some time of the year (e.g., winter rain on the lower terraces), the assumptions permit an estimate of the upper limit of groundwater recharge that can be expected in the TLU. The maximum volume of potential groundwater recharge is estimated at approximately 122,000,000 m^3/yr in the area above 1,200 m elevation (determined by multiplying the area above 1,200 m elevation by 224 mm).

It is possible that actual groundwater recharge rates are considerably less than the maximum noted above, since the annual potential evapotranspiration on the plateau (based on the Thornthwaite method using temperature normals from Peachland – Brenda Mines) is estimated to be 390 mm (and the total of recharge and actual evapotranspiration is only 224 mm). Although data on actual evapotranspiration rates for the plateau are unavailable, it is likely to be considerably less than 390 mm. Discussion with representatives of Noranda Inc. (owners of the closed Brenda Mine) suggest that groundwater recharge in the high elevation portions of the TLU is "negligible". If it is assumed that 90% of the difference between precipitation and runoff goes into evapotranspiration and 10% goes into recharging regional aquifers, then the total annual groundwater recharge in the TLU is 22 mm (12 million m^3 per year).

8.2.5 Groundwater Discharge

Groundwater flows under the influence of gravity from the upland areas west of Okanagan Lake towards the valley floor. Shallow groundwater flow likely occurs along the bedrock - soil interface, through the shallow bedrock and then into any fractures that are present (Figure 8.18). Discharge from the soil bedrock interface is likely into local surface water bodies.

The Glenrosa report (Golder, 1992) indicates that groundwater discharge occurs below 650 m elevation. This area roughly corresponds to the area where sand and gravel deposits occur near surface, which may form regional discharge areas at certain times of the year.

Most of the groundwater in the deep aquifers likely discharges into Okanagan Lake, which is a large regional feature. There is likely some component of discharge from the deep bedrock aquifers into the granular deposits that host the six aquifers listed in Table 8.8.

8.2.6 Potential Groundwater Issues

Potential present and future issues related to groundwater use in the TLU include contamination, local well interference and local over extraction, given the limited extent of the surficial aquifers. As the population in the TLU increases, the potential demand on water resources may also increase and the problems listed above could potentially arise.

Contamination issues could result from surface activities and land use practises, especially over the coarse-grained surficial deposits located in and around Westbank, which host the highest yielding aquifers. The siting of potential point source contamination sources including small retail businesses, manufacturing and some agricultural activities could potentially impact groundwater quality.

Potential well interference issues and over-extraction, which could lower the water table, may arise as population increases and development spreads. Additional pressure on the groundwater resource may occur from industrial or manufacturing sources, or from agricultural users, especially irrigation. Over exploitation would likely be more acute in the bedrock aquifers, if wells are developed in the same fractures or fracture network. Well interference could also arise, however, in the sand and sand and gravel aquifers if large volume wells are installed in close proximity to each other. Additional aquifer data is required in order to determine the distances and pumping rates that would minimize potential well interference problems.

8.2.7 Summary

The following summarizes the key findings with respect to groundwater in the TLU:

- Six large aquifers have been identified in the TLU, all located in the vicinity of Westbank. There are likely additional, smaller aquifers in the upland area of the TLU that have not yet been identified;

- The six identified aquifers were assigned moderate to low development values, moderate to low vulnerability and low ranking points, within the provincially derived aquifer classification system;
- The predominant mechanism of regional groundwater recharge is likely vertical infiltration during spring freshet. There is likely some recharge over the lower elevation areas of the TLU (below 1,200 m), however the water balance estimate revealed a negative water balance below 1,200 m;
- Regional groundwater discharge occurs in topographically low areas of the TLU, such as into Okanagan Lake; and
- Detailed assessments of aquifer size and extent, aquifer yield and aquifer use are not possible due to a lack of basic hydrogeological data and information.

9.0 INSTREAM FLOWS AND FISH REQUIREMENTS

This section reviews the present state of knowledge of instream flows and fish requirements in the major streams of the TLU, and compares suggested instream flow requirements with present-day flows.

9.1 INTRODUCTION

Aquatic resources in tributaries to Okanagan Lake have been impacted by a long-history of industrial, agricultural, and urban/residential activities. For example, logging in the headwaters and urbanization near the mouths of some of the tributaries may contribute to increased loads of fine sediment and increased peak flows. Agricultural storage and withdrawals have in many cases decreased both the magnitude and frequency of sediment flushing and sorting flows, and have reduced flows during periods of fish spawning, incubation, and rearing. Incremental flow and channel changes have resulted in poor habitat conditions for fish and other instream aquatic resources in many Okanagan Lake tributaries (Galbraith and Taylor, 1969, Koshinsky and Willcocks, 1973, Wightman and Taylor 1978, Tredger and Wightman 1978, and Tredger, 1988, 1989, Shepherd and Ptolemy, 1999). For example, some stream channels have aggraded and flows are at times insufficient for spawning kokanee to reach the spawning grounds. Other streams have gradually coarsening beds, resulting in poor growing conditions for the invertebrates that resident fish and rearing juveniles rely on.

At present, there is no standard method in B.C. for setting instream flow requirements. However, several attempts have been made to set flows to meet the needs of aquatic resources in Okanagan Lake tributaries. The first major initiative was one of the supporting studies for the Okanagan Basin Agreement (Canada – British Columbia Okanagan Basis Agreement, 1974). The OBA was focussed on increasing fish production for recreational fishing (kokanee salmon and rainbow trout) and on increasing the amount of water available for agricultural and domestic use. This valuation of aquatic resources is reflected in one of the stated goals of the project coming out of the consultative process:

> "*That major conflict in water use between irrigation and fishery requirements in tributary streams be avoided by managing Mission, Equesis, and Trepanier Creeks for fisheries and irrigation purposes, and developing other major creeks primarily for domestic and agricultural use.*"

In addition to managing water in these three tributaries for both fisheries and irrigation, the Consultative Board recommended that spawning beds in these streams be restored and fisheries resources be enhanced in the mainstem and headwater lakes. Fisheries values in the other tributary streams were considered less valuable since more fish could be produced in the lakes through water-level management, stocking, and spawning habitat for lake-residents than could be produced if the water were released for in-stream fisheries. The fisheries management philosophy has since changed and all fish-bearing tributaries to Okanagan Lake are managed to protect fisheries values, at least as far as is possible within the flow availability constraints. The idea of *conservation* flows represents a shift away from maximizing basin-wide fish production at the expense of stream-resident fish and those lake-resident species and stocks that spawn in "less important" Okanagan Lake tributaries.

More recent attempts to set stream flows to meet the needs of aquatic resources include work by NHC (2003a, 2003b, 2003c, 2003d) and Rood (2001). All of these studies are similar in that they utilize estimated "naturalized" hydrographs to set fisheries flows as percentages of the Mean Annual Discharge (MAD). The fisheries flows vary over the course of the year depending on the fish species and life stages that are most flow limited at any given time. Of the creeks in the TLU, Peachland, Trepanier, Powers, and Lambly have all been re-evaluated in these two recent studies.

In order to attempt to calibrate the recommended Conservation Flows that were based on a percentage of MAD, the NHC (2003a, 2003b, 2003c, 2003d) reports analyzed the results of three years of flow and fish habitat assessment in Lambly, Peachland, Powers, and Trepanier Creeks. The flow and fish habitat assessment data was collected by MWLAP between 1999 and 2001 and consisted of repeated trips each year to quantify available fish habitat over a range of flows. Unfortunately the linkages between flow and fish habitat were not strong and the type of fish habitat information that was collected has resulted in the data being of limited value for calibrating the recommended Conservation Flows (NHC, 2003a, 2003b, 2003c, 2003d).

A process of addressing short-term fish flow requirements in Trepanier Creek and Peachland Creeks has been underway for about two years. This effort involves Peachland, Brenda Mine, Trepanier Ditch Water Users Community, LWBC, DFO and MWLAP. In addition, LWBC, DFO and MWLAP have been engaged in ongoing discussions with the Westbank Irrigation District to specify fish flow requirements for Powers Creek.

All of the identified streams in the TLU are known to contain at least rainbow trout (stream-residents and spawning or incubating lake-residents) and most also contain kokanee salmon. In addition, some of the streams may be used by other species such as burbot, sculpins, suckers, and brook trout (MSRM, 2003). However, for the purposes of this project rainbow trout and kokanee salmon have been selected as the target species. Table 9.1 and Figure 9.1 present the distribution of the target fish species in the TLU streams, referenced in distance from the mouth.

Table 9.1 Summary of the distribution of rainbow trout and kokanee salmon in the project streams

Creek	**Upstream Limit of KO Distribution**	**Upstream Limit of RB Distribution (km)**
Lambly Creek	1.2 km	1.2 km for lake-residents, throughout for stream residents
McDougall Creek	0.0 km	6.4 km or 12.8 km for lake-residents, throughout for stream residents.
Powers Creek	0.8 km	2.6 km for lake-residents, throughout for stream residents
Trepanier Creek	0.8 km	1.3 km for lake-residents, throughout for stream residents
Peachland Creek	1.2 km	1.2 km for lake-residents, throughout for stream residents

Fish distributions are based on Wightman and Taylor (1978), Tredger (1989), and Inkster (1992).

The term “throughout” in the above table is intended to imply that resident fish, most notably rainbow trout, are present in the mainstem and major tributaries that have suitable fish habitat. The upstream limit of fish presence in each tributary has not been documented in the present report, although this information is likely available for many streams from the forestry companies and government sources (e.g. RDCO "SHIM" data).

The following report sections for each of the TLU streams summarize habitat information that can be used to calibrate the conservation flow recommendations of Rood (2001) and NHC (2003a, 2003b, 2003c, 2003d). In addition, we have extended the presentation of conservations flows presented in Section 8.0 by considering conservation flows in relation to net and naturalized flows in drought years and in wetter than average years. Appendix N provides 14 figures (one for each of the 14 points-of-interest (POIs) used for the present plan) that illustrate the conservation flows in relation to 1 in 5 year drought flows.

While there are no spawning or incubating kokanee upstream of the second point-of-interest in most creeks, the conservation flows have remained unaltered from those presented in Rood (2001) due to the presence of rearing rainbow trout. It may be reasonable to reduce conservation flows during the fall and winter in stream sections without kokanee, although the over-wintering needs of rainbow trout would have to be considered. However we have used a universal set of conservation flows for the discussion in Section 8.0 and the following discussion.

The maximum monthly conservation flow is proposed for May, at 200% of the mean annual discharge (MAD). A flow of this magnitude will permit spawning and migration of rainbow trout and will connect most side channels and some riparian areas to the main channel. However, in order to maintain stream channels and sort instream substrate for spawning habitat it is necessary to have much higher flows, up to 500% MAD, periodically (every 2 – 3 years). The necessary duration of these higher flows has yet to be firmly established.

Since universal conservation flows are being used in this report it is useful to keep in mind that these flows do not apply equally well to all channel types. In general, if a channel is wide and shallow more flow is required to provide optimum fish habitat than if the channel is narrow and confined (e.g., canyon). Determination of the characteristics of each stream on this continuum will require field measurements of each stream reach.

Due to water management practices there can be sharp changes in flow downstream of storage or diversion points in all of the streams. These short duration changes (lasting for hours or days), while of critical importance to fish, are not reflected in the monthly flow analysis, which uses average monthly flows.

9.2 LAMBLY CREEK

There is a 30 m high falls on Lambly Creek that is 1.2 km from the mouth. The channel below this point is accessible to kokanee and lake-resident rainbow trout. However, this section of channel is subject to severe summer and fall flow restrictions because of the flow diversion to Rose Valley reservoir (Dobson 1990a). Only a small number of trout are likely to use the creek downstream of the falls (Galbraith and Taylor, 1969, Wightman and Taylor, 1978).

Due to the high channel gradient and large substrate size there is little available kokanee spawning habitat, although kokanee escapements as high as 2,670 spawners have been recorded (Tredger, 1989). Typically by fall low flows likely restrict the amount of kokanee spawning habitat that is wetted and available for spawning to less than the total available habitat.

A weighted usable area analysis of kokanee spawning habitat downstream of the falls suggested that habitat availability increases with flow up to about 0.20 m^3/s, beyond which there is little increase in habitat. The study evaluated habitat availability over the range of flows between 0.03 m^3/s and 0.39 m^3/s. There was about a five-fold increase in habitat between flows of 0.03 m^3/s and 0.20 m^3/s (Tredger, 1989). One shortcoming of this analysis is that the habitat suitability curves on which the analysis was based were not made explicit, making a thorough review impossible.

Rearing habitat for rainbow trout parr followed a similar pattern to that described for kokanee spawning, with habitat availability increasing fairly rapidly with flow to about 0.20 m^3/s then slowing at higher flows (Tredger, 1989).

Conservation flows for Lambly Creek under average flow conditions are tabulated and plotted in Appendix I, and addressed in Section 8.0. Conservation flows in relation to 1 in 5 year drought flow conditions are presented in Appendix N.

Under wet-year conditions there is currently sufficient flow in all months at all POIs to meet the recommended conservation flows. This is not the case under mean or dry-year conditions, with current usage patterns. Since the actual water usage in this basin is much less than the licensed volume, the ability to meet conservation flows is likely to be further compromised in future.

In general, the naturalized flow (reconstructed natural hydrograph) is higher than the net flow during freshet months because water is being diverted to storage. However, in some of the drier months the net flow is higher than the naturalized flow, depending on the pattern of water release from storage and the volume diverted.

Conservation flows are readily met during all of the freshet months at all POIs and they are higher than even the mean monthly naturalized flows in some months (December, January, and February) at all POIs. The conservation flows are higher than naturalized flows in all but three months (May, June, and July) under dry conditions. This suggests that the recommended conservation flows are set too high, if even in the absence of water use the flows could often not be met. The conservation flows have been set to provide “optimal” conditions, not “natural” conditions. Under natural flow conditions there will be periods in most streams when flows are low enough to limit fish production (i.e. not enough spawning or rearing habitat). While low flows may have a negative impact on fish numbers, reproductive success or biomass in the stream, it seems reasonable to manage flows such that the impacts occur with the same severity and frequency as would be the case in the absence of flow management (i.e. no storage, release, or diversion).

Under current water usage patterns the instream flow is similar to the naturalized flow in non-freshet months at all points of diversion, except downstream of the Lakeview Irrigation District's diversion, where July and August flows at the lowest POI are well below the conservation flows under mean conditions. Under dry-year conditions flows are very low, near zero, at this POI during August and well below the conservation flows in most of the other non-freshet months.

As presented above, Tredger (1989) reported that the availability of habitat in the mouth reach of the creek for spawning kokanee and rearing rainbow trout parr increased fairly rapidly with flow to about 0.20 m^3/s, beyond which the rate of increase slowed considerably. This change in the rate of habitat accumulation with flow is often considered a reasonable minimum stream flow for maintaining fisheries values. A flow of 0.20 m^3/s is about the flow that is found in this reach during the lowest flow months of the year under dry-year conditions (1-in-5 year return period), and is about half of the recommended conservation flow for these months. While this analysis suggests that the conservation flows are set too high, we would recommend that a more thorough analysis of change in habitat availability with flow be completed before reducing the recommended conservation flows. Water temperature was not thoroughly considered in the Tredger (1989) work and should be incorporated into future analyses. In addition, any future IFIM-type habitat analysis should include more assessments of changes in habitat with flow in the range of flows under consideration as the conservation flows, as the shape of the flow-habitat curve in this flow range is critical to the analysis and must be supported with several data points to be thoroughly defensible.

9.3 McDOUGALL CREEK

McDougall Creek is reportedly accessible to lake-resident rainbow trout to 6.4 km (Galbraith and Taylor, 1969), 10.7 km (Inkster, 1992), or 12.8 km (Wightman and Taylor, 1978). During a fish inventory of the creek Inkster (1992) captured rainbow trout throughout the surveyed section of stream, which ended at a 14 m high falls at 10.7 km from the mouth.

There is apparently no suitable spawning habitat for kokanee in the stream due to the relatively steep channel gradient, large substrate size, and lack of flow at the mouth in nearly all years (Inkster, 1992). The stream is subject to very low summer/fall flows, such that the dry channel stretches up to 4.5 km upstream from the mouth in some years.

Conservation flows for McDougall Creek under average flow conditions are tabulated and plotted in Appendix J, and addressed in Section 8.0. Conservation flows in relation to 1 in 5 year drought flow conditions are presented in Appendix N.

In general, the naturalized flow (reconstructed natural hydrograph) is higher than the net flow during freshet months because water is being diverted to storage. However, in some of the drier months the net flow is higher than the naturalized flow depending on the pattern of water release from storage and volume diverted.

Under wet-year conditions there is currently sufficient flow in all months and at all POIs to meet the recommended conservation flows. This is not the case under mean or dry-year conditions with current usage patterns. Since the actual water usage in this basin is less than the licensed volume the ability to meet conservation flows is likely to be further compromised in future.

Conservation flows are readily met during all of the freshet months at all POIs. However, they are higher than even the mean monthly naturalized flows in some months (December, January, and February) at all POIs, and are higher than naturalized flows in all but three months (May, June, and July) under dry conditions. This suggests that the recommended conservation flows are set too high, if even in the absence of water use the flows could often not be met.

Under current water usage patterns (net flow) the instream flow is similar to the naturalized flow in non-freshet months at the upstream point of interest. However, downstream of the main point of diversion August and September flows are well below the conservation flows under mean conditions. Under dry-year conditions flows are zero at this POI during August and September, and well below the conservation flows in most of the other non-freshet months.

No detailed flow-habitat assessments have been completed that can be used to calibrate the proposed conservation flows for McDougall Creek.

9.4 POWERS CREEK

Only the lowest 800 m of Powers Creek are accessible to kokanee, but rainbow trout from Okanagan Lake can access the creek to 2.7 km from the mouth (Tredger and Wightman, 1988). The portion of channel accessible to kokanee has been channelized and consequently has little suitable spawning habitat for this species as the substrate is generally either too fine or too coarse. However, between 0.8 km and 2.6 km the fish habitat is excellent. Protection of instream flows are considered an extremely high priority (Galbraith and Taylor, 1969, Wightman and Taylor, 1978), both because the flow is relatively stable (an asset to the fishery), but also because there is insufficient flow for both fish and irrigation during dry years (Dobson, 1990b).

Water temperatures in Powers Creek reach their peak during the summer months, with the highest reported temperature (only periodic measurements) at the mouth of the creek being 19.5ºC in June 1969 (Environment Canada, 1977). There is a significant input of groundwater at about 2.6 km that may influence stream temperature (Tredger and Wightman, 1988).

Observations of instream conditions suggest that 0.14 m^3/s provides a good flow for juvenile trout rearing downstream of the barrier (2.6 km) (Tredger and Wightman 1988), while 0.13 m^3/s produced good (not necessarily optimal) conditions for spawning kokanee (Tredger, 1987).

Conservation flows for Powers Creek under average flow conditions are tabulated and plotted in Appendix K, and addressed in Section 8.0. Conservation flows in relation to 1 in 5 year drought flow conditions are presented in Appendix N.

As presented above, the flows that produced good juvenile trout rearing and kokanee spawning conditions in the reach upstream of the lowest POI are 0.14 m^3/s and 0.13 m^3/s respectively (Tredger and Wightman, 1988, Tredger, 1987). These flows are about 25% less than the lowest proposed conservation flows (0.18 m^3/s). The lowest conservation flows include the kokanee spawning period in October.

The proposed conservation flows are slightly higher than the naturalized monthly flows during the winter months (December – February) under average flow conditions, but can be met in all other months if there is no water usage. Under dry-year conditions (1-in-5 year return period) the conservation flows would only be met during freshet (May-July). With current water usage patterns conservation flows are met between July and March, even under dry year conditions, but are not met under dry-year conditions between April and June or even average conditions in April. The reduction in freshet flows reflects the large volume of water that is stored during this period, for release later in the year. During the period when stored water is released net flows are much higher than naturalized flows at all points of interest, suggesting that less water could be released or more diverted while still meeting reasonable conservation flow targets.

9.5 TREPANIER CREEK

Only the lowest 800 m of Trepanier Creek are accessible to kokanee, but rainbow trout from Okanagan Lake can access the creek to 1.3 km from the mouth. The portion of the creek that is accessible from Okanagan Lake has been largely channelized and consequently has few pools and little suitable spawning gravel for trout and kokanee (Rescan, 1992). In addition, there are seasonal flow deficits that limit fish production (Dobson, 1990c). Rainbow trout densities in the lower section of Trepanier Creek were less than half of those found in the lower section of Peachland Creek in September of 1991 (Rescan, 1992). The best trout habitat in this section is the most upstream 100 m (Wightman and Taylor, 1978). Upstream of the obstructions (at 1.3 km) the creek supports fair numbers of resident trout.

A weighted usable area analysis of kokanee spawning habitat downstream of the barrier suggested that habitat availability increases with flow throughout the flow range that was examined (0.06 m^3/s and 0.17 m^3/s). There was about a five-fold increase in kokanee spawning habitat between flows over this range (Tredger, 1989). One shortcoming of this analysis is that the habitat suitability curves on which the analysis was based were not made explicit, making a thorough review impossible. In addition, habitat availability was only examined at four flows, making it difficult to identify precisely when flow increases begin producing diminishing returns of fish habitat.

Rearing habitat for rainbow trout parr followed a similar pattern to that described for kokanee spawning, with habitat availability increasing steadily over the entire range of flows that were examined. However, rearing habitat for rainbow trout fry began decreasing at flows greater than 0.11 m^3/s (Tredger, 1989).

Conservation flows for Trepanier Creek under average flow conditions are tabulated and plotted in Appendix L, and addressed in Section 8.0. Conservation flows in relation to 1 in 5 year drought flow conditions are presented in Appendix N.

As presented above, Tredger (1989) reported that the availability of kokanee spawning habitat in the accessible reach of Trepanier Creek increased with flow up to about 0.20 m^3/s, beyond which there was little, if any, increase. This flow is very similar to the proposed conservation flow at the POI in this reach (0.218 m^3/s), suggesting that the conservation flows provide optimal flow conditions for kokanee. The rainbow trout habitat response with flow was more complex than for kokanee since parr rearing habitat increased with flow over the range considered, while fry habitat availability decreased at flows above 0.11 m^3/s, which are approximately half of the minimum proposed conservation flows.

As with the other creeks in the TLU, the proposed conservation flows are higher than even the naturalized flows under average flow conditions in some months (August through February). Under dry-year conditions (1-in-5 year return period) the only months when the conservation flows are met are between May and July. This suggests that the proposed conservation flows at all POIs are unreasonably high. Even under wet-year conditions the conservation flows would not naturally be met between December and February.

When current water usage is factored in the conservation flows are only met between April and July under average flow conditions, at all POIs. Under dry-year conditions conservation flows are only met during May and June at all POIs, with the addition of July at the upper two POIs. This condition is likely to be exacerbated as water demand increases, particularly considering that the irrigation district only uses a portion of existing water licences.

9.6 PEACHLAND CREEK

Peachland Creek has 1.2 km of channel, downstream of Hardy Falls, that is accessible to fish from Okanagan Lake. Downstream of the falls the habitat is fairly homogeneous, with a deficit of high-quality spawning gravel (Wightman and Taylor 1978). However, fish habitat has been improved with the installation of gravel-catching structures. This lower section of Peachland Creek now has abundant cover and suitable spawning substrates (Rescan, 1992). The flow regime is reported to be stable, but is susceptible to flow interruptions in late-summer (Bull, 1977, as cited in Wightman and Taylor 1978).

Conservation flows for Peachland Creek under average flow conditions are tabulated and plotted in Appendix M, and addressed in Section 8.0. Conservation flows in relation to 1 in 5 year drought flow conditions are presented in Appendix N.

The proposed conservation flows are slightly higher than the naturalized monthly flows during the winter months (December – February) under average flow conditions, but can be met in all other months if there is no water usage. Under dry-year conditions (1-in-5 year return period) the conservation flows would only be met during freshet (May-July). With current water usage patterns conservation flows are met in all months except April at all POIs (also May at the upper two POIs) under average flow conditions, and between April and June under dry-year conditions. There is much more water in the channel during low-flow months at all POIs under the current flow regime than would have occurred naturally.

Under dry-year conditions there is sufficient storage capacity in this watershed to nearly eliminate freshet flows. Under more severe dry conditions there would be no freshet. Considering the high instream flows during the fall and winter that now occur throughout the channel where once flows were more modest it may be prudent to re-evaluate the storage and release policy in this creek. It may be possible to store and release less water, more closely mimicking natural conditions.

9.7 SETTING OF FUTURE CONSERVATION FLOWS

There are two philosophies upon which conservation flows can be based. One is based on the identification of optimal conditions for aquatic resources and setting the conservation flow at this optimum level or where conditions begin to rapidly deteriorate. The second is based on mimicking natural conditions, even when these conditions are clearly poor for aquatic resources, as occurs under drought conditions. Agreement on the underlying philosophy is key since it determines what information will be required to manage water for aquatic resources in the coming years. The mandate for setting instream flow values lies with MWLAP, however for these values to be adopted in practice they will require the support of other stakeholders, including LWBC. If the first philosophy is selected then it will be necessary to design and implement the studies required to identify optimal or break-point conditions for aquatic resources. If the second philosophy is selected then water managers will have to obtain the tools to decide what the natural conditions would have been in a given year or month in the absence of human intervention. In addition, similar habitat information should be collected as for the first philosophy so that the impacts of mimicking natural low-flow conditions will be explicit. The first step is to decide on how conservation flows will be set and then proceed with detailing the studies or analyses that must be completed to support the selected conservation flow setting methodology.

Several recommendations for making conservation flows more defensible are provided in Section 16.0.

9.8 SUMMARY

Streams in the TLU support a variety of fish species, including rainbow trout and kokanee salmon. Fish have faced pressures in recent decades due to flow withdrawals from tributaries and habitat impacts, particularly in the lower reaches of TLU creeks. There is no standard accepted method for setting conservation flows in B.C., but there have been ongoing efforts to set conservation flows in the major creeks of the TLU.

The conservation flows that have been proposed for streams in the TLU are based on percentage of the mean annual discharge (MAD), with the percentage changing by month. In many stream reaches these flows will produce optimal conditions for fish, although more flow may be required in shallow, braided channels and less may be required in narrow, confined channels.

In general, under average climate conditions the five project streams have naturalized flows during the low-flow months that are close to the proposed conservation flows. However, conservation flows exceed base flows in dry years (e.g., 1 in 5 year dry drought), suggesting that conservation flows may be set unrealistically high.

When current water usage is factored in (net flow), most of the streams experience flow deficits relative to the proposed conservation flows during some low-flow months under average climate conditions, and during nearly all low-flow months under 1-in-5 year dry conditions.

10.0 WATER QUALITY

This section describes the potential water quality impacts that are being experienced in the TLU, and summarizes the available water quality data for the TLU and Okanagan Lake.

10.1 POTENTIAL LAND USE EFFECTS ON TLU WATER QUALITY

Human activity in the TLU affects water quality. Protection of water quality has been identified as a major issue by the TAWG. However, the TLU water quality data are generally not well suited to specific analyses of land use effects, so this section describes in general the mechanisms by which urban development, agriculture, forestry, mining, and recreation and tourism can potentially affect water quality in settings such as the TLU. Where possible, specific reference is made to the TLU.

10.1.1 Urban Development

Urban development can result in a variety of impacts on water quality. These impacts are related primarily to increases in the imperviousness of surfaces, increases in the number of sources of potential contamination, and physical changes in streams, wetlands, and lake shores.

Imperviousness. Urbanization is accompanied by pavement. Roads, driveways, structures, parking lots, industrial storage facilities, and similar features of the urban landscape increase the imperviousness of watersheds. Imperviousness has been widely studied and is implicated in increases in peak flows, decreases in base flows, reduced water quality, and related ecological harm. Standard techniques are available for reducing “effective” imperviousness in urban areas. Practicing these techniques would pay a variety of benefits in the TLU, including:

- improved infiltration of runoff,
- greater groundwater recharge,
- improved runoff quality,
- reduced risk to downstream areas from channel-altering high flows and flooding, and

- greater stream bank stability.

Water Pollution. The contaminants typically associated with urban development include:

- sediments (primarily from erosion from roadsides and construction areas),
- pathogens and nutrients from poorly functioning wastewater treatment systems,
- chemicals from domestic (e.g. gardening) activities;
- chemicals from industrial (e.g. direct discharges or runoff from large impervious surfaces) and commercial (e.g. petroleum stations) activities;
- biochemical oxygen demand (BOD) due to the release of organic material to water bodies, and
- atmospheric deposition of particulates and chemical compounds.

Human activities in urban areas can increase contaminant loading of surface water and groundwater. These contaminants are typically associated with:

- stormwater runoff (particularly from roads and parking lots) that can carry hydrocarbons, metals, fertilizers, pesticides, de-icing chemicals, solvents and detergents,
- domestic wastewater (particularly from septic systems) that can release pathogens, raise biological oxygen demand in receiving waters, and cause eutrophication,
- runoff and discharges from industrial activities,
- spills of toxic materials, and
- leachate and runoff from solid waste disposal.

Because of the difficulty and expense of removing contaminants once they are in groundwater or surface water, the most economical and effective method of protecting water quality is source control. Source control emphasizes reducing the release of contaminants at source. To be effective, source control requires that industrial, agricultural and domestic users of chemicals be educated in methods of reducing the release of contaminants, and that they are willing apply that knowledge. RDCO currently operates an education program aimed at reducing impacts on water quality.

In recent years, more exotic contaminants from urban and industrial settings have been identified that can affect water quality. These include compounds such as hormones and pharmaceuticals that could enter the water supply from human and livestock waste. No work has been completed in the TLU to assess whether such compounds are present, but there is increased public awareness of these issues.

Waste in the TLU is treated by either septic systems or by a community treatment plant. Ground disposal systems work reasonably well as long as (a) the septic system was properly designed and sited, and (b) it is properly installed and operated. RDCO's Liquid Waste Management Plan calls for servicing of all urban properties in the TLU by community sewers. Many properties along the shore o Okanagan Lake have been sewered, and several hundred properties per year are being converted from septic to the community system. However, to date, none of the homes along Westside Road have been connected to municipal sewer.

RDCO operates a sewage treatment plant in the TLU that provides tertiary treatment for all waste. The effluent is disinfected with ultraviolet radiation before being discharged to Okanagan Lake. Few "package" treatment plants are currently used to serve development in the TLU.

Pathogens in domestic water supply (from either human or natural sources) have resulted in the need for care in disinfection and treatment of water supply. Chlorination of water containing organic matter may create trihalomethanes (THMs), which have been linked to increased human cancer risk, although THMs have not been a major source of public concern in the TLU to date.

Solid waste management practices can affect water quality, but modern landfills are designed to minimize the release of leachate and runoff to groundwater and streams. RDCO operates a single landfill in the TLU and maintains monitoring wells near its landfill, and is prepared to take action if problems are identified.

Physical changes. Urban development is frequently accompanied by filling and culverting of streams, draining and filling of wetlands, and related changes to the hydrologic system. Agriculture in the Okanagan probably triggered the most widespread changes in the hydrology of the major tributaries, and in addition, the Okanagan River and lake system has been altered and regulated to accommodate needs for flood control, drainage, recreation, and irrigation. In the TLU, the hydrologic system has been controlled to facilitate irrigation, domestic water supply, and urban development. All major streams in the TLU are regulated, and water is withdrawn from streams for a variety of uses. Recreational boating has resulted in construction of launching facilities on larger TLU lakes, potentially impacting the riparian and aquatic environment through physical and biological impacts. The network of resource roads on Crown land has the potential to influence drainage patterns. However, recent studies done in the major watersheds of the TLU have addressed and corrected any road-related drainage problems, and the Forest Practices Code Act now prevents alteration of natural drainage patterns.

10.1.2 Agriculture

Agriculture is a common cause of non-point source (NPS) pollution. Controlling NPS is challenging because many individual producers contribute to the problem. With such a cumulative effect, it is difficult to show direct cause and effect between a specific user and a water impact. Legal remedies are limited, and controlling agricultural NPS depends on farmer and rancher practice.

Agricultural pollution can result from applying fertilizers and pesticides, from erosion and sedimentation related to land clearing and cultivation, and from microbial pollution associated with livestock manure. The effects of agricultural activity can include human health impacts (from pesticide drift and aquifer contamination), effects on aquatic

ecosystems (e.g., eutrophication), and destruction of riparian habitat from the expansion of areas under
cultivation. Grazing on unimproved range and forest land can result in damage to stream banks, sedimentation, loss of riparian vegetation, and contamination by animal waste.

NPS problems from agriculture can be largely controlled by widespread adoption of best management practices by farmers. Changes in cultivation and grazing practices, improved manure management, improved tillage practices, and reductions in application of agricultural chemicals can make substantial differences to NPS loads.

Water quality is affected by cattle watering, particularly in the Lambly Creek and Powers Creek watersheds. Watershed assessment reports (Dobson, 2001a and b) note that:

> "The most sensitive water use in Lambly Creek watershed [is] the potable water supply. Forest harvesting and cattle grazing have the greatest potential to impact water quality;
>
> Cattle activity around channel crossings [in the Lambly Creek watershed] has resulted in delivery of sediment to channels. The impacts are generally localized and minor, but chronic;"
>
> "Cattle are present in the [Powers Creek] watershed and contribute to channel disturbance in those areas where they congregate for water. Repeated movement in and out of the channels, along with grazing of the riparian vegetation, leads to destabilization of the banks and an influx of sediment to the channel system. The cattle activity often occurs in the same locations year after year."

Water quality can also be affected where cattle contribute fecal coliform bacteria to watercourses. A one-year study in Lambly Creek, however, found that wildlife appeared to be the major source of *E. coli* in the stream water (Phippen, 2001). The sample size, however, was small and that result is not conclusive. Additional sampling may be warranted to verify sources of *E. coli* if coliform bacteria counts increase.

10.1.3 Forestry

The following water related issues can be associated with forest harvesting and related activities:

- Building roads relatively close to the mainstems of streams can damage riparian areas. However, in the TLU, roads generally stay outside riparian zones.
- The compatibility between logging and protection of water quality in community watersheds is an ongoing challenge. In the TLU, the major forestry companies and the major water utilities have developed cooperative working relationships in which each is sensitive to the others objectives.
- Timber harvesting can increase total annual water yield (because evapotranspiration by trees is reduced), and increase peak flows and base flows. In the TLU, such potential changes have been addressed in "watershed assessment" studies conducted in each of the five major tributaries, and recommendations have been made to limit these effects. At present, there is no evidence that any of these potential effects are significant in any streams within the TLU.
- Forest harvesting can also increase stream temperature, alter nutrient dynamics, and change stream habitat. These potential effects have been considered in the watershed assessments noted above, and the effects found to be minimal.
- Road construction and maintenance can cause sediment to enter streams. However, in the TLU, stakeholders report that roads do not represent a major water quality concern.
- Reforestation can affect water use and the ecology of watersheds, depending on the timing, species, and density of replanting. In the TLU, forestry firms have applied no fertilizers, pesticides, or herbicides since the early 1980s. Chemical use in forestry, therefore, is not considered to be of concern in the TLU.

In the TLU, communications among forest companies, water purveyors, and regulators is extensive, ongoing, and effective in identifying problems and issues. Water purveyors in the TLU have identified relatively few water quality issues associated with forestry operations.

10.1.4 Mining

Aggregate extraction may affect water in the TLU depending on the methods used. Generally, however, water is required to wash deposits clean of sediments and to sort deposits by size. Operations may result in relatively localized effects on stream patterns, the timing and volume of flows, and water quality. No information was available regarding the water use of existing aggregate producers in the TLU, so it is not possible to identify specific impacts on water and their severity.

Potential water related issues associated with the decommissioning of the Brenda Mine site are primarily related to the on-going discharge of molybdenum and other metals to McDonald and Trepanier Creeks and potential effects on cattle and ruminant wildlife, although concerns related to human health have also been expressed by local residents. The water treatment system and monitoring program at Brenda Mine is described briefly in Section 10.2. Ongoing impacts from past mining activities are expected to lessen over time as reclamation efforts continue.

10.1.5 Recreation and tourism

Recreational facilities and activities in the TLU that have the potential to affect water quality are golf courses, boating, and off-road vehicles. In addition, there is concern amongst health authorities and water utilities about a current proposal from LWBC to privatize leased recreational properties located around upland lakes and reservoirs. Golf courses regularly apply fertilizers, herbicides, and other pesticides for turf management. Fertilizers and pesticides are also commonly used on playing fields and other outdoor recreation facilities. Boating occurs primarily in Okanagan Lake, where boat engines may release hydrocarbons into the water. All terrain vehicle (ATV) use in the Bear Creek watershed has increased in recent years, with construction of a track and reported widespread ATV and motorcycle use throughout the middle portions of the Bear Creek watershed.

Tourism and backcountry recreation can affect water quality by physical disturbance of stream banks or upland slopes. Increased sediment in local streams as a result of trail bike crossings has been identified as a key issue in the TLU, particularly in the Bear Creek watershed. Potential impacts on drinking water quality are also associated with camping and boating, as human and pet animal waste may enter watercourses.

10.2 WATER QUALITY IN THE TLU

This section summarizes the available information on water quality in streams in the TLU and in Okanagan Lake. The amount of water quality data for each stream is variable and depends on the whether or not the stream is a source of drinking water and what industrial activities take place in the watershed. Table 10.1 lists the water quality sampling stations that are on record in the B.C. provincial government's Environmental Management System (EMS) database. Table 10.2 provides the median, 90th percentile, and coefficient of variation values from the EMS for several fundamental water quality variables at the monitoring stations that are closest to the water intakes in Trepanier, Powers, Lambly, Peachland, and McDougall Creeks. In addition to the variables shown on Table 10.2, the EMS database contains data for a range of variables including metals, sulphate, dissolved oxygen, and pesticides, although the sample sizes for some variables are relatively small. Other water quality data has been collected by the water purveyors, but not necessarily transferred to the EMS.

Provisional Water Quality Objectives (WQO)[12] were set for Trepanier and Peachland Creeks in 1992 (Swain, 1992), based on data collected up to 1988 and the B.C. water quality criteria that existed at that time. The technical appendix to the WQO report provides a thorough summary of water quality conditions up to 1988 in Trepanier and Peachland Creeks as well as Lambly and Powers Creeks (Swain, 1990). There was insufficient data at that time to set WQO for Lambly and Powers Creeks, and no data were available then for McDougall Creek.

[12] See the Glossary for definitions of Water Quality Objectives and Water Quality Guidelines (criteria).

MWLAP conducted water quality monitoring in Trepanier, Lambly, Powers, and Peachland Creeks from June 1996 to fall 2000 as part of a program aimed at identifying effects of

Table 10.1 Water quality monitoring sites on record in the provincial EMS database.

EMS ID	NAME	DESCRIPTION	LATITUDE	LONGITUDE	ESTABLISHED DATE	NUMBER OF SAMPLES	FIRST COLLECT. START DT	LATEST COLLECT. START DT
E239618	GREATA CREEK AT WATER SURVEY CANADA STATION	located at Girl Guide Camp; approx. 500 m upstream of Peachland Creek	49.7942	119.8478	22-Nov-99	1	19-Oct-99	19-Oct-99
E244936	GREATA CREEK TRIB A		49.7917	119.9442	13-Aug-01	0		
0500041	LAMBLY C @ WESTSIDE RD. BRIDGE	SAMPLED AT WESTSIDE ROAD BRIDGE NEAR MOUTH	49.9283	119.5114	30-Nov-84	167	17-Apr-72	26-Jun-03
E223646	LAMBLY CR BELOW LAMBLY LAKE	equis# 0500192	49.9619	119.7064	15-Aug-96	0		
E223648	LAMBLY CR U/S OF TERRACE CR	equis# 0500191	49.9999	119.6345	15-Aug-96	96	11-Jun-97	24-Nov-99
E223216	LAMBLY CR. @ LID DIVERSION CWS	Sampled on corner of cement intake	49.957	119.557	20-Jun-96	233	19-Jun-96	30-Oct-02
E223324	LAMBLY CR. D/S LID INTAKE	about 4 km downstream of the Lakeview Irrigation Districtintake	49.9285	119.5137	12-Jul-96	19	12-Jul-96	17-Oct-96
E223659	LAMBLY CREEK U/S OF BALD RANGE	equis# 0500170	49.9834	119.5718	15-Aug-96	19	17-Apr-72	11-Oct-72
E223649	LAMBLY D/S OF TERRACE CR	equis# 0500190	49.9928	119.5892	15-Aug-96	3	11-Jun-97	06-Aug-97
E220725	MACDONALD CRK D/S GRAVEL PIT				18-Jul-94	14	06-Feb-92	06-Dec-93
E223252	MCDOUGAL CREEK U/S DIVERSION	McDougal Creek above diversion ditch to Hascheak Creek	51.5933	119.9897	04-Jul-96	184	10-Jul-96	08-Jul-03
E242784	MCDOUGALL CREEK AT SHANNON LAKE RD		49.8686	119.5924	28-Sep-00	5	10-Oct-00	24-Oct-01
0500056	PEACHLAND C - PE00263 @ MOUTH	SAMPLED AT HWY 97 BRIDGE IMMED. SOUTH OF PEACHLAND	49.7411	119.7622	18-Sep-90	593	28-Feb-69	26-Jun-03
0500851	PEACHLAND C -PE00263 D/S PEACHLAND L DAM	SITE ABOUT 25 M D/S DAM. THIS SITE STUDIED BY BC RESEARCH IN MID-70'S WHEN THERE WAS ALGAE GROWTH DUE TO NITROGEN FROM MINE	49.8317	119.9606	18-Sep-90	19	21-Apr-83	20-Jan-87
0500354	PEACHLAND C -PE00263 U/S MCDONALD C –BRENDA M	SAMPLED 1 MILE U/S OF CONFLUENCE WITH MCDONALD CR. NEAR BRENDAMINES	49.8637	120.012	18-Sep-90	126	01-Sep-71	09-Jun-97
0500856	PEACHLAND C-PE00263 @ P.I.D. INLET CWS	SAMPLE FROM POND D/S OF WALKWAY @ PEACHLAND IRRIG DISTRICT WATER INLET. ACCESS THRU OLD CZ MILL SITE OFF BRENDA MINE ROAD	49.755	119.806	18-Sep-90	247	14-May-85	11-Dec-02

Table 10.1 Water quality monitoring sites on record in the provincial EMS database (continued).

EMS ID	NAME	DESCRIPTION	LATITUDE	LONGITUDE	ESTABLISHED DATE	NUMBER OF SAMPLES	FIRST COLLECT. START DT	LATEST COLLECT. START DT
0500355	PEACHLAND C-PE00263 @DIVERSION U/S PEACHLND L	SAMPLED AT DIVERSION WORKS 400 M UPSTREAM PEACHLAND LAKE	49.8414	119.9711	18-Sep-90	254	17-Nov-67	20-Nov-97
0500055	PEACHLAND C-PE00263 U/S GREATA C @ BRIDGE	APPROX 6 MILES DOWNSTREAM OF PEACHLAND LAKE AT ROAD BRIDGE APPROX 2000 FT UPSTREAM OF GREATA CK. CO-S-9	49.7985	119.8467	18-Sep-90	145	28-Sep-71	11-Dec-02
E234069	TERRACE CR @ WEIR D/S ESPERON DAM CWS	go through gate to spillway on left side dam. sample @ WSC gauging weir	50.0675	119.0633	28-Sep-98	37	28-Sep-98	24-Nov-99
E227070	TERRACE CR. U/S BEAR MAIN FSR CWS	sample taken @ 15m u/s of the culvert on Bear Main (Lambly Cr.) Forest Service Rd.	49.9994	119.6131	07-Jul-97	4	11-Jun-97	06-Aug-97
0500079	TREPANIER C -PE00263 D/S MCDONALD C-PEACHLAND	SAMPLE CREEK APPROX. 200 M CONFLUENCE WITH MACDONALD CREEK	49.8781	119.8781	18-Sep-90	196	14-Jul-70	08-Oct-02
0500078	TREPANIER C -PE00263 HWY 97 BRIDGE-PEACHLAND	SAMPLED AT HWY 97 BRIDGE NEAR MOUTH	49.7831	119.7125	18-Sep-90	318	24-Jan-68	26-Jun-03
0500352	TREPANIER C U/S IRRIGATION INTAKE CWS	SAMPLED 200 M..UPSTREAM OF DAM LOCATED 3 MILES U/SFROM MOUTH	49.293	119.276	18-Sep-90	328	17-Nov-67	11-Dec-02
0500362	TREPANIER C-PE00263 U/S MCDONALD C	SAMPLED APPROX. 0.25 MILES UPSTREAM OF CONFLUENCE OF TREPANIERAND MACDONALD CREEKS.	49.8839	119.8817	18-Sep-90	233	14-Jul-70	08-Oct-02
E206895	TREPANIER CR.-MAXWELL RD @ LOT 17 RD	APPROX. 1.7KM E OF GRAVEL SCREEN PLANT	49.8233	119.7544	29-Jan-87	14	29-Jan-87	23-Sep-87

Table 10.2. Descriptive water quality statistics from selected sampling locations in the TLU.

Variable	Statistic*	McDougall u/s Diversion	Lambly Creek at LID Diversion	Peachland Creek at PID Inlet	Trepanier u/s Irrigation Intake	Powers u/s Intake Reservoir
		EMS # E223252	EMS #223216	EMS #0500856	EMS #0500352	EMS #E223136
pH	Median (*n*)	8.02 (98)	7.99 (85)	8.09 (114)	7.90 (237)	7.74 (89)
	90^{th} Percentile	8.17	8.25	8.20	8.13	8.00
	CV%	5%	4%	3%	5%	3%
Specific Conductance	Median (*n*)	164 (100)	157 (157)	203 (167)	207 (168)	87 (151)
	90^{th} Percentile	211	219	241	484	100
	CV%	41%	33%	20%	65%	21%
Turbidity (NTU)	Median (*n*)	0.40 (106)	0.70 (167)	1.0 (177)	0.50 (268)	0.95 (149)
	90^{th} Percentile	10.0	2.9	3.6	3.3	3.0
	CV%	354%	195%	141%	1147%	167%
Total Suspended Solids (mg/L)**	Median (*n*)	1.0 (83)	1.0 (118)	<5 (117)	<5 (229)	<5 (105)
	90^{th} Percentile	5.0	6.3	9.2	17.2	5.0
	CV%	240%	265%	86%	936%	260%
Fecal coliforms (CFU/100 mg/L)	Median (*n*)	<1 (110)	2 (85)	3 (97)	4 (92)	2 (94)
	90^{th} Percentile	1.0	32.2	17.2	20.7	19.4
	CV%	594%	254%	179%	179%	281%
Total P (mg/L)	Median (*n*)	0.003 (106)	0.022 (74)	0.012 (112)	0.013 (110)	0.020 (79)
	90^{th} Percentile	0.015	0.044	0.027	0.100	0.047
	CV%	192%	73%	116%	464%	73%
True colour (TCU)	Median (*n*)	6.0 (84)	30 (66)	8.0 (76)	7.3 (66)	22 (71)
	90^{th} Percentile	24	60	30	33	43
	CV%	154%	50%	83%	113%	54%

* *n* is the sample size. CV% is the coefficient of variation (= standard deviation ÷ mean × 100%). NTU – Nephelometric turbidity units. CFU – colony forming units. TCU true colour units. ** Non-filterable residue in the EMS database.

forestry activity on water quality (Einarson, pers. comm., 2003). The monitoring by MWLAP in Trepanier and Peachland ceased in 2000 when funding from FRBC was no longer available, but Riverside Forest Products has continued in Powers and Lambly as part of the TFL 49 forest practices pilot project. Some of the data from the FRBC and TFL 49 monitoring programs has been entered in the EMS database, but not all. The data was being reviewed as of mid-December 2003 and summary reports are expected to be available from MWLAP in 2004 (Einarson, pers. comm., 2003).

10.2.1 Trepanier Creek

There is more information available on Trepanier Creek than any of the other TLU streams because of the presence of the Brenda Mine site in the watershed. The mine operated from 1967 to 1990 when it was closed and the site reclaimed. Copper and molybdenum were the principal metals that were mined at Brenda Mine, with smaller amounts of gold and silver (Stroiazzo, 1999). Discharge from the mine site continues to be treated and Noranda, the mine's owner, continues to monitor water quality in MacDonald Creek and Trepanier Creek as a provision of their permit (PE-00263) to discharge treated effluent to MacDonald Creek. The permit was last amended on May 27, 2003.

The contaminant that has been the greatest concern in Trepanier Creek is molybdenum (Mo), primarily because of its potential to cause molybdenosis in ruminant animals including cattle and deer. Dissolved Mo concentrations in the mine drainage waters and water stored in the tailings pond averaged about 3 mg/L (Stroiazzo, 1999). The B.C. drinking water guideline for dissolved Mo is 0.25 mg/L, the aquatic life guideline is 1.0 mg/L, and the guideline for irrigation water is 0.01 to 0.03 mg/L for the average, depending on soil type, and 0.05 mg/L for the maximum. The water treatment plant was constructed in 1998 using a ferric molybdenum co-precipitation process, and operates under a discharge permit under the *Waste Management Act* [see Stroiazzo (1999) for a description of the plant].

Monitoring for the permit takes place at the end of the pipe where it discharges to MacDonald Creek and at the municipal intake on Trepanier Creek. The permit requires that the Mo concentration at the intake (which is intended to represent the reach of Trepanier Creek below the discharge point) meet the following objectives:

- During the irrigation season (June 1 to September 30) the single sample concentration is less than or equal to 0.03 mg/L;
- From October 1 to May 31 the single sample concentration is less than or equal to 0.06 mg/L; and
- The maximum monthly concentration is less than or equal to 0.03 mg/L.

Noranda's permit also requires monitoring for copper, iron, manganese, zinc, sodium, sulphates, dissolved nitrogen, total phosphate, total suspended solids (TSS), total dissolved solids (TDS), pH, and toxicity to rainbow trout (96-hr LC_{50}). The issuance of the permit by the provincial government was appealed to the B.C. Environmental Appeal Board (EAB). The permit concentrations stood but some of the terms of the permit were revised. For details of the issues that were the basis of the appeal the reader is referred to the EAB web site[13].

Water Quality Objectives were set for molybdenum in 1992 that are similar to the permit concentrations (Swain, 1992), but WQO have no legal standing and the permit concentrations are the better benchmark for water quality in Trepanier Creek.

The EMS database contains only limited molybdenum data (n=19 for dissolved Mo), and all samples in the database for the water intake site had concentrations less than the most restrictive permit level of 0.03 mg/L. Data from Noranda's sampling program is not in the EMS database. Swain (1990) reported that only two of 29 samples collected near Peachland up to 1988 exceeded the average concentration guideline of 0.01 mg/L, and all met the maximum concentration guideline. The exceedances were both 0.02 mg/L, and thus would meet the current permit maximum concentration.

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[13] See http://www.eab.gov.bc.ca/waste/98was22a.htm and http://www.eab.gov.bc.ca/waste/98was22b.htm.

Water quality data from the EMS database indicate that Trepanier Creek water is slightly alkaline (median pH 7.9) with moderate concentrations of dissolved solids. Suspended sediment concentrations, as indicated by turbidity and TSS, are generally low but turbidity values do occasionally exceed the B.C. water quality guideline for raw water of 5 NTU during spring freshet. True colour levels, an indicator of dissolved organic matter content, also exceed the relevant drinking water guideline of 15 TCU during freshet. Coliform bacteria counts can be somewhat high on occasion, but generally during the summer months. Nutrient concentrations are low. Swain (1992) noted that concentrations of copper, molybdenum, and zinc occasionally exceeded water quality guidelines. The other water quality variables that were reviewed by Swain (1992) were within guidelines, and dissolved oxygen concentrations were high.

In addition to molybdenum, provisional WQO were set in Trepanier for TDS (max. 500 mg/L), sodium (max. 270), pH (6.5-8.5), and dissolved aluminum (max. 0.1 mg/L, ≤0.05 mean) (Swain, 2002). Samples exceeding these WQO at the water intake site are rare. For pH only 6 out of 237 samples fell outside the objective, for sodium one out of 16, and for TDS it is one out of 156. For dissolved aluminum the mean concentration (0.04 mg/L, n=10) was within the guideline, but one sample slightly exceeded the maximum objective. The concentration on July 14, 1999 was 0.12 mg/L.

10.2.2 Powers Creek

Powers Creek at the intake site has slightly alkaline pH and low dissolved solids. The limited available hardness data in the EMS indicates that the water would be characterized as "soft", but Swain (1992) characterized it as moderately hard. Like the other streams in the TLU, turbidity and colour levels routinely exceed drinking water quality guidelines during spring freshet, and coliform bacteria counts can be elevated during the summer and occasionally at other times during the year. The water is disinfected with chlorine.

The Westbank Irrigation District monitors regularly for turbidity, colour, residual chlorine, trihalomethanes (THMs), *Cryptosporidium*, and *Giardia* on a regular basis (Westbank Irrigation District, 2003a) and produces annual reports. The most-recently available report is for 2002 (Westbank Irrigation District, 2003b). Of the 19 samples of raw water that were obtained in 2002, 14 (or 74%) exceeded the Canadian Drinking Water Guideline for fecal coliforms of 0 colonies/100 mL. However 100% of the 113 samples of treated water met the guideline. All of the 13 samples taken in 2002 tested negative for *Cryptosporidium* but nine (69%) tested positive for *Giardia* (all at <5 counts/100 mL). The aesthetic guideline for true colour of 15 TCU was exceeded in all 21 samples collected at the WID intake in 2002. The average was 42 TCU. Of the six samples collected for trihalomethanes in 2002, three exceeded the interim B.C. guideline maximum of 100 μg/100 mL for total trihalomethanes, largely due to the presence of chloroform. The average was 118 μg/100 mL.

Preliminary analyses of the EMS data indicate changes in the concentrations of some water quality variables as Powers Creek flows through urbanized areas. For example, concentrations of total phosphorus are significantly higher ($p<0.05$) in Powers Creek near the mouth (at the Gellatly Road bridge) than at the water intake. In contrast, turbidity levels were not significantly different between these sites. Additional comparisons of water quality at different locations may be possible when MWLAP's water quality inventory data are available.

10.2.3 Lambly Creek

Lambly Creek water has higher true colour levels than the other TLU streams where data exists. The majority of samples (63 out of 66) in the EMS database had true colour readings greater than the drinking water guideline of 15 TCU. This guideline is primarily set for aesthetic reasons, but high dissolved organic matter concentrations can be a concern in situations where chlorine is used to disinfect drinking water. The sources of the colour in Lambly Creek are the wetlands and associated organic soils in the upper watershed. The water at the LID diversion contains moderate concentrations of dissolved solids, has a neutral to alkaline pH, and turbidity can be high during freshet.

Lambly Creek was one of three Kelowna area streams (along with Mission Creek and Kelowna Creek) that were studied to assess effects of recreation activity in the watershed on water quality (Phippen, 2001). Lambly Creek had lower concentrations of true colour and coliform bacteria than the other two streams. Several water samples tested positive for both *Giardia* and *Cryptosporidium*. Ribosomal RNA analyses of *E. coli* samples found in the water indicated that wildlife was the largest source of *E. coli* in those samples, but human and cattle RNA were also detected. One sample of cow manure was found to contain *Giardia* cysts.

10.2.4 Peachland Creek

Peachland Creek water at the PID inlet is moderately hard and alkaline in pH. Coliform bacteria counts are similar to the other streams in the TLU with the exception of McDougall Creek (see below). Turbidity and TSS concentrations are within water quality guidelines for most days throughout the year, although concentrations above guidelines do occur, mostly during spring runoff. Swain (1992) described water quality in Peachland Creek as usually meeting guidelines for ammonia, nitrate, nitrite, and dissolved solids. Concentrations of copper and molybdenum were noted to frequently exceed guidelines for aquatic life and irrigation, respectively.

Provisional WQO were set for Peachland Creek (Swain, 1992). Table 10.2 lists the WQO along with the EMS median, mean, maximum, sample size, and the numbers of times that the WQO was exceeded at the PID intake in the EMS data. The only exceedances were for sodium (1 sample), total molybdenum, and total copper. All samples in the EMS database met the molybdenum guideline for the maximum, but the average total Mo concentration slightly exceeded the WQO. For total copper, two of 15 samples exceeded the maximum WQO but the mean concentration was within that WQO.

Table 10.3 Peachland Creek Water Quality Objectives and frequency of exceedances in EMS data.

Variable	Water Quality Objective	Sample size	Number of exceedances of WQO	Median	Mean	Maximum
TDS	500 mg/L max.	23	0	120	115	166
Sodium	270 mg/L max	9	1	4.36	71	341
pH	6.5-9.0	114	0	8.09	8.02	8.30
Total Mo	0.05 mg/L max.(1) 0.01 mg/L mean	15	0 for max. Mean does exceed WQO	0.017	0.014	0.030
Total Cu	10.3 mg/L max (2) 3.51 mg/L mean	15	2 for max. Mean meets WQO	0.001	2.73	27
Dissolved Al	0.10 mg/L max 0.05 mg/L mean	-	No data	-	-	-
Nitrate-N	10 mg/L max.	123	0	0.02	0.03	0.15
Nitrite-N	0.06 mg/L max. 0.02 mg/L mean	10	0	0.003	0.002	0.005
Ammonia-N	1.92 mg/L max (3)	6	0	0.003	0.003	0.007
Periphyton chlorophyll *a*	100 mg/m^2 mean	-	No data	-	-	-

Notes: (1) The WQO for Mo, Cu and Al also include a maximum of 20% increase, but the sampling schedule does not make it feasible to assess whether this guideline was met. (2) Based on mean total hardness value of 87.8 mg/L $CaCO_3$ (3) At pH 8.5 and water temperature of 20°C. Objectives for lower pH and temperatures are higher.

10.2.5 McDougall Creek

McDougall Creek has much lower concentrations of fecal coliform bacteria than at the intake or diversion sites of the other four streams. Hardness ranges from “soft” to “moderately hard” and the pH is slightly alkaline. Like the other streams, turbidity levels can be high during high flows in freshet or in response to significant rainfall events.

10.2.6 Okanagan Lake

The Okanagan Lake Action Plan (OLAP) program has been collecting water quality data at seven stations in the lake since 1996 (Kirk, 2000). Some of these stations were also sampled during earlier initiatives, but this section focuses on the 1996-1999 data as indicators of recent conditions in the lake. The closest of the seven stations to the TLU is near Rattlesnake Island (#OK3, EMS #E223295).

Okanagan Lake becomes thermally stratified during the summer. The epilimnion (upper layer) is typically above 20ºC in summer. The hypolimnion (lower layer) begins at a depth of about 20 m and is usually between 5ºC and 10ºC in summer. Dissolved oxygen concentrations in the summer are highest in the hypolimnion (with the exception of Armstrong Arm at the north end of the lake). The lake undergoes thermal mixing in the fall and is isothermal (i.e. temperature similar from top to bottom) in winter, typically in the range of 3-5ºC (Kirk, 2000).

Biological productivity is generally thought to be limited by phosphorus concentrations (Kirk, 2000). Jensen (1999) reports that total phosphorus concentrations in Okanagan Lake declined slightly from 1973-1998 but that there is considerable variation between years that is linked to variations in tributary stream discharge (i.e. higher concentrations in years with higher stream inflows). Total nitrogen concentrations have been trending slightly up. Water clarity increased from 1973 to 1987 in response to improvements in sewage treatment in the Okanagan Basin, but has been declining since then.

10.2.7 Summary

Water quality in the streams in the TLU is influenced by a number of natural and human-caused processes. Land use effects on water quality include urban development, agriculture, forestry, mining, recreation, and tourism. Urban stressors on water quality include sedimentation from construction sites, stormwater runoff, leachate from poorly functioning septic fields, and spills or overuse of household and automotive chemicals. A number of measures have been implemented by RDCO to reduce impacts from existing urban areas and to avoid water quality effects from future development. Agriculture is a potential cause of non-point source (NPS) pollution, with runoff from farms and ranches possibly contributing sediment, nutrients, pesticides, and pathogens. Range activity on Crown Land can also result in damage to riparian areas and stream banks. Forestry impacts can include sedimentation from roads and landslides, changes in the timing and magnitude of peak flows, and elevated stream temperatures. Local water purveyors have, however, identified few issues with forest practices, and water quality protection is an integral part of forest development planning in the TLU. Mining effects include sedimentation and the potential for elevated concentrations of metals due to discharges from reclaimed mine sites (see below). Finally, water quality concerns over recreation include cabin development on upland reservoirs, chemicals in runoff from golf courses and playing fields, erosion from ATV traffic, and spills from boats along the Okanagan Lake shoreline.

Water quality data is available through the provincial EMS database for sites within the Lambly Creek (6 locations), Peachland Creek (6 locations), Trepanier Creek (6 locations including McDonald Creek), Powers Creek (3 locations), and McDougall Creek (2 locations) watersheds. Other data not in the EMS may be available through the water purveyors, Noranda, Riverside, and others. Provisional Water Quality Objectives were set for Trepanier and Peachland Creeks in 1992. MWLAP is currently revising and/or developing new Water Quality Objectives for Lambly, Peachland, Trepanier, and Powers Creeks based on monitoring conducted between 1996 and 2000, with the reports expected in spring 2004.

In general, water in the streams in the TLU can be characterized as having neutral to alkaline pH with moderate concentrations of dissolved solids. All of the major streams that serve as sources of domestic and irrigation water occasionally have turbidity, coliform bacteria, and true colour concentrations that do not meet the B.C. water quality guidelines for raw water, and thus require treatment. The causes of the above-guideline concentrations of these variables likely includes a mix of natural factors and land use effects, although the relative importance of each has not been quantified. Exceedances of water quality guidelines or objectives for molybdenum and copper have occurred on occasion in Trepanier and Peachland Creeks, but the majority of sample results are within guidelines/objectives. Noranda continues to treat the discharge from the Brenda Mines site under permit from MWLAP and monitors for molybdenum, copper, and other parameters under the terms of their permit.

Preliminary analyses of the EMS data sets indicate changes in the concentrations of some water quality variables as the streams flow through urbanized areas. For example, concentrations of total phosphorus are significantly higher ($p<0.05$) in Powers Creek near the mouth than at the water intake.

11.0 ECONOMICS OF WATER

This section presents an analysis of the economics of water, focussing on water rate structures and prices in the TLU, with comparisons with other areas in B.C., Canada, and the world.

11.1 BASIC CHARACTERISTICS OF WATER

A crucial characteristic of water from an economic perspective is that the assignment of property rights is difficult (Dalhuisen, 2001). Water falls from the sky, flows, and evaporates with no regard to boundaries, private, provincial or national. However, three basic characteristics can be used to describe water:

- Water is largely non-excludable and because it is consumed it is rivalerous, so it cannot be categorized as a true public good. Water is often labelled as a common pool resource, meaning that there is a finite amount that must be shared in common over a variety of uses and over geographic areas. The classical "tragedy of the commons" arises when users ignore the effects of their actions in pursuing their own self-interest, creating a significant risk of over-exploitation.

- The renewal of water is both stochastic and seasonal, implying uncertainty in its supply. These characteristics create several problems, given the crucial importance of a constant and steady supply of water to meet the constant need for water. The response to these problems is often manifested in significant infrastructure investment that enables storage and regulation of the supply of water.

- Water is not considered a homogeneous good. There are varying levels of quality, ranging from surface water to drinking water, each with their own supply and demand characteristics.

11.2 CATEGORIZING WATER USES

There are several different demands placed on a typical water supply. These demands can be distilled into the following major categories, which have been utilized in earlier sections of this report in the analysis of water use in the TLU.

Domestic use is the most fundamental role of water in households and is central to human health, with this water typically being used for drinking, washing, and hygiene. Water in this category is used by three categories of consumers: municipal households, farm households, and rural non-farm households.

Agricultural production primarily uses water for irrigation to increase the productivity of agricultural land. Adequate irrigation has been clearly shown to increase the productive capacity of land. Water is directly correlated to the value of agricultural production. Livestock watering is also included in this category.

Commercial production covers water used by commercial and institutional users. Most of this water use is associated with hygienic and personal uses.

Industrial production requires water for a variety of manufacturing, cleaning, and other purposes. In Canada, key industrial users include pulp and paper, chemical production, mineral extraction, petroleum products, and metal smelting.

Power generation includes instream use of water in the generation of power. Although hydroelectric and thermal power generation using water does not remove water from a stream, it often alters stream flow and aquifers, and can have adverse impacts on other water users and associated economic values.

Use of ecosystem service functions (natural processes) water supports natural processes that contribute to the productivity of the economy and the welfare of households. Industrial and domestic uses of water can generate negative externalities by disposing of waste into water and using waste absorption functions that water provides. Major uses in this category include storage and recycling of organic matter, nutrients, and human waste.

Instream uses include use by aquatic plants and animals and human recreation. Water can also provide a sense of satisfaction knowing that a stock of water will be available for others to enjoy and to be passed on to future generations.

11.3 ECONOMIC VALUE OF WATER TO HUMAN ACTIVITY

Having reviewed the characteristics of water and the many uses of water, it should come as no surprise that there are many economic values for water. Water use and associated value will vary with use type, season, location, quantity, and time. For example, industrial and commercial uses of water at current levels of use typically have higher economic values than residential uses. Indoor use, which dominates winter residential water demand, has a higher economic value than outdoor use, occurring mostly in summer. As water shortages intensify, the marginal value of water increases (Jenkins, 2001).

Differences across water service areas in housing, socio-economic characteristics, level of conservation or efficiency, and other attributes of water users cause both the level of residential water use, and the value of residential water to differ by location. Likewise, industrial water use and its economic value depend on the specific operations, size, water costs, and water efficiency of the mix of industries located in a particular area.

However, underlying these varied and unique characteristics of water is the fundamental value placed on each unit of water. Historically, water has been priced below the actual value that the resource holds. Even today, many water consumers in Canada (including the TLU) continue to pay a flat amount for the water they use, regardless of whether they use it efficiently or not. In many instances, low pricing has lead to overuse of the resource.

A good case study of this dynamic comes from a 1970 comparison of water use between Calgary, which at that time used an unmetered, flat rate pricing structure and Edmonton, a fully metered municipality of similar size, geography and socio-economic make-up (Kellow, 1970). In this research it was revealed that the unmetered municipality of Calgary consumed approximately double the volume of water that Edmonton did on a per capita basis. (The City of Calgary is presently moving to full metering, and as of 2003, about half of the City is now metered.)

More recent comparisons reinforce these earlier findings where water users in a flat rate system use more water per capita than do people under more cost-sensitive pricing structures. Data from Environment Canada (2001) indicate that in 1999, residential use by B.C. residents paying a flat rate averaged 526 litres of water daily, while the per capita use for volume-based price structures was 459 litres per day (a 13% difference). (The average usage under all pricing structures (flat only, volume only, and combinations of flat and volume) was 439 litres per capita.) At the national level, the difference is even more noticeable: in 1999, 269 litres was consumed per capita by volume-based residential consumers, compared with 457 litres by flat rate consumers (a 59% difference).

In economic terms, in these cases the price charged for water does not capture the full "consumer surplus", where "consumer surplus" is defined as the difference between what the consumer pays and the actual value. Throughout much of the past hundred years, the desire to capture the full consumer surplus (to charge customers the full value) was not pursued, leading to undervaluing of water resources worldwide. Under valuation has been particularly noticeable in the United States and Canada, although there is some evidence that this is changing in the United States. In 1900 in the U.S., water withdrawals for all purposes were estimated at 56 cubic kilometres (km^3) per year. Water use in the U.S. peaked in 1980 at over 610 km^3 per year, a tenfold increase in water withdrawal during a period when population increased by a factor of four. However, beginning in the 1980s the demand for water began to decline, and today it is 10 percent below peak usage levels of the 1980s. This decline occurred despite continued population and economic growth. The reduction in water use can be attributed to a shift in the philosophy of water resource management. Two of the key factors affecting this shift include improved understanding about the environmental impacts of water projects and the increasing economic costs of new water development projects (Gleik, 2000).

11.4 WATER PRICING METHODS

Given the various functions and users of water, how should water be priced in the market place? This question is becoming more critical and is receiving considerable attention in many jurisdictions in the world. There is also a growing emphasis on incorporating ecological values into water policy, a re-emphasis on meeting basic human needs for water services, and a conscious breaking of the ties between economic growth and water use (Gleik, 2000).

Different Rate Types

Traditionally there have been two common approaches of pricing water, either for consumption or for water used for disposal (sewer charges). Specifically approaches can be divided into flat rate systems and volume-based rate systems.

Flat rates consist of a base charge that is paid every month regardless of water use. All water delivered is charged at a flat rate. Municipalities determine flat rate charges in a variety of ways, taking into account the cost of providing service and, in some cases, expected use. Charges may vary among user classes (i.e., residential and commercial) in the same jurisdiction. The principal disadvantage of flat rate pricing is that it results in higher water use than volume-based pricing, because the price of an additional volume of water is zero. Interestingly, a 1995 study found British Columbia and Quebec lead Canada in charging low flat rates for water (Tate, 1995).

Volume-based rates are more complex but simple to administer if the water supplier has the proper tracking abilities, typically water metres. Volume-based rates relate the amount paid for water servicing to the amount of water used. Several types of volume-based pricing systems can be considered, including the following (Tate, 1995):

- **Constant Unit Charge (CUC) –** where there is a constant charge for each unit of water used. CUC may also have a base component that is a charge unrelated to the actual volume of water used.
- **Declining Block Rate (DBR) –** water use in each billing period is divided into successive volumes or blocks, with use in each ascending block charged at a lower price per unit than the previous block. Typically, one or two initial blocks cover residential and light commercial water use, with subsequent blocks serving light and heavy industry. The savings claimed for serving large industries are usually used to justify the lower unit prices in the upper blocks.
- **Increasing Block Rate (IBR) –** water prices increase as the number of units of water used increases. In this structure, consumers have an incentive to conserve water to avoid the higher rates in the upper blocks.
- **Complex rate –** attempts to combine two different types of block rates (mostly declining rates) into one schedule. Under this type of schedule prices appear to fall until a certain usage, then rise, and later fall again. These rates attempt to combine components of residential and commercial pricing systems into one schedule. Complex rates may also occur if sewer charges are calculated differently than the water usage rates.
- **Ascending block rate** is even more complex in that it provides a water use target for each customer, based on size of landscape area, family size, and current weather conditions, as measured by evapotranspiration. Irrigation application efficiency is also accounted for in setting the targets. This system is not widely used currently but is being explored in some parts of the United States.

Flat rate and volume rate systems are not mutually exclusive. Often a flat rate will be charge on an initial block of water, with an increasing block rate system added on an over use amount. This type of combined system is often an initial way to encourage efficient water use without causing a shortfall in revenue. However, it should be noted that when it comes to water conservation, neither the flat rate system nor the volume-based systems have a method of identifying wasteful or efficient behaviours.

National and Provincial Rate Type Distribution

Detailed rate types for residential and commercial customers for municipalities in British Columbia are outlined in Table 11.1 for 1991 and 1999.

Table 11.1 British Columbia Distribution of Residential and Commercial Water Rates by type in 1991 and 1999.

	Residential (number of municipalities)		**Commercial (number of municipalities)**	
	1991	**1999**	**1991**	**1999**
Flat Rate Type	108	118	72	85
Volume-Based Rate Types				
Constant Unit Charge	19	37	35	55
Declining Block Rate	16	7	47	28
Increasing Block Rate	4	9	7	12
Complex Rate	1	2	5	2
Total	**148**	**173**	**166**	**182**

Source: Environment Canada, 2001.

In 1999, the flat rate structure was by far the most common among residential rate structures and was used by 68 percent of municipalities. However, this is down from 73 percent of communities in 1991. For commercial rates, 43 percent of communities used a flat rate system in 1991, while in 1999 this figure had climbed to 47 percent.

Typically, British Columbia has trailed the country when it comes to using volume-based rate types that are better designed to promote conservation and water efficiency. Figure 11.1 highlights the change in the percentage of the population using residential water metres for British Columbia and all of Canada between 1991 and 1999.

11.5 WATER USE AND PRICES

It has been well documented that there is an inverse relationship between water prices and water use. With both water supply and wastewater treatment, the higher the price, the lower the use.

Brandes and Ferguson (2003) have summarized data presented by the Organization for Economic Cooperation and Development (OECD) on water use and prices. According to Brandes and Ferguson (2003), Canadians use at least twice as much water per person as residents in many other industrialized countries (Figure 2.2 of Brandes and Ferguson, 2003). In fact, none of the countries examined in that report have a higher per capita rate of water consumption than Canada. The average daily residential water use in Canada in 1996 was 326 L per person per day, as compared with 128 in Germany, 130 in the Netherlands, and 149 in the United Kingdom. The U.S. figure was about 300 L per person per day. The Canadian figure had risen to 343 L per person per day by 1999. In B.C., the average rate of residential water use was 439 L per capita per day in 1999 (Environment Canada, 2001).

Communities in the southern interior of B.C. use more water than both the B.C. and the Canadian averages. Urban Systems (2001) indicates that Kamloops residents use about 800 L per capita per day, Kelowna (prior to metering) used 775 L per capita per day, and Peachland residents use about 900 L per capita per day. By 1998, after the introduction of meters, daily per capita usage in Kelowna had dropped to 570 L (a saving of over 25%). Usage in the summer months is approximately triple the winter rate, due to the outdoor irrigation demand from both the agricultural and residential sectors.

Comparing Canada to the international community reveals that Canadians enjoy one of the lowest pricing levels for water among developed countries. The OECD data summarized by Brandes and Ferguson (2003) demonstrates an inverse relationship between water use and the price paid for water. While Canadians use more water per capita than residents of every other major industrialized country, the prices paid for water are the lowest of any of these countries (Figure 5.8 of Brandes and Ferguson, 2003). The average Canadian price paid for residential water is about $0.70 USD per cubic metre ($0.93 Can dollars, at 75 cents to the US dollar), compared with about $1.20 USD ($1.60 Can $) in the U.S., and an average of about $3.10 USD ($4.13 Can) in Denmark, France, and the United Kingdom.

Within Canada, British Columbia enjoys favourable prices compared to elsewhere in the country. Table 11.2 outlines the total residential and commercial water prices for British Columbia and Canada in 1991 and 1999. Comparison of these data with the above-noted value of 439 L per person per day reveals that in B.C. in 1999, the average price paid for residential water was about $0.63 per m^3. This compares with the Canadian average of $0.93 per m^3, which is in turn lower than that of all other major industrialized countries in the world.

Table 11.2. Average monthly prices paid for residential and commercial water for British Columbia and Canada (1991 & 1999).

	Residential				Commercial			
	1991		1999		1991		1999	
Monthly Volume	B.C.	Canada	B.C.	Canada	B.C.	Canada	B.C.	Canada
10 cubic metres	$11.79	$13.94	$24.09	$19.34	$17.92	$20.48	$27.67	$25.90
25 cubic metres	$12.65	$20.54	$25.63	$28.56	N/a	n/a	n/a	n/a
35 cubic metres	$13.39	$25.14	$27.14	$34.95	$21.39	$28.65	$33.60	$36.62
100 cubic metres	n/a	n/a	n/a	n/a	$33.46	$52.94	$53.18	$68.93

Source Environment Canada, 2001. Values are expressed in 1999 dollars.

11.6 TLU WATER RATES AND PRICES

11.6.1 Study Area Customer Profile and Rate Types

Within the TLU, there are four major water utilities and several smaller utilities, as described in Section 6.0. **Lakeview Irrigation District** services approximately 10,000 residents in an area covering about 930 hectares. Of the total area, 158 hectares are irrigated (86 ha of orchards, 37 ha of vineyards, and 35 ha currently vacant). In 2002, the Lakeview Irrigation District had just over 3,300 connections, of which approximately 240 were commercial connections, with most of the remainder being residential connections. A flat rate system is in place for all customers.

Westbank Irrigation District serves 4,156 residential customers, 204 commercial customers, 41 industrial customers, and 144 agricultural customers. In total, the Westbank Irrigation District serves a population of 11,886 and an additional 388.5 hectares of irrigated agriculture land. A flat rate system is in place for all customers.

The Municipality of Peachland serves approximately 1,900 domestic services (and approximate population of 4,600) and several agricultural and commercial services.
Flat rate systems are used for all customers.

The **Westbank First Nation** provides water to 5,878 residents, as well as some commercial and agricultural operations. Rates used are all flat rate, but the rates depend on the size of the connection, so the rate structure is a combination of flat rate and constant unit charge.

While there are some water meters in the study area, on the whole, water meters are not used for residential, commercial, and agricultural properties. By contrast, approximately 20% of the B.C. population is on water meters, and at the national level over 50% of the population is on water meters.

11.6.2 Study Area Water Prices

In the **Lakeview Irrigation District,** the 2003 rate for a standard residential connection was \$133.40 per year plus an additional \$33.35 for water taxes, for a total annual water price of \$166.75 or **\$13.89 per month**. Based on the number of connections and the population served, the approximate residential price is about \$0.19 per m^3.

The standard commercial rate is \$163.75 annually, with the water tax bringing the total annual price to \$197.10 or **\$16.42 per month**. With about 300 connections, the revenue derived from commercial/industrial water is about \$60,000 per year.

Although meters were installed in the Lakeview industrial park in summer 2003, in general, commercial and industrial operations are not metered, and it is thus not possible to derive an accurate estimate of the unit rates for commercial and industrial water in the LID. However, an estimate is possible, as follows: total annual water use in the LID is about 4.2 million m^3, and residential use is about 2.6 million m^3, so commercial/industrial and agricultural use combined is about 1.6 million m^3. If half of this value was commercial/industrial and half was agricultural, the average rate for commercial/industrial water would be $0.08 per m^3.

The annual rate for agricultural water use in the Lakeview Irrigation District is **$75.40 per ha**. Serving approximately 250 ha of agricultural land, the total annual revenue to LID from agricultural customers is about $18,000. Using the approximation in the above paragraph, the average rate for agricultural water would be about $0.02 per m^3 (similar to the WID price).

In the **Westbank Irrigation District**, detached homes are the largest category of residential water users, representing approximately 75% of the revenue received. In 2003, the rate for a detached housing connection was $216.00 per year. However, $72.00 of this amount is associated with a water quality improvement fee, which is being collected to pay for future water quality improvements. The WID also charges a water tax of $48.00 per year, which brings the total water charge to $264.00 per year or **$22.00 per month** for a residential detached dwelling. An additional 18 percent of water user fees come from residents living in townhouses and apartments, residents who pay less than the detached housing residents. Based on 4,156 connections and a population of 11,886,the approximate price for residential water works out to be about $0.32 per m^3.

The remaining 7 percent of water user revenue comes from the commercial, industrial, and agricultural sectors. The largest group here is the light commercial sector (low water users). The light commercial rate is $204.00 per year plus $48.00 per year for the water tax, for a total of $252.00 per year or **$21.00** per month. The light commercial category also includes the $72.00 annual charge for future water quality improvement.

For agricultural irrigation the rate is $138 per year per hectare, and there are 338 irrigated hectares. Thus, the total annual revenue from agricultural operators is approximately $45,000 per year. It is estimated that WID's agricultural customers use about 1,500,000 m^3 of water per year (Jamieson, pers. comm, 2003c). Therefore, the approximate price paid for agricultural water is $0.03 per m^3.

In **Peachland**, the cost for an average single family connection is **$217 per year** and the annual cost of irrigation water is **$169 per hectare** (District of Peachland, 2003). Pricing among the several smaller water systems ranges considerably, as indicated in Table 11.3.

Table 11.3 Monthly and annual water rates charged by some of the small utilities in the TLU.

Utility	Annual rate	Monthly rate
Killiney Beach Water System	$200	$16.66
Pritchard Water System	$170	$14.16
West Kelowna Estates Water System	$250	$20.83
Star Place Water System	$800	$66.65
Westshore Water System	$200	$16.66
Jennens Road	$120	$10, plus a $300 first-time connection charge
Casa Loma Water Utilities Ltd.	$276	$23

Overall, the majority of water users in the study area enjoy water prices that are noticeably below both the provincial and national water price averages. This price difference becomes more pronounced as water users in the study area consume larger volumes of water, since with flat-rate systems, the more that is used, the cheaper the price per unit.

In the TLU, the average rate of residential water use is 789 L/day per person (from Section 6.0), which on an annual basis amounts to 288 m^3 per person. Assuming 3 people per connection, and using the average annual price per connection of $216 based on the prices used by WID, LID, and Peachland, the approximate cost of residential water in the TLU is **25 cents per cubic metre**. Commercial rates are even lower, and agricultural water is even cheaper, averaging about **3 cents per cubic metre**.

Figure 6.1 of Reid Crowther (2000) demonstrates that the average annual rate for water supplied by the Lakeview Irrigation District was smaller than nearly all of 14 other B.C. municipalities (including several in the Okanagan), and four other Canadian cities (Yellowknife, Winnipeg, Edmonton, and Calgary). Comparison of TLU prices with those for B.C., Canada, and other countries (as outlined in Section 11.5) indicates clearly that water is very inexpensive in the TLU.

In summary, as indicated in Section 6.0, the average rate of water use in B.C. is 439 L per person per day, and the average rate across Canada is 343 L per person per day. TLU residents use about 789 L per person per day, comparable to other communities in the southern interior of B.C. before the introduction of metering and constant unit charge pricing. TLU residents therefore use nearly twice as much water per person as do British Columbians on average, and more than twice as much as the average Canadian. This situation exists despite the fact that the Okanagan is one of the driest areas of B.C. and Canada.

The average TLU price for residential water is about 25 cents per m^3. This value compares with 70 cents per m^3 in Vernon, the B.C. average of 63 cents per m^3, and the Canadian average of about 93 cents per m^3. Costs for water in all other major industrialized countries in the world exceed the Canadian average. TLU water prices are therefore amongst the lowest in B.C., Canada, and the world.

Finally, most of the water used in the TLU is not metered. The pricing structures are nearly all flat-rate structures, which incorporate no conservation incentive.

11.7 EFFECT OF WATER ECONOMICS AND PRICING ON ECONOMIC DEVELOPMENT

In a regional and community economic development context, the interaction between consumers and water resources can lead to very pronounced response in the local economy. This response is often greater than could be anticipated from strictly economic implications.

Domestic and Commercial Use

Economic techniques for municipal water management focus on using pricing policies to influence the level of water demand. For water, the demand curve is inelastic over the initial quantity of water use. This means that price change affecting initial water use will not be very effective in inducing a decrease in water demand. Intuitively, this makes sense because the initial demand for water is considered essential (uses such as drinking, washing and cooking).

As water becomes less essential, the elasticity of demand increases. At this stage, as water prices go up, residents will use proportionally less of the resource. This stage includes outdoor uses such as lawn and garden watering. It is at this stage that price increases can have the greatest impact on water use. A good example is provided by the experience in the West Colorado basin of Utah, where managers have attempted to promote water conservation in the range where water demand is elastic. Water managers recognized that as water becomes less essential, people are less willing to pay for additional units of water. Therefore, the managers operate a water pricing schedule that incorporates a flat block rate for the first increment of use, with an increasing block rate system for higher amount of use, thereby focusing the price increases where the consumer is likely to be most price-sensitive (e.g. water for lawn watering). The objective of this pricing system is to encourage water conservation and deter water wastage. The monthly water rates for selected communities in the region are outlined in Table 11.4.

Table 11.4 Residential Water Rates Structured to Encourage Water Efficiency in West Colorado Basin, Utah (Source: Utah State Water Plan).

		Initial portion		First Overage		Second Overage	
Water Supplier	**Use Rate (gpcd)**	**Price ($)**	**Maximum quantity (gals)**	**Overage Charge ($)/gal**	**Maximum quantity (gals)**	**Overage Charge ($)/gal**	**Maximum quantity (gals)**
Bicknell	141	$30	24,000	$1.00/1,000	10,000	$1.20/1,000	None
East Carbon	270	$12	5,000	$1.25/1,000	All	N/a	N/a
Torrey	700	$10	30,000	$0.50/1,000	20,000	$1.00/1,000	None

gpcd = gallons per capita per day

From an economic development perspective, it becomes critical that the essential requirements for water are fulfilled or there will be undesirable implications for economic development opportunities. To illustrate the impacts of insecure water supply in the study area, the current situation for the Westbank First Nation and their subdivision development is instructive. A residential development project has been delayed several years as water issues are explored, effectively deferring the economic development opportunity associated with this venture.

Agriculture

Traditional Water Pricing **–** Irrigators generally face water charges that are substantially lower than the cost of bringing water to the land. In Alberta, the cost of irrigation development has been subsidized at about 85 percent by the province. In addition to artificially low prices, irrigators pay water charges based on irrigated area, not on actual water volumes used. Consequently, there is little incentive for water demand management.

Current Water Pricing **–** In British Columbia, the provincial government requires payment by private users and local authorities for withdrawals of raw water for irrigation or stock-watering purposes. In turn, a local water distributor can charge the cost of water treatment and delivery services to agricultural and other water treatment and delivery services.

In British Columbia, particularly in the interior, agriculture represents some of the earliest large-scale users of water for economic development purposes. However, given the large water requirements for agriculture, the sector is increasingly involved in discussions of how to use a limited water supply to generate the highest and best economic development return for a region.

In other areas of the world, water use in agriculture has shifted focus from securing water for existing agriculture activities to ensuring the local water resource use is contributing to value added activities. For example, with little formal direction, the mix of California crops and planting patterns has been changing. These changes are the result of decisions made by large numbers of individuals, rather than any intentional actions by state policymakers. California farmers are planting increasingly high-valued fruit and vegetable crops, which have lower water requirements than the field and grain crops they are replacing.

The new crops can also be irrigated with more accurate and efficient precision irrigation technologies. As a result, California is slowly increasing the “water productivity” of its agricultural sector – increasing the revenue or yield of crops per unit of water consumed. Over time, these changes have the potential to dramatically change the face of California agriculture, making it even more productive and efficient than it is today, while saving vast quantities of water (Source: Pacific Institute for Studies in Development, Environment, and Security, Oakland, California). The goal is to ensure agriculture makes the strongest possible contribution to the local economy using an increasingly scarce resource.

Industrial Use

One of the key issues associated with industrial activity is water pollution. Pollution is often seen as an economic problem, the result of a legacy of failing to recognize the value of water to industry for waste removal, and to price water accordingly. Therefore, a significant part of the solution lies in water management that is based on a sound understanding of the economic characteristics of industrial processes, including both the financial and the allocation dimensions of the problem.

Like other water users, industry is sensitive to water pricing. Typically, water use is reduced by increased water prices. However, for industry the decline in water use is typically driven by water recycling and other process changes. This phenomenon suggests that prices should reflect the waste amelioration characteristics of receiving water.

Over the past decade, industrial water use has been declining while industrial activity has continued to grow. From an economic development perspective, this suggests a win-win situation, as a scare resource is conserved for future opportunities and industry continues to thrive and prosper.

Recreational Water Use

Millions of Canadians engage in water-based recreation of various kinds. These activities have substantial economic value. No data were available for quantifying the value of the recreational use of water in the TLU. This lack of information is not unusual, as valuing recreational use of resources is technically and methodologically difficult. Direct measurements of the recreational value of water cannot be undertaken, so indirect measurement techniques such as fishing-days, boat or camping equipment ownership, areas of beach, and willingness to travel must be used.

Despite the lack of data, it can be said with confidence that water—particularly Okanagan Lake, but also smaller lakes and streams--contributes to the well-being and the quality of life that TLU residents identify as being important. In turn, water makes the area more attractive and easier to promote as a place to live and do business. Water provides the region with an economic “comparative advantage” when compared to communities that do not have similar water features. The quality and quantity of water for recreation can be affected by water withdrawals for human use and by waste disposal measures applied in a watershed. Hence, the value of recreation and associated economic activity is related to water management decisions made by other sectors.

11.8 SUMMARY

Water in the TLU is used for domestic, agricultural, commercial, industrial, and instream purposes. Water in Canada and elsewhere in the world has historically been priced below its actual value. Users in jurisdictions that employ volume-based pricing use less water than those that pay flat rates.

Water can be sold under a range of pricing methods. Flat-rate systems charge a fixed price regardless of the volume used. Volume-based systems charge users according to how much they use. There are several variations of the volume-based system. A variety of systems are used in the TLU, but the flat rate system is by far the most common.

Although plans for extending the use of water meters are being developed by some TLU water purveyors, presently very few residential, commercial or agricultural users are connected to water meters. Without meters, volume-based billing cannot be applied, and economic tools to encourage conservation are unavailable.

Canadians use more water per capita for residential use than do residents of the United States and the major European countries (343 L per person per day); British Columbians use more than the Canadian average (439 L per person per day); and TLU residents use 789 L per person per day. This level of use is similar to levels experienced in Kelowna, Vernon, and Kamloops prior to the introduction of metering.

Canadians pay less for water than do residents of the United States and the major European countries (averaging $0.93 per m^3); British Columbians pay less than the Canadian average (an average of $0.63 per m^3); and TLU residents pay even less (averaging about $0.25 per m^3). Similarly, commercial, industrial, and agricultural water users pay relatively low prices for water in the TLU.

Using pricing methods, there are opportunities to affect water use in the "elastic" portion of the use curve, where uses are less essential. However, pricing strategies should consider the potential for negative economic implications.

12.0 PRESENT STATUS AND FUTURE WATER PRESSURES

Chapters 1 through 11 contain information on “present-day conditions” and water-related issues within the TLU. For the purposes of this report, “present-day conditions” are defined as conditions occurring in 2003. It has been assumed that current conditions are represented by the most recent available data (e.g., population estimates for 2001, streamflow data normalized to the period 1961-1995). Section 12.0 summarizes present-day conditions in the TLU that have been described in Sections 4.0 through 11.0, and describes future pressures on the water resource. The section provides a link between Phase 1 work (present conditions) and Phase 2 work (future conditions) that are presented in Sections 13.0 to 15.0.

12.1 SUMMARY OF PRESENT CONDITIONS

12.1.1 Summary of Phase 1 Work Program

Phase 1 of the project included:

- Evaluation of biophysical characteristics of the TLU (Section 4.0);
- A workshop with major stakeholders (government agencies and others with a tenured interest in water resources in the TLU) to identify water issues and barriers to effective water management (Section 5.0);
- Evaluation of land use in the TLU (Section 6.0);
- Calculation of total water use, and distribution of water use according to source (surface, groundwater, and Okanagan Lake), and according to sector (residential, commercial/industrial, and agricultural) (Section 7.0);
- Hydrologic analysis and separation of recorded flow into “natural” and “altered” flow, as well as analysis of licensed and actual use at several locations along each of the five major streams (Section 8.0);
- Evaluation of fisheries issues and proposed fish conservation flows (Section 9.0);
- Evaluation of water quality (Section 10.0); and
- Analysis of the rate structures and prices paid for water in the TLU, and comparison with other jurisdictions (Section 11.0).

12.1.2 Summary of Phase 1 Findings

Biophysical Description

The Trepanier Landscape Unit covers 990 km^2 on the west side of Okanagan Lake within the boundaries of the Regional District of Central Okanagan. The area includes the watersheds of five major creeks: Lambly, McDougall, Powers, Trepanier, and Peachland. Elevations range from 342 m at Okanagan Lake to a maximum of about 1,900 m at the highest elevations along the western boundary of the TLU. The bulk of the land base (the mid and upper elevations) is managed by the provincial crown, where land uses include forestry, agriculture (range), recreation, and mining. Lower elevations along the shore of Okanagan Lake include one small municipality (Peachland), a first nation community (Westbank I.R. #9 and I.R. #10), and a large rural unincorporated area, where land uses include urban, commercial, industrial, recreation, and agriculture. There are five biogeoclimatic zones represented in the TLU. Bedrock geology is typically of volcanic origin. Lower elevations are mantled by glaciofluvial and glaciolacustrine deposits, and higher elevations are typically mantled with colluvium and/or glacial till. Annual precipitation in the TLU varies with elevation, and is relatively low, averaging about 600 mm per year. Average annual runoff varies from about 120 mm to 230 mm. Streamflows rise to a peak in spring in response to snowmelt, then decline through the summer to baseflow levels by late summer. These baseflows are maintained through the winter.

Water Management Goals, Policies and Issues

Major water stakeholders in the TLU identified several water-related issues that affect the TLU, including unregulated groundwater use, potentially over-licenced streams, reductions in flow that affect fish, urban development along watercourses, increasing competition for water, and water quality impacts associated with range, forestry, mining and urban land use.

The Okanagan-Shuswap Land and Resource Management Plan (LRMP) and four Official Community Plans (OCPs) provide goals and objectives, as well as policies for water management in the TLU. Water-related LRMP policies can be categorized into 6 groups (allocation, flow regime, water quality, land use in urban areas, and use in resource areas, and land use in riparian areas). Agencies with responsibility for water management, however, reported that their rates of implementation of LRMP and OCP policies was relatively low, even though the policies were not in general perceived to have a negative effect on them.

Stakeholders identified several challenges to effective water management, including ineffective management tools, lack of data, limited education on water value and use, organizational barriers, and differing institutional priorities and conflicting objectives.

Although there is good cooperation among the agencies responsible for water management in the TLU, and they agree on some principles of water management, there is little coordinated management. To ensure long-term economic and environmental sustainability in the TLU, it is important that agencies operating in the TLU agree on water management goals, and work together to implement improved water management.

Land Use

Land uses in the TLU include forestry, mining, range and recreational activities in the mid and upper elevation "resource" areas, and residential, agricultural, commercial and industrial activities in low elevation "urban" areas close to Okanagan Lake. Many of these land use activities require water and thus affect water quantity, and also have the potential to affect water quality and aquatic resource values.

Except for the water storage reservoirs, water use by activities occurring on the mid and upper elevation "resource" lands is relatively minor, compared with water use on the "urban" lands, where most of the population of 36,336 live. Residential development is concentrated in the District Municipality of Peachland, the unincorporated areas around Westbank, Westbank First Nation reserves #9 and #10, and several other subdivisions. The population has doubled in the last 20 years, and is expected to continue to grow. Commercial and industrial operations include a nursery, two wineries, retail malls, an industrial park, and several aggregate operations. There are 982 ha of intensive agriculture in the TLU, much of which is irrigated.

Surface Water Use

The following summarizes water use in the TLU:

- Water licences have been issued for 66.269 million m^3 per year (53.674 million m^3 for offstream uses and 12.595 million m^3 for instream uses) on approximately 184 streams and waterbodies in or adjacent to the TLU (including Okanagan Lake);
- In addition, storage licences total 36.098 million m^3, of which 28.950 million m^3 is actually utilized at present;
- Based on the average of two methods (supply-side and demand-side), total annual offstream water use in the TLU is estimated to be 24.554 million m^3, which is 46% of the total amount licensed for offstream use for the TLU;
- Approximately 66% of the total water used in the TLU (on an annual basis) is obtained from surface sources, of which 90% is obtained from the five principal streams in the TLU (Lambly, McDougall, Powers, Trepanier, and Peachland Creeks). Approximately 30% of the total water used is pumped from Okanagan Lake, and the remaining 4% is obtained from groundwater sources;
- The estimated annual average per capita residential water use rate in the TLU is 789 L/day; and
- Approximately 41% of the total water used in the TLU (on an annual basis) is used for residential purposes, while 20% is used for commercial/industrial purposes, and 34% is used for agriculture (including golf courses). Distribution system losses account for approximately 5% of the TLU water demand.

Surface water hydrology

The following summarizes the current hydrology of the principal streams in the TLU:

- Flows in all major streams in the TLU are regulated. Therefore, naturalized flows have been estimated (at 14 points-of-interest) on the basis of site-specific and regional flow information, and licensed and actual water use information;

- On an annual basis, net flows are 13% less than naturalized flows in the five principal streams of the TLU. The estimated naturalized and net annual flows at the mouths of the five principal streams in the TLU under average conditions are:

	Naturalized	Net
o Lambly Creek:	1.77 m^3/s	1.58 m^3/s
o McDougall Creek:	0.119 m^3/s	0.084 m^3/s
o Powers Creek:	0.920 m^3/s	0.849 m^3/s
o Trepanier Creek:	1.09 m^3/s	1.03 m^3/s
o Peachland Creek:	0.570 m^3/s	0.515 m^3/s

- Under 1 in 5 year drought conditions, the naturalized and net annual flows are expected to be roughly 67% of the above-noted estimates;
- In all but McDougall Creek, streamflows should persist year-round in principal streams of the TLU under average hydrologic conditions;
- On average, offstream water licences account for 28% of the naturalized annual flow in the principal streams of the TLU. Actual offstream use in the TLU averages 15% of the naturalized annual flow. The percentage of naturalized flow represented by water licences for offstream use and actual use for the five principal streams are:

	Licences	Actual
o Lambly Creek:	23%	11%
o McDougall Creek:	30%	30%
o Powers Creek:	29%	18%
o Trepanier Creek:	13%	5%
o Peachland Creek:	43%	10%

- On an annual basis, actual storage supports between 37% and 516% (i.e., all) of the water use in the principal streams of the TLU, while 19% to 191% (i.e., all) of licensed offstream use is supported by licensed storage and 19% to 145% of licensed offstream and instream use is supported by storage. The breakdown of these percentages by principal stream is as follows:

	Actual storage as a percentage of actual offstream use	Licensed storage a percentage of licensed offstream use	Licensed storage as as a percentage of licensed offstream and instream use
Lambly Creek:	44%	37%	37%
McDougall Creek:	37%	43%	43%
Powers Creek:	303%	191%	145%
Trepanier Creek:	46%	19%	19%
Peachland Creek:	516%	115%	51%

- On an annual basis, the quantity of water which is not presently licensed for offstream or instream use is as follows:

	Annual flow not presently licensed
o Lambly Creek:	1.36 m^3/s
o McDougall Creek:	0.084 m^3/s
o Powers Creek:	0.569 m^3/s
o Trepanier Creek:	0.953 m^3/s
o Peachland Creek:	0.012 m^3/s.

Groundwater hydrology and use:

- Six large aquifers have been identified in the TLU, all located in the vicinity of Westbank. There are likely additional, smaller aquifers in the upland area of the TLU that have not yet been identified.
- The six identified aquifers were assigned moderate to low development values, moderate to low vulnerability and low ranking points, within the provincially derived aquifer classification system.
- The predominant mechanism of regional groundwater recharge is likely vertical infiltration during spring freshet. There is likely some recharge over the lower elevation

areas of the TLU (below 1,200 m), however the water balance estimate revealed a negative water balance below 1,200 m.

- Regional groundwater discharge occurs in topographically low areas of the TLU, such as into Okanagan Lake.
- Detailed assessments of aquifer size and extent, aquifer yield and aquifer use are not possible due to a lack of basic hydrogeological data and information.
- Maximum current groundwater extraction rates in the TLU are estimated at 400 L/s (12.6 million m^3 per year), which represents 10% of the maximum potential recharge rate, and is approximately equivalent to the probable annual recharge rate. There is likely additional room to develop groundwater resources.

Instream Flows and Fish Requirements

Streams in the TLU support a variety of fish species, including rainbow trout and kokanee salmon. Fish have faced pressures in recent decades due to flow withdrawals from tributaries and habitat impacts, particularly in the lower reaches of TLU creeks. There is no standard accepted method for setting conservation flows in B.C., but there have been ongoing efforts to set conservation flows in the major creeks of the TLU.

The conservation flows that have been proposed for streams in the TLU are based on percentage of the mean annual discharge (MAD), with the percentage changing by month. In many stream reaches these flows will produce optimal conditions for fish, although more flow may be required in shallow, braided channels and less may be required in narrow, confined channels.

In general, under average climate conditions the five project streams have naturalized flows during the low-flow months that are close to the proposed conservation flows. However, conservation flows exceed base flows in dry years (e.g., 1 in 5 year dry drought), suggesting that conservation flows are set unrealistically high.

When current water usage is factored in (net flow), most of the streams experience flow deficits relative to the proposed conservation flows during some low-flow months under average climate conditions, and during nearly all low-flow months under 1-in-5 year dry conditions.

Water Quality

Water quality in the streams in the TLU is influenced by a number of natural and human-caused processes. Land use effects on water quality include urban development, agriculture, forestry, mining, recreation, and tourism. Urban stressors on water quality include sedimentation from construction sites, stormwater runoff, leachate from poorly functioning septic fields, and spills or overuse of household and automotive chemicals. A number of measures have been implemented by RDCO to reduce impacts from existing urban areas and to avoid water quality effects from future development. Agriculture is a potential cause of non-point source (NPS) pollution, with runoff from farms and ranches possibly contributing sediment, nutrients, pesticides, and pathogens. Range activity on Crown Land can also result in damage to riparian areas and stream banks. Forestry impacts can include sedimentation from roads and landslides, changes in the timing and magnitude of peak flows, and elevated stream temperatures. Local water purveyors have, however, identified few issues with forest practices, and water quality protection is an integral part of forest development planning in the TLU. Mining effects include sedimentation and the potential for elevated concentrations of metals due to discharges from reclaimed mine sites (see below). Finally, water quality concerns over recreation include cabin development on upland reservoirs, chemicals in runoff from golf courses and playing fields, erosion from ATV traffic, and spills from boats along the Okanagan Lake shoreline.

Water quality data is available through the provincial EMS database for sites within the Lambly Creek (6 locations), Peachland Creek (6 locations), Trepanier Creek (6 locations including McDonald Creek), Powers Creek (3 locations), and McDougall Creek (2 locations) watersheds. Other data not in the EMS may be available through the water purveyors, Noranda, Riverside, and others. Provisional Water Quality Objectives were set for Trepanier and Peachland Creeks in 1992. MWLAP is currently revising and/or developing new Water Quality Objectives for Lambly, Peachland, Trepanier, and Powers Creeks based on monitoring conducted between 1996 and 2000, with the reports expected in spring 2004.

In general, water in the streams in the TLU can be characterized as having neutral to alkaline pH with moderate concentrations of dissolved solids. All of the major streams that serve as sources of domestic and irrigation water occasionally have turbidity, coliform bacteria, and true colour concentrations that do not meet the B.C. water quality guidelines for raw water, and thus require treatment. The causes of the above-guideline concentrations of these variables likely includes a mix of natural factors and land use effects, although the relative importance of each has not been quantified. Exceedances of water quality guidelines or objectives for molybdenum and copper have occurred on occasion in Trepanier and Peachland Creeks, but the majority of sample results are within guidelines/objectives. Noranda continues to treat the discharge from the Brenda Mine site under permit from MWLAP and monitors for molybdenum, copper, and other parameters under the terms of their permit.

Preliminary analyses of the EMS data sets indicate changes in the concentrations of some water quality variables as the streams flow through urbanized areas. For example, concentrations of total phosphorus are significantly higher ($p<0.05$) in Powers Creek near the mouth of the creek than at the water intake.

Economics of Water

Water in the TLU is used for domestic, agricultural, commercial, industrial, and instream purposes. Water in Canada and elsewhere in the world has historically been priced below its actual value. Users in jurisdictions that employ volume-based pricing use less water than those that pay flat rates.

Water can be sold under a range of pricing methods. Flat-rate systems charge a fixed price regardless of the volume used. Volume-based systems charge users according to how much they use. There are several variations of the volume-based system. A variety of systems are used in the TLU, but the flat rate system is by far the most common.

Although plans for extending the use of water meters are being developed by some TLU water purveyors, presently very few residential, commercial or agricultural users are connected to water meters. Without meters, volume-based billing cannot be applied, and economic tools to encourage conservation are unavailable.

Canadians use more water per capita for residential use than do residents of the United States and the major European countries (343 L per person per day); British Columbians use more than the Canadian average (439 L per person per day); and TLU residents use 789 L per person per day. This level of use is similar to levels experienced in Kelowna, Vernon, and Kamloops prior to the introduction of metering.

Canadians pay less for water than do residents of the United States and the major European countries (averaging \$0.93 per m^3); British Columbians pay less than the Canadian average (an average of \$0.63 per m^3); and TLU residents pay even less (averaging about \$0.25 per m^3). Similarly, commercial, industrial, and agricultural water users pay relatively low prices for water in the TLU.

Using pricing methods, there are opportunities to affect water use in the "elastic" portion of the use curve, where uses are less essential. However, pricing strategies should consider the potential for negative economic implications.

12.2 FUTURE WATER RESOURCE PRESSURES IN THE TLU

The current state of the TLU is summarized in Section 12.1. The anthropogenic pressures that currently affect water quantity and quality in the Trepanier Landscape Unit are projected to increase in future. There are two key factors that will influence water resources in the TLU in the future: climate change and population/land use change. Population changes will influence demands for water. Climate changes will influence water supply, and in addition will influence water demand, because the growing season will likely be longer, warmer, and drier. These two factors are introduced in this section.

12.2.1 Climate Change

Research based on a number of Coupled Global Circulation Models (GCMs), has projected possible climate change and subsequent hydrological change that may occur in the Okanagan Basin over the next 80 to 90 years. Neilsen et al. (2001) used regional climate change modelling to estimate future crop water demand for the Summerland area. Cohen and Kulkarni (2001) developed hydrological models of the impacts of climate change on six unregulated Okanagan sub-catchments, comparing future hydrographs for the 2020s, 2050s, and 2080s to the period of record. Cohen and Neale (2003) forecasted changes in mean daily temperature and precipitation, snow to rain ratio, peak flow, annual flow (relative to the 1961-1990 climate normals baseline) in the Okanagan Basin for the 2020s, 2050s, and 2080s. Results from these three studies have provided some general insight into the impacts and severity of likely future climate change in the Okanagan Basin. The results of these studies and their relevance to the TLU are discussed below.

Projected Climate Change in the Okanagan

Cohen and Neale (2003) forecast potential temperature and precipitation change for the Okanagan Basin using three different GCMs: the Canadian global coupled model (GCCM2), the United Kingdom's Hadley Centre model (HADCM3), and the Australian model from the Commonwealth Scientific and Industrial Research Organization (CSIROMk2). Each of these models was run with a "high emissions" and "low emissions" scenario for the 2020s, 2050s, and 2080s for a total of six possible climate change scenarios for each time period. Also, for each climate change scenario changes in winter, summer, and annual temperature and precipitation were projected. Table 12.1 summarizes the modelling results.

Table 12.1 Summary of climate change projections (after Cohen and Neale, 2003).

	Time Period **2020s**	**2050s**	**2080s**
	^oC	^oC	^oC
Change in winter temperature	+0.8 to +3.2	+1.5 to +4.0	+2.5 to +6.0
Change in summer temperature	+1.0 to +2.0	+1.8 to +4.0	+2.5 to +7.0
Change in annual temperature	+1.0 to +2.0	+1.5 to +3.0	+2.5 to +5.0
	%	%	%
Change in winter precipitation	+6 to +18	+3 to +22	+10 to +30
Change in summer precipitation	-25 to +8	-33 to +3	-50 to 0
Change in annual precipitation	+1 to +8	-2 to +12	+1 to +10

Notes:
1. Changes are relative to the 1961-1990 baseline.
2. The range of possible temperature and precipitation changes is based on six modeled scenarios.
3. Temperature change: represented as increases in daily maximum and minimum temperatures in degrees Celsius.
4. Precipitation change: represented as increases in daily precipitation expressed as percent.
5. Positive values indicate increases; negative values indicate decreases

Based on these models, winter, summer, and annual temperature are expected to increase steadily over the next 80 years in the TLU. This would mean that not only evaporation and melt rates would generally increase, but also the freezing level during winter would generally be higher.

Seasonal precipitation values are expected to change considerably with winter precipitation forecast to increase gradually to as much as 30% in the 2080s. Summer precipitation on the other hand is expected to decrease by as much as 50% by the 2080s. Overall, the expected change in annual precipitation is less than 12%.

The increased winter precipitation combined with increased winter temperatures will mean that less precipitation will occur as snow, and the snow pack that does develop will be located at relatively higher elevations than it is currently. Summer months are expected to be considerably warmer and drier than are at present and cause additional pressure on water management in the TLU.

Projected Hydrologic Change in the Okanagan

Cohen and Kulkarni (2001) initiated the study of water management and climate change in the Okanagan Basin in order to better understand how the current hydrologic system will respond to the expected rise in temperatures and changes in the precipitation regime. They focused their study on six watersheds in the Canadian portion of the Okanagan Basin and concluded that: (1) an earlier onset of spring peak flows, by as much as four to six weeks, will occur and (2) peak flow volumes will decrease. Prior to this study similar research was completed on the American side of the Columbia Basin (Mote et al., 1999; Hamlet and Lettenmaier, 1999; Miles et al., 2000). These studies produced similar findings; that a warmer climate would lead to changes in hydrology, most notably a reduced snow pack and earlier snowmelt peaks. More recently, Cohen and Neale (2003) published some preliminary hydrologic modelling results for several unregulated and gauged watersheds in the Okanagan Basin, including Trepanier Creek. Modelling was done using the University of British Columbia (UBC) Watershed Model and their climate change modelling results (discussed above) were the basis of the predicted hydrologic changes. The UBC Watershed Model reproduced streamflow adequately for periods of record on which the model was not calibrated and was therefore deemed suitable for application to regions like the Okanagan Basin (Cohen and Kulkarni, 2003). Whichever climate change scenario was input into the model, all hydrologic model results for every watershed showed: (1) an earlier onset of spring freshet; (2) a higher rain to snow ratio; and (3) considerable reductions in annual and freshet flow volumes. The only published results included in this report that are directly relevant to the TLU were projected changes in the snow to rain ratio for Trepanier Creek for the periods 2020s, 2050s, and 2080s. Regardless of which climate change scenario that was input into the UBC Watershed Model (CGCMS; CSIROMk2; or HADCM2) the snow to rain ratio for Trepanier Creek decreases steadily from the baseline average to 2080, particularly for the months of October and April. The snow to rain ratio for January remains relatively constant throughout. The implication of these climate and hydrologic modelling results is that overall water availability for the TLU will likely gradually decrease between now and the 2080s, reservoirs will fill earlier, summers will be longer and drier, and growing seasons and agricultural demand will increase (Neilsen et al., 2001). These changes could result in lower late summer flows and increased pressures on the fisheries resource. In addition, there could be changes in the distribution of native vegetation.

For the present report, we separated the effects of climate change on water supply from its effects on water demand. To examine the effects on water supply, detailed daily outputs of the UBC Watershed Model runs conducted by the Faculty of Forestry at the University of B.C. for each of the five principal streams of the TLU were obtained. The outputs are summarized in the following table, which indicates the predicted reductions in annual flow caused by climate change.

	2020	2050
o Lambly Creek:	11%	30%
o McDougall Creek:	11%	36%
o Powers Creek:	17%	34%
o Trepanier Creek:	20%	39%
o Peachland Creek:	18%	34%
Average	**15%**	**35%**

Naturalized monthly flows are summarized in Figures 12.1 through 12.5. Naturalized flows are estimates of flows that will occur in the creeks in the absence of human influence. They clearly indicate the effects of climate change on water supply. In 2020 the average annual naturalized flow is expected to be an average of 15% smaller than it is today. In 2050, average annual flows are expected to be 35% smaller than they are today. As outlined in Section 14.0, “net” flows (flows remaining in the creeks after withdrawals for offstream uses) will be an even smaller percentage of present-day values, due to the additional effects of climate change on water use and the effects of increased population on water use.

12.2.2 Land Use and Population Changes

Extensive Agriculture

No significant change in range operations is expected by 2020. Range tenure is currently fully allocated so no significant expansion of range operations is likely. Impacts on water demand and supply will remain very limited. The potential for water quality impacts may decrease if current OSLRMP and OCP policies regarding the management of cattle away from riparian areas are implemented.

There is significant pressure in urban areas to remove land from the ALR, but this pressure has not been identified as a major issue on resource lands. This report assumes that rural lands will remain in the ALR, and that the land will continue to be used for grazing rather than intensive agriculture.

Forestry

Timber supply analyses have been conducted for several portions of the TLU. Based on these analyses, it is expected that harvest levels will remain relatively constant until about 2050 (Rouck, 2003). However, over a longer time frame, harvest levels will be reduced. J. Paul et. al. (1998) notes that:

> "…past harvesting practices have not always concentrated on the oldest stands first, due to insects, disease, or wind impacts on younger stands. For the future harvest to more accurately reflect the harvest profile, older stands will have to be harvested to a greater extent. This shift will focus on areas of cedar/hemlock, spruce/balsam, and the Interior Douglas Fir biogeoclimatic zone."

Figure 6.4 suggests that upper portions of Peachland Creek and Trepanier Creek watersheds may be the focus of future logging, as the area harvested is currently less than 30 percent and Douglas fir and spruce are common. Similarly, lower portions of Lambly Creek, and southern portions of Powers Creek watersheds may be of interest to future logging operations.

Current provincial legislation (particularly the *Forest Practices Code* and the *Forest and Range Practices Act)* is intended to protect riparian and aquatic habitat and watercourses from potential impacts. OSLRMP policies reflect the existing *Forest Practices Code* and so implementation should have no additional effect on forestry in the TLU. Where existing regulations remain in effect and are followed, limited impacts on water in the TLU are expected to occur in the future. Should these regulations change or no longer be enforced, impacts on water may occur.

Energy and Mining

Although potential for energy and mineral development exists in the TLU, J. Paul et. al. (1998) notes the following future trends:

- The potential for oil, natural gas, and coal resources to be produced in the plan area is very low to zero.
- It is unlikely that [geothermal energy] will be commercially developed within the next ten years. Uranium deposits within the plan area are not likely to be developed given today's economic and regulatory climate.
- Grassroots or generative exploration is significantly under-funded. Exploration opportunities emerging from new geological data and concepts are thus unlikely to be tested in the near future. Reasons for this are attributed to land use uncertainty, aboriginal land claims, regulatory and tax burdens, and long and uncertain environmental review and permitting processes.

Commercial placer activities are likely to remain unchanged unless new areas are open for production. Interest in recreational placer appears to be increasing. No additional development is anticipated at Brenda Mine, and no additional changes to stream patterns or hydrology are expected. It is anticipated that aggregate extraction will increase in the TLU over the next several decades. EBA (2001) estimates that as RDCO population increases, approximately 59 million tonnes[14] of aggregate will be required over the next twenty years, and given that only 39 million tonnes are under permit, additional sand and gravel pits will need to be established. As shown in Figure 6.5, numerous sand and gravel pits are already operating in urbanized areas, and as population growth increases demand for residential land, resource land will "be increasingly required for aggregate resource supply" (J. Paul et. al., 1998).

Numerous areas of aggregate potential exist on resource land. Figure 12.6 shows generalized areas of aggregate potential (identified in EBA 2001) on resource lands, all located along major watercourses. It is important to note that EBA (2001) refers to the entire regional district, and so there are many other areas with aggregate potential outside of the TLU.

Tourism and Recreation

Tourism and outdoor recreation in the TLU are increasing, and there is significant potential for growth of this sector in the next twenty years. J. Paul et. al. (1998) notes that

> "there is a growing market for outdoor adventure and wilderness experiences. The ability to access natural settings is a major factor in attracting this emerging market and providing the related services and facilities. Although statistics are not available for the [OSLRMP] area, there have been several studies which indicate that this emerging product is experiencing growth rates of 5 – 25%".

In the TLU, there is a current tentative proposal to develop additional ski runs and associated accommodations and services at the Crystal Mountain Ski Resort in the Powers Creek watershed. Approximately 29 ha of forest is proposed for clearing between 2001 and 2006, which is dependent on several factors (i.e., ski hill use, development of housing, etc.) (Dobson, 2001b). RDCO estimates that there could be an additional 1,200 dwelling units if the proposed development occurs. Water use associated with new dwelling units is included in the analysis of future residential use. Information on future developments at Crystal Mountain Ski Resort was not available to support any conclusions on the impact future development may have on local watercourses.

Grant Thornton (2003) recommends the following actions to increase tourism and recreation in RDCO:

- Enhance existing lodges;

[14] Based on 2.25 % growth rate, a shortfall of 20 million tonnes is forecast. If growth occurs at rates of 1.5% or

- Develop two “high end” resorts;
- Support the proposed development at Crystal Peaks;
- Convert the potential for several adventure and nature-based products into commercial tourism / recreation activities; and
- Develop cycle touring.

A provincial government study of the water quality effects of recreation in the TLU concluded that “recreational use poses a significant risk to human health by contributing pathogens to the water supply” (Phippen, 2001). The study found that *E. coli* from humans, cattle, and wildlife were found in water samples from Lambly Creek watershed, with wildlife being the most common source. *Cryptosporidium* and *Giardia* were also found in Lambly Creek water samples. These results suggest that care should be exercised in permitting and managing recreational activities in community watersheds or near to private points of diversion.

Management zone policies in the OSLRMP promote the future development of tourism and recreation in the TLU (Figure 6.7), including:

<u>Tourism</u>

- Dispersed Tourism Use and Tourism Use. Objectives and strategies relate specifically to scenic quality and do not directly affect water supply, demand, or quality.

<u>Recreation</u>

- Bear Creek Motorcycle Use Area. Objectives are to provide an area where organized clubs frequently ride and organized competition events may occur.
- Telemark Cross Country Skiing Use Area, Brenda Mine Road and Silver Lake Winter Non-Motorized Use Area. These areas are restricted to non-motorized traffic during winter months.

3.5%, shortfalls are estimated to be 14 million tonnes and 26 million tonnes respectively (EBA, 2001).

- Peachland Summer Motorized / Shared Use Area. Objectives and strategies in the Shared Use zone promote the establishment of a wide range of recreational opportunities, including motorized sports and activities.

The Bear Creek Motorcycle Use Area is in the Lambly Creek watershed, where TLU water managers and regulators have identified significant concerns about the effects of motocross riding on local water quality. Increased motorized activity have the potential to increase impacts on water quality in watercourses in the Use Area.

Population

Estimates of expected residential growth to 2020 were provided by RDCO, and are included in Appendices F and H. These projections are based on the available OCPs and are compatible with B.C. Stats 20-year growth projections. The actual development locations are subject to the timing of individual development decisions and other factors, including potentially this report. Estimates of 2050 population are based on assuming a continued rate of growth similar to that projected to occur between 2001 and 2020.

In 2020, given an estimated 23,601 additional residents, water use is expected to be about 47.289 million L/day or 16.835 million m^3 per year, an increase of 65% (Table 12.2). By 2050 the population is estimated to increase a further 37,264 (to a total of 97,201) and residential water use is expected to rise to 27.302 million m^3 per year. These estimates assume that annual per capita residential water use remains at the current estimate of 789 L/day. If however, we assume that climate change will occur, it is likely that per capita residential water use will rise based on the increase in outdoor domestic use [accounting for roughly 57% of total residential use (Jamieson, 2003)]. The rise in outdoor domestic use is expected to roughly mirror increases in agricultural use (+16% by 2020 and +30% by 2050). Therefore by 2020 and 2050, the per capita residential water use is estimated to be 857 L/day and 924 L/day, respectively. Thus, if climate change is assumed, residential water use by 2020 and 2050 will be an estimated 18.286 million m^3 per year and 31.974 million m^3 per year, respectively (Table 12.3).

Table 12.2 Estimates of 2020 and 2050 residential water use in the TLU assuming annual per capita residential water use remains at the current level of 789 L/day (i.e., assuming no climate change).

		2020				**2050**			
Community		**Population**	**Average Annual Residential Water Use**		**Change from 2001**	**Population**	**Average Annual Residential Water Use**		**Change from 2001**
			(L/day)	(m^3/year)	(%)		(L/day)	(m^3/year)	(%)
A	Rural Westside Road	2,516	1,985,124	706,704	88	4,379	3,455,156	1,230,035	228
B	Crystal Mtn & Brenda Mines	1,629	1,284,942	457,439	694	3,876	3,058,410	1,088,794	1791
C	Westlake Road & West Kelowna Estates	3,860	3,045,540	1,084,212	27	5,166	4,075,808	1,450,988	70
D	Westbank I.R. #10	3,404	2,685,362	955,989	298	7,426	5,859,010	2,085,808	768
E	Shannon Lake	5,090	4,016,010	1,429,700	91	8,927	7,043,278	2,507,407	236
F	Lakeview	8,262	6,518,718	2,320,664	19	10,337	8,155,685	2,903,424	49
G	Smith Creek	4,197	3,311,433	1,178,870	215	8,718	6,878,128	2,448,614	553
H	Upper Glenrosa	3,123	2,464,402	877,327	220	6,513	5,139,050	1,829,502	567
I	Westbank I.R. #9	9,777	7,714,053	2,746,203	95	17,285	13,637,782	4,855,050	244
J	Lower Glenrosa	4,976	3,926,064	1,397,679	0	4,976	3,926,064	1,397,679	0
K	Westbank North	3,020	2,382,780	848,270	49	4,591	3,622,341	1,289,553	127
L	Trepanier	100	78,900	28,088	-8	87	68,311	24,319	-20
M	Goats Peak & Gellatly	3,706	2,924,113	1,040,984	68	6,081	4,797,905	1,708,054	176
N	Peachland	6,277	4,952,553	1,763,109	35	8,840	6,974,469	2,482,911	90
Total		**59,937**	**47,289,993**	**16,835,238**	**65**	**97,201**	**76,691,397**	**27,302,137**	**168**

Note: Communities are shown on Figure 6.2.

Table 12.3 Estimates of 2020 and 2050 residential water use in the TLU assuming annual per capita residential water use increase as a result of climate change (857 L/day by 2020 and 924 L/day by 2050).

		2020				2050			
Community		Population	Average Annual Residential Water Use		Change from 2001	Population	Average Annual Residential Water Use		Change from 2001
			(L/day)	(m^3/year)	(%)		(L/day)	(m^3/year)	(%)
A	Rural Westside Road	2,516	2,156,212	767,611	105	4,379	4,046,342	1,440,498	284
B	Crystal Mtn & Brenda Mines	1,629	1,395,684	496,864	763	3,876	3,581,712	1,275,090	2114
C	Westlake Road & West Kelowna Estates	3,860	3,308,020	1,177,655	38	5,166	4,773,189	1,699,255	99
D	Westbank I.R. #10	3,404	2,916,800	1,038,381	332	7,426	6,861,502	2,442,695	916
E	Shannon Lake	5,090	4,362,130	1,552,918	108	8,927	8,248,402	2,936,431	293
F	Lakeview	8,262	7,080,534	2,520,670	29	10,337	9,551,145	3,400,208	74
G	Smith Creek	4,197	3,596,829	1,280,471	242	8,718	8,054,994	2,867,578	665
H	Upper Glenrosa	3,123	2,676,797	952,940	247	6,513	6,018,355	2,142,534	681
I	Westbank I.R. #9	9,777	8,378,889	2,982,884	111	17,285	15,971,243	5,685,762	303
J	Lower Glenrosa	4,976	4,264,432	1,518,138	9	4,976	4,597,824	1,636,825	17
K	Westbank North	3,020	2,588,140	921,378	62	4,591	4,242,133	1,510,199	166
L	Trepanier	100	85,700	30,509	0	87	79,999	28,480	-7
M	Goats Peak & Gellatly	3,706	3,176,128	1,130,701	83	6,081	5,618,839	2,000,307	223
N	Peachland	6,277	5,379,389	1,915,062	46	8,840	8,167,820	2,907,744	122
Total		**59,937**	**51,365,683**	**18,286,183**	**79**	**97,201**	**89,813,499**	**31,973,606**	**213**

Note: Communities are shown on Figure 6.2.

The largest percentage changes in residential population occur in potential new development areas such as the Crystal Mountain and Brenda Mine area, Westbank I.R. #10, Smith Creek, and Upper Glenrosa areas.

Commercial and Industrial

Commercial and industrial development will accompany population growth in the TLU, and associated water demand will increase. Commercial and industrial water use in all community areas except Peachland was calculated based on Urban Systems (1999) estimates of the number of people employed in a variety of sectors in 2018, and using the same conversion factors (from commercial and industrial use to single family dwellings) used for the 2001 assessment. Data for Peachland were developed from Economic Development Commission (2002) figures for current employment by sector. Appendix H shows the conversion from the number of projected people employed within each sector to the average annual water use.

Assuming that the climate does not change, commercial and industrial use is expected to increase by 58% by 2020 (to 7.805 million m^3 per year) and by 85% by 2050 (to 8.478 million m^3 per year) (Table 12.4). If climate change is assumed to occur, by 2020 commercial and industrial use will increase by 85% (to 9.101 million m^3 per year) and by 2050, it will increase by 116% (to 10.658 million m^3 per year). By 2020 and 2050, retail and wholesale development and institutional development are the largest factors contributing to the change in use (Tables 12.5 and 12.6).

Table 12.4 Estimates of 2020 and 2050 commercial/industrial water use in the TLU (with and without climate change).

		2020				2050			
Assumption:		No climate change		Climate change		No climate change		Climate change	
Community		Average Annual Commercial / industrial Water Use	Change from 2001	Average Annual Commercial / industrial Water Use	Change from 2001	Average Annual Commercial / industrial Water Use	Change from 2001	Average Annual Commercial / industrial Water Use	Change from 2001
		(m^3/year)	(%)	(m^3/year)	(%)	(m^3/year)	(%)	(m^3/year)	(%)
A	Rural Westside Road	0	-	0	-	0	-	0	-
B	Crystal Mtn & Brenda Mines	0	-	0	-	0	-	0	-
C	Westlake Road & West Kelowna Estates	1,889,078	107	2,051,888	125	1,888,996	107	2,212,208	143
D	Westbank I.R. #10	66,924	1822	72,692	1987	68,169	1858	79,832	2193
E	Shannon Lake	443,378	83	481,590	99	443,339	83	519,195	115
F	Lakeview	412,517	137	448,070	157	412,712	137	483,328	178
G	Smith Creek	2,504	-	2,720	-	2,503	-	2,932	-
H	Upper Glenrosa	1,039,222	0	1,128,788	9	1,038,982	0	1,216,755	17
I	Westbank I.R. #9	391,595	160	425,345	183	408,518	172	478,417	218
J	Lower Glenrosa	25,725	79	27,942	95	25,728	79	30,131	110
K	Westbank North	339,060	88	368,282	104	339,277	88	397,328	120
L	Trepanier	0	-	0	-	0	-	0	-
M	Goats Peak & Gellatly	263,913	214	286,658	241	264,255	215	309,469	268
N	Peachland	2,931,658	38	3,184,323	50	4,208,531	98	4,928,621	132
Total		**7,805,574**	**58**	**8,478,298**	**72**	**9,101,009**	**85**	**10,658,216**	**116**

Table 12.5 Percent change in commercial and industrial water use by employment sector assuming that climate change does not occur.

Community		2020 Finance, Insurance, Real Estate (% change from 2001)	2020 Institutional (% change from 2001)	2020 Retail, Wholesale (% change from 2001)	2020 Industry* (% change from 2001)	2050 Finance, Insurance, Real Estate (% change from 2001)	2050 Institutional (% change from 2001)	2050 Retail, Wholesale (% change from 2001)	2050 Industry* (% change from 2001)
A	Rural Westside Road	-	-	-	-	-	-	-	-
B	Crystal Mtn & Brenda Mines	-	-	-	-	-	-	-	-
C	Westlake Road & West Kelowna Estates	0	100	23	122	0	100	23	122
D	Westbank I.R. #10	-	-	1783	-	-	-	1818	-
E	Shannon Lake	0	26	-24	131	0	26	-24	131
F	Lakeview	0	20	32	1251	0	20	32	1251
G	Smith Creek	-	-	-		-		-	-
H	Upper Glenrosa	-	0	-	0	-	0	-	0
I	Westbank I.R. #9	49	98	230	9	56	106	244	14
J	Lower Glenrosa	-	0	480	-	-	0	480	-
K	Westbank North	66	16	97	-	66	16	97	-
L	Trepanier	-	-	-	-	-	-	-	-
M	Goats Peak & Gellatly	5	13	245	242	5	13	245	242
N	Peachland	-	113	56	34	-	299	145	87
Total		**30**	**76**	**83**	**54**	**31**	**180**	**102**	**79**

*Includes resource, manufacturing, construction, and utilities.

Table 12.6 Percent change in commercial and industrial water use by employment sector assuming that climate change does occur.

Community		2020 Finance, Insurance, Real Estate (% change from 2001)	2020 Institutional (% change from 2001)	2020 Retail, Wholesale (% change from 2001)	2020 Industry* (% change from 2001)	2050 Finance, Insurance, Real Estate (% change from 2001)	2050 Institutional (% change from 2001)	2050 Retail, Wholesale (% change from 2001)	2050 Industry* (% change from 2001)
A	Rural Westside Road								
B	Crystal Mtn & Brenda Mines								
C	Westlake Road & West Kelowna Estates	9	117	33	141	17	134	44	160
D	Westbank I.R. #10			1945				2146	
E	Shannon Lake	9	37	-18	151	17	48	-11	170
F	Lakeview	9	31	43	1367	17	41	55	1482
G	Smith Creek								
H	Upper Glenrosa		9		9		17		17
I	Westbank I.R. #9	62	115	258	18	82	141	303	33
J	Lower Glenrosa		9	530			17	579	
K	Westbank North	81	26	114		95	36	131	
L	Trepanier								
M	Goats Peak & Gellatly	14	23	274	271	23	33	304	301
N	Peachland		132	69	45		367	187	119
Total		**42**	**91**	**99**	**67**	**53**	**228**	**136**	**110**

*Includes resource, manufacturing, construction, and utilities.

Intensive Agriculture

As indicated in Table 7.7, there are about 982 hectares of land currently used for intensive agriculture in the TLU. There is no information available to suggest that there will be a change to the total area under cultivation, or to the specific distribution of crop types in the future. It is possible that new techniques in irrigation and removal of land from the Agricultural Land Reserve (ALR) could decrease agricultural water demand. On the other hand, climate change could increase agricultural water demand. For this report we have assumed that there will be no change in agricultural water demand as a result of population change (by 2020 and 2050). However, there will be an increase in agricultural demand of roughly 16% by 2020 (to a total of 8.415 million m^3 per year) and 30% by 2050 (to a total of 9.409 million m^3 per year). These estimates are based on the increased average annual water demand per unit area (for each of nine crop types identified in Section 7.3.4) estimated by Dr. Denise Neilsen of Agriculture and Agri-Food Canada (2003b). Tables 12.7 and 12.8 present the estimated annual agricultural water demand in the TLU by community and crop type for 2020 and 2050, respectively, assuming that climate change does occur.

Golf Courses

The projected water use by golf courses in 2020 and 2050 was estimated assuming there will be no change in water demand as a result of population change only. That means that we have assumed no change in the number of golf courses or in the estimated irrigated area presented in Table 7.8. Assuming that climate change will occur, we have projected that water demand from golf courses will increase by 16% and 30% for 2020 and 2050, respectively, which mirrors the overall increases expected in intensive agriculture. In total it is estimated that 1.211 million m^3 of water per year and 1.357 million m^3 per year will be used by golf courses in the TLU by 2020 and 2050 respectively (Table 12.9).

Table 12.7 Estimated annual agricultural water demand in the TLU by community and crop type by 2020.

	Crop Type:	APPLE	APRICOT	CHERRY	PEACH	PEAR	PLUM	CROP-LAND	PASTURE	VINE-YARD	TOTAL	TOTAL
	Annual Water Demand[1] (m^3/ha):	8697	9782	8708	9253	9154	9100	8919	8769	6039	**Agricultural**	**Water**
											Area	**Demand**
		Area[2]	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**		
	Community	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(m^3/year)
A	Westside Road – Rural							29.8	1.5		31.2	278,230
B	Crystal Mountain & Brenda Mine	9.6						9.2			18.8	165,399
C	Westlake Road & West Kelowna Estates	6.7		27.2	1.7			24.5		0.7	60.9	534,609
D	Westbank I.R. #10				0.3						0.3	2,802
E	Shannon Lake							103.0	78.4		181.5	1,606,546
F	Lakeview	114.2		8.1	5.2	21.0	1.5	13.8		71.0	234.8	1,869,803
G	Smith Creek	36.2		1.1	1.0	1.6		10.1			50.0	438,453
H	Upper Glenrosa							65.0	16.0		81.0	719,912
I	Westbank I.R. #9							7.0	79.2		86.2	757,272
J	Lower Glenrosa	0.6						18.4	0.0		19.0	169,707
K	Westbank North	48.5	0.2	4.3	3.8	3.1	1.2	5.0	0.9	12.9	80.0	666,943
L	Trepanier							21.5			21.5	191,325
M	Goats Peak & Gellatly	55.7		2.4	1.0	5.1		25.6			89.8	789,211
N	Peachland	18.7		1.6	0.8	1.7	1.0	0.0		2.7	26.5	225,182
	Total:	290	0.2	44.7	13.7	32.6	3.7	333	176	87.4	**982**	**8,415,394**

Notes:
1. Annual water demand estimates for each crop type are based on data from the Okanagan Crop Water Demand Model provided by Agriculture and Agri-Food Canada (2003b).
2. Areas for each crop type are based on agricultural land use data provided by Agriculture and Agri-Food Canada (2003a).

Table 12.8 Estimated annual agricultural water demand in the TLU by community and crop type by 2050.

	Crop Type:	**APPLE**	**APRICOT**	**CHERRY**	**PEACH**	**PEAR**	**PLUM**	**CROP-LAND**	**PASTURE**	**VINE-YARD**	**TOTAL**	**TOTAL**
	Annual Water Demand[1] (m^3/ha):	9900	10953	9917	10401	10333	10252	9826	9676	6838	**Agricultural**	**Water**
											Area	**Demand**
		Area[2]	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**	**Area**		
	Community	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(m^3/year)
A	Westside Road – Rural							29.8	1.5		31.2	306,566
B	Crystal Mountain & Brenda Mine	9.6						9.2			18.8	185,271
C	Westlake Road & West Kelowna Estates	6.7		27.2	1.7			24.5		0.7	60.9	600,422
D	Westbank I.R. #10				0.3						0.3	3,150
E	Shannon Lake							103.0	78.4		181.5	1,771,218
F	Lakeview	114.2		8.1	5.2	21.0	1.5	13.8		71.0	234.8	2,118,701
G	Smith Creek	36.2		1.1	1.0	1.6		10.1			50.0	495,536
H	Upper Glenrosa							65.0	16.0		81.0	793,417
I	Westbank I.R. #9							7.0	79.2		86.2	835,528
J	Lower Glenrosa	0.6						18.4	0.0		19.0	187,171
K	Westbank North	48.5	0.2	4.3	3.8	3.1	1.2	5.0	0.9	12.9	80.0	755,905
L	Trepanier							21.5			21.5	210,796
M	Goats Peak & Gellatly	55.7		2.4	1.0	5.1		25.6			89.8	889,452
N	Peachland	18.7		1.6	0.8	1.7	1.0	0.0		2.7	26.5	255,875
	Total:	290	0.2	44.7	13.7	32.6	3.7	333	176	87.4	**982**	**9,409,007**

Notes:
1. Annual water demand estimates for each crop type are based on data from the Okanagan Crop Water Demand Model provided by Agriculture and Agri-Food Canada (2003b).
2. Areas for each crop type are based on agricultural land use data provided by Agriculture and Agri-Food Canada (2003a).

Table 12.9 Estimated annual water use by golf courses in the TLU by 2020 and 2050 assuming climate change occurs.

Golf Course	**Community**	**Estimated Irrigated Area (ha)**	**Estimated average annual water use (m^3) by 2020**	**Estimated average annual water use (m^3) by 2050**
Shannon Lake	Shannon Lake	39.0	452,400	507,000
Vintage Hills	Westbank I.R. #9	40.4	468,640	525,200
Ponderosa	Peachland	25.0	290,000	325,000
Total:		**104**	**1,211,040**	**1,357,200**

Distribution System Losses

Distribution system losses (i.e., leakage) throughout the TLU is not known precisely, however EarthTech (2003) has reported that it could possibly range from 5 to 10%. For the purposes of this report, we have assumed that this value remains at 5% (i.e. unchanged from the base case) in 2020 and 2050.

Combined Water Demand

Assuming that the climate remains the same, by 2020 and 2050 annual water demand in the TLU is estimated to total **34.581 million m^3** and **46.932 million m^3**, respectively (Table 12.10 and Figure 12.7). This represents an increase from 2001 of 41% and 91% for 2020 and 2050, respectively. Assuming that climate change does occur, by 2020 and 2050 annual water demand in the TLU is estimated to total **38.210 million m^3** and **56.068 million m^3**, respectively (Table 12.11 and Figure 12.7). This represents an increase from current conditions of 55% and 128% for 2020 and 2050, respectively.

Table 12.10 Total 2020 and 2050 water use in the TLU by land use assuming that climate change does not occur.

		2020					**2050**				
		Residential	**Commercial / Industrial**	**Agricul-tural[1]**	**Dist. Losses**	**TOTAL**	**Residential**	**Commercial / Industrial**	**Agricul-tural[1]**	**Dist. Losses**	**TOTAL**
		(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
A	Rural Westside Road	706,704	0	241,968	47,434	**996,106**	1,230,035	0	241,968	73,600	**1,545,604**
B	Crystal Mtn & Brenda Mines	457,439	0	141,045	29,924	**628,408**	1,088,794	0	141,045	61,492	**1,291,331**
C	Westlake Road & West Kelowna Estates	1,084,212	1,889,078	458,175	171,573	**3,603,038**	1,450,988	1,888,996	458,175	189,908	**3,988,066**
D	Westbank I.R. #10	955,989	66,924	2,387	51,265	**1,076,565**	2,085,808	68,169	2,387	107,818	**2,264,181**
E	Shannon Lake	1,429,700	443,378	1,807,053	184,007	**3,864,137**	2,507,407	443,339	1,807,053	237,890	**4,995,689**
F	Lakeview	2,320,664	412,517	1,575,308	215,424	**4,523,913**	2,903,424	412,712	1,575,308	244,572	**5,136,016**
G	Smith Creek	1,178,870	2,504	370,417	77,590	**1,629,380**	2,448,614	2,503	370,417	141,077	**2,962,610**
H	Upper Glenrosa	877,327	1,039,222	629,560	127,306	**2,673,416**	1,829,502	1,038,982	629,560	174,902	**3,672,947**
I	Westbank I.R. #9	2,746,203	391,595	1,083,956	211,088	**4,432,842**	4,855,050	408,518	1,083,956	317,376	**6,664,901**
J	Lower Glenrosa	1,397,679	25,725	147,185	78,529	**1,649,118**	1,397,679	25,728	147,185	78,530	**1,649,122**
K	Westbank North	848,270	339,060	562,247	87,479	**1,837,055**	1,289,553	339,277	562,247	109,554	**2,300,630**
L	Trepanier	28,088	0	166,106	9,710	**203,904**	24,319	0	166,106	9,521	**199,945**
M	Goats Peak & Gellatly	1,040,984	263,913	668,970	98,693	**2,072,560**	1,708,054	264,255	668,970	132,064	**2,773,343**
N	Peachland	1,763,109	2,931,658	439,237	256,700	**5,390,704**	2,482,911	4,208,531	439,237	356,534	**7,487,213**
	TOTAL	16,835,238	7,805,574	8,293,613	1,646,721	**34,581,146**	27,302,137	9,101,009	8,293,613	2,234,838	**46,931,597**

Notes: In this table, "agricultural" water use includes water used by golf courses.

Table 12.11 Total 2020 and 2050 water use in the TLU by land use assuming that climate change does occur.

		2020					2050				
		Residential	Commercial / Industrial	Agricul-tural[1]	Dist. Losses	TOTAL	Residential	Commercial / Industrial	Agricul-tural[1]	Dist. Losses	TOTAL
		(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)	(m^3/year)
A	Rural Westside Road	767,611	0	278,230	52,292	**1,098,133**	1,440,498	0	306,566	87,353	**1,834,417**
B	Crystal Mtn & Brenda Mines	496,864	0	165,399	33,113	**695,376**	1,275,090	0	185,271	73,018	**1,533,378**
C	Westlake Road & West Kelowna Estates	1,177,655	2,051,888	534,609	188,208	**3,952,360**	1,699,255	2,212,208	600,422	225,594	**4,737,480**
D	Westbank I.R. #10	1,038,381	72,692	2,802	55,694	**1,169,568**	2,442,695	79,832	3,150	126,284	**2,651,961**
E	Shannon Lake	1,552,918	481,590	2,058,946	204,673	**4,298,127**	2,936,431	519,195	2,278,218	286,692	**6,020,536**
F	Lakeview	2,520,670	448,070	1,869,803	241,927	**5,080,470**	3,400,208	483,328	2,118,701	300,112	**6,302,348**
G	Smith Creek	1,280,471	2,720	438,453	86,082	**1,807,726**	2,867,578	2,932	495,536	168,302	**3,534,347**
H	Upper Glenrosa	952,940	1,128,788	719,912	140,082	**2,941,722**	2,142,534	1,216,755	793,417	207,635	**4,360,341**
I	Westbank I.R. #9	2,982,884	425,345	1,225,912	231,707	**4,865,849**	5,685,762	478,417	1,360,728	376,245	**7,901,152**
J	Lower Glenrosa	1,518,138	27,942	169,707	85,789	**1,801,575**	1,636,825	30,131	187,171	92,706	**1,946,833**
K	Westbank North	921,378	368,282	666,943	97,830	**2,054,432**	1,510,199	397,328	755,905	133,172	**2,796,604**
L	Trepanier	30,509	0	191,325	11,092	**232,926**	28,480	0	210,796	11,964	**251,239**
M	Goats Peak & Gellatly	1,130,701	286,658	789,211	110,329	**2,316,899**	2,000,307	309,469	889,452	159,961	**3,359,189**
N	Peachland	1,915,062	3,184,323	515,182	280,728	**5,895,296**	2,907,744	4,928,621	580,875	420,862	**8,838,102**
	TOTAL	18,286,183	8,478,298	9,626,434	1,819,546	**38,210,460**	31,973,606	10,658,216	10,766,207	2,669,901	**56,067,929**

Notes: In this table, “agricultural” water use includes water used by golf courses.

Summary

An overall summary of future land use and population change and the effect on water use in the TLU is provided below, and summarized in Tables 12.12 and 12.13, and Figure 12.7.

- Population in the TLU is forecast to grow from 36,336 in 2001 to 59,937 in 2020 and 97,201 in 2050. The growth to 2020 will lead to a 65% (assuming no change in climate) to 79% (assuming climate change) increase in residential water use. By 2050, the increase in residential water use is projected to be 168% (assuming no change in climate) to 213% (assuming climate change);
- The economy will grow along with population. The commercial/industrial sector will see a 58% (assuming no change in climate) to 72% (assuming climate change) increase in water use by 2020. By 2050, the increase in commercial and industrial use is projected to be 85% (assuming no change in climate) to 116% (assuming climate change);

- Agriculture is anticipated to neither expand nor contract between now and 2020 or 2050. Farmland lost to urbanization is expected to be balanced by increased tillage elsewhere. Intensive agriculture currently uses approximately 7.249 million m^3 of water per year in the TLU. Climate change will increase evapotranspiration and lengthen growing seasons, increasing agricultural demand. By 2020, this demand in projected to increase by 16% to a total of 8.415 million m^3 per year. By 2050, the agricultural demand is expected to increase by 30% above the current demand to 9.409 million m^3; and
- In total, water demand in the TLU is expected to grow by 41% by 2020 and 91% by 2050 assuming that the climate does not change. However, if climate change is accounted for, total water use in the TLU is expected to increase by 55% by 2020 and 128% by 2050.

Table 12.12 Overall TLU water use (in millions of m^3/year) assuming that climate change does not occur.

Land use	2003	2020	2050
Residential	10.2	16.8	27.3
Commercial / Industrial	4.9	7.8	9.1
Agricultural[1]	8.3	8.3	8.3
Distribution system losses	1.2	1.6	2.2
TOTAL	**24.6**	**34.5**	**46.9**

Note: In this table, “agricultural” water use includes water used by golf courses.

Table 12.13 Overall TLU water use (in millions of m^3/year) assuming that climate change does occur.

Land use	2003	2020	2050
Residential	10.2	18.3	32.0
Commercial / Industrial	4.9	8.5	10.6
Agricultural[1]	8.3	9.6	10.8
Distribution system losses	1.2	1.8	2.7
TOTAL	**24.6**	**38.2**	**56.1**

Note: In this table, “agricultural” water use includes water used by golf courses.

13.0 INTRODUCTION TO WATER SUPPLY/DEMAND SCENARIOS

13.1 PROCESS OVERVIEW

Phase 2 of the Trepanier Landscape Unit water management planning study consisted of the following activities:

- Defining a reasonable range of future water resource pressures to consider, making use of input received from the Steering Committee and TAWG in a meeting September 25, 2003;
- Identifying specific “scenarios” (specific future conditions and specific dates) to consider for planning purposes;
- Examining the effects of the scenarios on streamflows and evaluating scenario outputs; and
- Using scenario output and LRMP and OCP goals and policies for guidance, developing recommendations for water management in the TLU.

13.2 OVERVIEW OF SCENARIOS AND ANALYSES

Four specific scenarios were examined, as defined as follows:

<u>Scenario 1: Effects of Population Growth</u>

- <u>Scenario 1.1: Effects of Population Growth to 2020</u>
- <u>Scenario 1.2: Effects of Population Growth to 2050</u>

<u>Scenario 2: Effects of Population Growth and Climate Change</u>

- <u>Scenario 2.1: Effects of Population Growth and Climate Change to 2020</u>
- <u>Scenario 2.2: Effects of Population Growth and Climate Change to 2050</u>

In addition, in each case, we have examined the effect of conservation measures, specifically the effects of 10%, 20%, and 30% reductions in demand due to implementation of conservation measures, as directed by the Steering Committee and the TAWG.

In each case, the scenario output consists of tabular and graphical presentations of monthly hydrographs for an "average" year, for the five principal tributaries within the TLU. Increases in water demand between the present and 2020 and between 2020 and 2050 are assumed to be satisfied from surface sources only. Thus this analysis is an examination of the ability of surface sources to satisfy future water demand. Results are presented as "average", which means representative of conditions at that time. The climate in 2020 and 2050 will produce wet years and dry years, but we have not analyzed for these conditions.

Finally, note that in the text that accompanies each of the above-noted scenario outputs, we have not made detailed comments on the effects of replacing surface sources with groundwater or Okanagan Lake. It is a simple matter to use the information presented in this report to propose any number of hypothetical reductions in the future use of surface water in any of the five principal streams.

The analyses that have been completed for each scenario are as follows:

- Analysis of the effects of the increased demands on average monthly streamflows at the 14 points-of-interest identified in Section 8.0;
- Evaluation of the output in terms of potential water availability conflicts, and effects on fish and water quality;
- Evaluation of economic and environmental implications; and
- Comparison of the scenario outputs with current (2003) conditions.

13.3 SCENARIOS DESCRIPTIONS AND ASSUMPTIONS

The four scenarios are described in this section. Results are provided in Appendices I through M and O, and results are summarized in Section 14.0.

13.3.1 Scenarios 1.1 and 1.2 (Population growth to 2020 and 2050)

Scenarios 1.1 and 1.2 examine the effects of population growth to 2020 and 2050, respectively. The population of the TLU in 2001 was 36,336 (RDCO, 2003b). Population is expected to continue to increase. RDCO (2003b) indicates that the population will likely reach 59,937 by 2020, and assuming the same rate of growth the population will be 97,201 in 2050. Because of these projected changes, residential, commercial, and industrial water use will increase, which will place an increased demand on the TLU's water resources. Scenario 1 examines the impact of these pressures on surface water resources in the TLU.

Assumptions:

- A very important assumption is that 100% of the additional water demands resulting from population growth and climate change are satisfied from surface streams (not groundwater or Okanagan Lake) – variations from this assumption will reduce the impacts on surface flows identified in this report;
- There is no change in the seasonal patterns of water storage use in the upper elevation reservoirs;
- Population projections to 2020 are taken from Table 12.2. The census reference year of 2001 is assumed to apply to 2003. Population projections to 2050 are derived by assuming the same rate of growth as projected between 2001 and 2020;
- Employment projections developed by Urban Systems for the year 2018 have been assumed to apply to the 2020 reference year;
- Per capita residential water use rates are assumed to remain the same in 2020 and 2050 as they are in 2003;
- The relations between residential water use and commercial and industrial water use that were utilized in Section 7.0 of this report are assumed to remain valid in 2020 and 2050;
- Future climate and other influences (such as land use) on water supply do not change relative to 2003;
- 2020 is assumed to be an "average" streamflow year – we have analyzed the scenario output for an average year, not a wetter or a drier year than average; and
- It is assumed that no new water licences are issued to support the demand – this is just an analysis of the changes in demand.

Scenario 1.1 and 1.2 outputs reflect the above-noted assumptions.

Note that, although we have assumed a certain geographic distribution of growth beyond 2003 based on existing RDCO data, the actual locations of future growth may be partly determined by the outcomes of this project. The geographic distributions of future population and economic activity within the TLU indicated in Section 12.0 are not intended as actual forecasts of the future geographic distributions.

13.3.2 Scenarios 2.1 and 2.2 (Population growth and climate change - 2020 and 2050)

In addition to the expected pressures on water resources related to population and economic growth, climate changes are also expected to directly affect both water supply and water demand. The changes in water demands due to climate will in turn affect streamflows. The Sustainable Development Resource Institute at the University of B.C., in cooperation with Agriculture Canada and Environment Canada, is presently engaged in a study of the changes in climate that can be expected in the Okanagan between 2003 and 2080. Interim results of this ongoing study have included estimates of changes in streamflows and of changes in agricultural water demands for both 2020 and 2050. Climate changes will also affect residential and some commercial (e.g., nurseries and golf courses) irrigation demands, and the changes in demand, if satisfied from surface sources, will cause further reductions in streamflows. Scenarios 2.1 and 2.2 examine the combined effects of population growth and climate change to 2020 and 2050, respectively.

All of the assumptions made for Scenarios 1.1 and 1.2 (except for the assumption of no climate change) are also made for Scenarios 2.1 and 2.2. Additional assumptions specific to Scenarios 2.1 and 2.2 are as follows:

- There are no agricultural changes (such as the area under cultivation, or the types of crops grown) up to 2050, except changes due to a longer growing season and higher summer temperatures (as predicted by the climate change models);
- Indoor domestic water use rates are assumed to remain the same in 2020 and 2050 as they are in 2003, but the outdoor component of domestic use is assumed to increase, based on projected changes in agricultural demand for 2020 and 2050;

- Demand and streamflow changes are based on climate changes predicted for 2020 and 2050. These predicted climate changes are based on an average of the output of 6 climate model runs, as outlined by Cohen and Neale (2003): using three global circulation models (the Canadian global coupled model - CGCM2, the UK's Hadley Centre model - HadCM3, and an Australian model – CSIROMk2) and two realistic future CO_2 emission scenarios. Specifically, changes in water demand for the specific crops grown in the TLU and for the specific locations and sizes of agricultural fields in the TLU have been taken from analyses prepared by Dr. Denise Nielsen of Agriculture Canada (Agriculture and Agri-Food Canada, 2003b). Estimated future mean monthly streamflows for the five major streams in the TLU were based on runs of the UBC Watershed Model conducted by Dr. Y. Alila of the Faculty of Forestry at the University of B.C. Scenario 2.1 and 2.2 outputs are based on the best information available at the present time. However, because both of these analyses are based on averages of 6 reasonably possible future climates, and because demand and streamflow modelling involves uncertainty, Scenario 2.1 and 2.2 outputs are more uncertain than the Scenario 1.1 and 1.2 outputs.

14.0 SUMMARY OF PERFORMANCE INDICATOR ANALYSIS

14.1 INTRODUCTION

This section presents a summary of the output of scenario runs (outlined in Section 13.0) that were performed for each of the 14 points-of-interest in the TLU[15]. Details on the methods used and results for each scenario at each point-of-interest are provided in Appendix O. Output from the scenario runs (provided in tabular format in Appendices I to M and in Figures 14.1 to 14.61) consists of the average monthly and annual estimates of several parameters:

(1) net flow;
(2) naturalized flow;
(3) total licensed quantities (offstream and instream);
(4) offstream licensed quantities;
(5) instream licensed quantities;
(6) estimated actual offstream use;
(7) estimated actual or licenced monthly storage (either as a withdrawal into or a release from storage), and
(8) conservation flows.

These terms are defined in the Glossary (Section 18.0).

14.2 SUMMARY OF SCENARIO OUTPUTS

Changes in streamflows under each of the Scenarios have been evaluated quantitatively by making comparisons amongst these parameters under current conditions and for each of the four scenarios; and by comparing each scenario to current conditions (Appendix O). This section summarizes these findings. Note that 2003 is taken as the base case – not the specific year 2003, but average hydrologic conditions at this time. Also, note that streamflows have

[15] For discussion purposes the points-of-interest (POIs) on Lambly, Powers, Trepanier and Powers Creeks have been referred to as either at "the mouth", at "the middle (i.e., canyon) point-of-interest (POI)" or at "the upper (i.e., plateau) point-of-interest (POI)". Only two points-of-interest (POIs) are located on McDougall Creek: "at the mouth" and "the upper POI".

already been reduced from historic levels (Table 8.7), so evaluations of future impacts relative to present conditions don't represent the total cumulative impact of human actions, only impacts relative to 2003.

Actual offstream water use in the TLU is the greatest along the lower portions of the five major creeks in the TLU, generally below the intakes of the major water purveyors. Thus, the effects of water use on streamflows are generally most significant at the mouths of the five major creeks. Figure 14.62 shows how offstream water withdrawals will increase in the future, while Tables 14.1 and 14.2 and Figures 14.57 through 14.61 show how flows will change in each month of the year in each creek in future. Table 14.3 provides a summary of selected performance indicators that identify where and under which scenario(s) significant streamflow-related issues are anticipated. These issues are discussed in detail in Appendix O and are highlighted in Sections 14.2.1 through 14.2.4.

Table 14.1 Estimates of current (2003) and projected (2020 and 2050) average August and annual net flows at the mouths of the five principal streams in the TLU assuming population change only (Scenarios 1.1 and 1.2).

Estimated net flow	Lambly Creek		McDougall Creek		Powers Creek		Trepanier Creek		Peachland Creek	
	August	Annual	August	Annual	August	Annual	August	Annual	August	Annual
2003	0.319	1.58	**0.000**	0.084	1.40	0.849	0.189	1.03	0.586	0.515
2020 (Scenario 1.1)	0.175	1.52	**0.000**	0.083	1.23	0.774	0.157	1.02	0.545	0.496
2050 (Scenario 1.2)	**0.000**	1.41	**0.000**	0.083	0.954	0.656	0.116	1.00	0.494	0.474

Notes: 1) all values in m^3/s; 2) zero flow is indicated in bold.

Table 14.2 Estimates of current (2003) and projected (2020 and 2050) average August and annual net flows at the mouths of the five principal streams in the TLU assuming population change and climate change (Scenarios 2.1 and 2.2).

Estimated net flow	Lambly Creek		McDougall Creek		Powers Creek		Trepanier Creek		Peachland Creek	
	August	**Annual**	**August**	**Annual**	**August**	**Annual**	**August**	**Annual**	**August**	**Annual**
2003	0.319	1.58	**0.000**	0.084	1.40	0.849	0.189	1.03	0.586	0.515
2020 (Scenario 2.1)	**0.000**	1.24	**0.000**	0.064	1.11	0.590	0.084	0.790	0.481	0.383
2050 (Scenario 2.2)	**0.000**	0.764	**0.000**	0.029	0.694	0.279	**0.000**	0.560	0.375	0.256

Notes: 1) all values in m^3/s; 2) zero flow is indicated in bold.

Table 14.3 Summary of selected performance indicators.

Issues	Lambly Creek				McDougall Creek				Powers Creek				Trepanier Creek				Peachland Creek			
Scenario:	1.1	1.2	2.1	2.2	1.1	1.2	2.1	2.2	1.1	1.2	2.1	2.2	1.1	1.2	2.1	2.2	1.1	1.2	2.1	2.2
Conservation flows		–	–	–				–	–	–	–	–				–				–
Zero flows		–	–	–		–	–	–				–				–				–
Availability of licensed flow for offstream use				–						–	–	–								

Notes:

"–" denotes an anticipated negative effect on a streamflow-related issue (with respect to current conditions).

14.2.1 Scenario 1.1 – Population change only (2020)

Under Scenario 1.1, total water use in the TLU is expected to be 41% higher than it is today. However, there will be **only small changes in annual and monthly streamflows across the five principal streams in the TLU, compared with 2003 conditions**. Flows in individual months will be reduced up to 17% in Trepanier Creek, up to 35% in Powers Creek, and up to 45% in Lambly Creek. At all points-of-interest, other than McDougall Creek at the mouth, the principal streams will remain flowing (under average hydrologic conditions). McDougall Creek is currently expected to dry up in August. With the exception of Powers Creek, streamflows at the mouths of the principal streams in 2020 are expected to meet conservation flows during the same months of the year as they do currently. Some quantity of licensed flow (for offstream use) at the mouths of all principal streams will remain unused, but flow reductions will mean that water quality issues will also decline because of reduced dilution capacity.

14.2.2 Scenario 1.2 – Population change only (2050)

Under Scenario 1.2, total water use in the TLU is expected to be 91% higher than it is today. This will result in **modest changes in the annual flows and monthly hydrographs in all five principal streams**, except Powers Creek, where changes will be more significant. The reduction in annual average flow is relatively greater at the mouths of the streams, however, these values remain modest, with Powers Creek showing the greatest reduction at 8%. At the mouths of all principal streams monthly flows are expected to drop throughout the year, with individual monthly reductions of up to 100%. In Lambly Creek, this reduction will result in zero flow conditions in August ("zero flow" means the creek is dry). In McDougall Creek the late summer flow reduction by 2050 will result in zero flow conditions in September as well as August (at present in August McDougall Creek dries up in an average year). All other points-of-interest should remain flowing by 2050. With the exception of Lambly and Powers Creek, streamflows at the mouths of the principal streams in 2050 are expected to meet conservation flows during the same months of the year as they do currently. Also by 2050 it is expected that some quantity of licensed flow (for offstream use) at the mouths of all principal streams (except for Powers Creek) will remain unused.

14.2.3 Scenario 2.1 – Population and climate change (2020)

Under Scenario 2.1, climate change will result in reduced streamflows, and in addition, total water use is expected to be 55% higher than today. This will mean **considerable reductions in annual flows and changes in monthly hydrographs in all five principal streams.** Annual flows will be reduced on average by 17% at the middle and upper POIs and by 25% at the mouths of the creeks. An average runoff year in 2020 will be similar to a 5-year drought year today (Table 8.5). Changes to the annual hydrograph will involve increases in late winter and early spring flows and decreases in the remainder of the year, particularly in late summer. McDougall Creek at the mouth (in August and September) and Lambly Creek at the mouth (in August) will experience zero flow by 2020 in an average year. By 2020, conservation flows will be met during different and slightly more months of the year than they are currently. Interestingly, anticipated increases of winter streamflows due to climate change will mean that February conservation flows (that are not met currently) will be met in 2020. Also by 2020, it is expected that some quantity of licensed flow (for offstream use) at the mouths of all principal streams (except for Powers Creek) will remain unused. The large reductions in both monthly and annual flows will have negative implications for water quality in all creeks.

14.2.4 Scenario 2.2 – Population and climate change (2050)

Under Scenario 2.2, continuing climate change will result in further reductions in streamflows, and total water use is expected to be 128% higher than today. This will mean **large changes in the annual flows and monthly hydrographs in all five principal streams**. Annual flows will be reduced on average by 38% at the middle and upper POIs and by 56% at the mouths of the creeks. An average runoff year in 2050 will be similar to a 20-year drought year today (Table 8.5). Changes to the annual hydrograph will include increases in winter and early spring flows (with the greatest increases occurring in February) and decreases in flow for the remainder of the year (particularly in late summer). These flow reductions should result in zero flow conditions in all principal streams (at one or more POIs) for at least one month of the year. The changes to the annual hydrograph also mean that conservation flows will be met less often in 2050 than they are currently. Generally, the months during which conservation flows (at the mouths) are not met will extend throughout the summer as opposed to being limited to winter and late summer months, as at present. Also, due to anticipated climate change impacts on late winter flows, February flows will meet conservation flows (that are not met currently). Finally, on an annual basis by 2050 additional licences for offstream use on Lambly and Powers Creeks will be required to satisfy demands and water quality will be significantly impacted.

14.3 EFFECTS OF ALTERNATIVE WATER MANAGEMENT

The detailed effects of population growth and climate change that are indicated on Figures 14.1 through 14.62, and the detailed performance indicator analysis of Appendix O are based on the assumptions outlined in Section 13.0. One key assumption is that 2020 and 2050 are "average" years. Because streamflows in the Okanagan are highly variable from year to year (see Section 4.5), in drier than average years, streamflows will be considerably lower than average. As shown in Table 8.5, a 5-year drought year, for example, would result in mean annual flows only 67% of average. So under Scenario 2.1, in which an average year is like a 5-year drought today, a 5-year drought will be like a 20-year drought today. In 2050, in which an average year will be similar to a 20-year drought today, a 5-year drought will be similar to a 50-year drought today.

Another key assumption is that all of the additional future demands are satisfied from surface sources. At present, however, 30% of the water used in the TLU is pumped from Okanagan Lake and 4% is drawn from wells, so only 66% of the current water use is provided from surface sources. Detailed streamflow outputs for a range of possible distributions of the future water supply (between surface, lake and groundwater) are beyond the scope of this report. If future demands can be satisfied from the lake or from groundwater, however, the impacts of the four future scenarios on streamflows will be reduced.

Finally, the four scenarios addressed in Section 14.2 have assumed that present rates of water use continue into the future. However, adoption of conservation measures can significantly mitigate the flow reductions and associated environmental impacts that are likely to occur. In Appendices I through M the effects of implementing 10%, 20%, and 30% reductions in water demand are explicitly identified, and on Figures 14.1 through 14.56, the effects of achieving a 30% reduction in demand are shown. The following text summarizes the predicted effects that demand management would have on the issues identified in Section 14.2.

If climate change does not happen, water use will still increase by 41% by 2020 and 91% by 2050. If the maximum effectiveness of demand-side measures is about 50% (as indicated in Section 15.0), then it is possible that demand measures alone could prevent changes in streamflow up to 2020. Supply augmentation would not be needed until after 2020. Conservation effectiveness of less than 41% (by 2020) will mean that reductions in streamflow will occur, but relatively modest demand reductions could prevent flows from dropping below important thresholds (e.g., meeting conservation flows), and from dropping to a point where zero flows occur. In particular, with a 10% demand reduction, conservation flows in Powers Creek could still be met in March by 2020. By 2050, a similar 10% demand reduction would prevent Lambly and McDougall Creeks from drying up in August and September, respectively. It would also mean that conservation flows would be met on Lambly Creek in October and additional licences would not be required in the upper portion of the watershed. In Powers Creek, a 30% demand reduction would reduce the need for additional water licences, but would not be sufficient to prevent March flows from dropping below conservation levels.

If climate change is accounted for, water use is predicted to increase by 55% by 2020 and 128% by 2050 compared with current conditions. In this case, even maximum demand management effectiveness (about 50%) will not be able to delay implementation of supply augmentation measures beyond 2020, and streamflows will be reduced unless additional supplies are sought. Significant supply augmentation will be needed by 2050. Tributary flows will be further altered unless these alternate supplies are sought from groundwater or Okanagan Lake. However, demand reductions can still be effective at preventing flows from dropping below important thresholds at certain times of the year and at certain locations. By 2020, a 10% demand reduction would prevent the need for additional licences (for offstream use) and prevent flows from dropping below conservation flow levels (in June) in Powers Creek. By 2050, a 10% demand reduction could prevent zero flow conditions in McDougall Creek (at the upper POI) and in Trepanier Creek (at the mouth). If 20% demand reductions were achieved, by 2020 potential zero flow conditions, July and October flow conditions below conservation levels, and a demand greater than total licences on Lambly Creek could be prevented. In addition, zero flow conditions could be prevented in McDougall Creek in

September. By 2050, a 20% demand reduction would prevent zero flows occurring in Lambly Creek and McDougall Creek in July. A similar reduction would prevent flows in McDougall Creek from dropping below conservation levels in June and prevent the need to issue additional licences for offstream water use on Lambly Creek. If 30% demand reductions were achieved, further mitigation of water management issues could be achieved. This includes preventing zero flows at the mouth of Lambly Creek in September and at the mouth of Peachland Creek in June, and preventing the need to issue more licences on Powers Creek.

14.4 SUMMARY

Based on the analysis above, the following key findings are made:

- If climate changes are not considered, streamflows in 2020 will be smaller than they are today due to population and economic growth, but no significant thresholds will be crossed in four of the five major creeks. Conservation flows, however, will not be met in Powers Creek;
- If climate changes are not considered, streamflows in 2050 will decrease further due to population and economic growth, resulting in additional impacts, concentrated on Lambly, McDougall, and Powers Creeks;
- If climate change is accounted for, significant streamflow reductions are anticipated in all five major creeks by 2020 (averaging 25%) due both to increased demand and reduced supply, resulting in zero flow at some locations for parts of the year in an average year. An average year will be like a 5-year drought year today, and a 5-year drought year will be like a 20-year drought year today;
- These impacts will be even more severe by 2050, when annual net flows will be reduced by an average of 56%, resulting in conservation flows not being met at many locations, and zero flow in all creeks for parts of the year. An average year will be like a 20-year drought year today, and a 5-year drought year in 2050 will be like a 50-year drought year today;
- Streamflow impacts will be concentrated below the intakes of the major water purveyors;

- If future demands are satisfied from sources other than tributary streams, the predicted impacts will be smaller;
- If the climate does not change, demand management alone to 2020 would allow additional demand to be satisfied from tributaries, and permit population and economic growth to occur, without streamflow reductions relative to 2003;
- However, by 2050 (even without climate change), both demand management and alternate supplies (from the lake and groundwater) will be needed to prevent streamflow reductions; and
- If the climate does change as predicted, augmentation of the water supply from Okanagan Lake and groundwater will be needed before 2020 (along with demand management) to prevent streamflow reductions relative to 2003.

15.0 MEASURES TO REDUCE IMPACTS

15.1 INTRODUCTION

The scenario outputs presented in Section 14.0 indicate that there are looming water resource conflicts in the TLU over the next few decades. Increases in population alone will result in increased demands for water, even if the climate is assumed to be static. However, there is strong evidence that the climate is changing. Climate change is predicted to result in smaller water supplies and increased demands. Taken together, population change and climate change will reduce water supply and increase demand. Hydrographs will likely be altered such that winter flows are higher, but flows in all other months (particularly late summer) are lower.

Accordingly, changes in water management will be necessary in order to delay and minimize conflicts, and to ensure a reliable supply of sufficient quantity and quality water to meet the needs of humans and the environment.

Strategies for altering water management practices (i.e. "adaptation strategies") can be broadly categorized into supply-side and demand-side approaches. These approaches and broad policy and practice recommendations relevant for Canadian municipalities have recently been outlined by Roach et. al. (2004), Maas (2003), and Environment Canada (2004). Other recommendations for urban management that include water conservation benefits based on Smart Growth principles (including a guide to municipal bylaws) are provided by Curran (2003a) and Curran (2003b). Each of the above-noted documents contains recommendations potentially relevant to the TLU and the entire Okanagan.

Both Earth Tech (2003) and Cohen and Neale (2003) have described supply and demand management approaches specifically relevant for the Okanagan. Earth Tech (2003) stated that elements of both approaches are needed for effective water management.

As part of ongoing research on climate change and adaptation strategies for the Okanagan, the Sustainable Development Research Institute at the University of B.C. (SDRI) is presently undertaking a series of workshops on climate change adaptation strategies. SDRI recently (December 9, 2003) held a meeting in Westbank to discuss adaptation strategies relevant in the TLU. Participants included water utilities, federal and provincial agencies and regional districts, and representatives of the agricultural community. Three supply-side options were evaluated by the participants:

- Increased upstream storage;
- Pumping from Okanagan Lake; and
- Increased use of groundwater.

The potential for diversion from the Shuswap River watershed was also raised but not evaluated.

Six demand-side options were also evaluated:

- Irrigation scheduling;
- Metering (domestic and agricultural, with appropriate pricing and enforcement);
- Public education;
- Leak detection;
- Water recycle, reuse, and reclamation; and
- Land use change, such as xeriscaping.

For each of these potential options, three issues were addressed by the participants:

- Social acceptability (who will benefit? who could oppose?);
- Legal framework (what existing regulations or policies support or hinder the option? what potential new laws could support it?);
- Political realism and acceptability (are politicians and public supportive? which agency has jurisdiction? who will implement? who will pay?)

Other questions were also posed, but time constraints did not permit a full analysis of the additional questions. SDRI plans to publish a summary of this workshop, and of others held in the Okanagan, in summer 2004.

Research has shown that a combination of several demand-side management approaches should be used for maximum effectiveness. In the following two sub-sections, supply-side and demand-side approaches recommended for the TLU are outlined.

15.2 SUPPLY-SIDE MANAGEMENT APPROACHES

Considering the analyses presented in the present report, several supply-side management approaches are potentially available to water suppliers in the TLU, including:

- Operational improvements, such as achieving operational efficiencies, leakage reduction in the primary conveyance systems, and system pressure reductions;
- Use or development of additional upstream storage;
- Pumping from Okanagan Lake; and
- Increased use of groundwater.

Other possible supply-side approaches include:

- Increased use of tributary flow without upstream storage development; and
- Inter-basin diversions into the TLU.

The latter two approaches are not consistent with the goals and policies for water management contained in the Okanagan-Shuswap LRMP. In addition, the first of these two options will results in further reductions in streamflow. Thus these options are not recommended for the TLU. Each of the above approaches is discussed in the following paragraphs.

Operational improvements:

It is assumed that achieving operational efficiencies, leakage reduction in the primary conveyance systems, and pressure reductions are feasible and achievable for each of the water utilities in the TLU. Costs will be utility-specific. It is recommended that the potential savings associated with these measures be investigated by each water utility.

The following supply-side alternatives are available, but may not be consistent with the water management goals of the Okanagan Shuswap LRMP or the analyses of Section 14.0.

Increased use of Okanagan Lake:

Okanagan Lake is already used as a water supply by many municipalities along the shore of Okanagan Lake, including those in the TLU. However, these systems all require pumping to the head of the distribution system, as opposed to the upstream storage option in which the water is delivered at no cost by gravity.

Earth Tech (2003) outlined the elements of a lake pumping system:

- an intake pipe;
- pumping station(s);
- watermains; and
- storage reservoirs.

That report also provided approximate costs for each element (including engineering, labour, materials, equipment, contingency, administration, and taxes). Lake intake pipes range from about $200 per metre to about $1000 per metre for pipes ranging from 100 mm to 1000 mm in diameter. Pump station costs vary as a function of horsepower. Above about 100 Hp, costs per horsepower are relatively constant (at $1,000 to $2,000 per Hp). However below about 100 Hp, costs can increase to about $30,000 per Hp because of the fixed costs of building construction, and structural, mechanical and electrical components of the building. The costs for watermains from the pump station to the reservoirs depend on several factors, but are similar to the costs of the lake intake pipe. Reservoir costs depend on the storage volume, but range from about $250 to $300 per cubic metre. The Earth Tech report also provides advice on sizing each of these elements for particular situations, and provides approximate long-term operation and maintenance costs.

Earth Tech (2003) estimated the cost of a lake system for Summerland at $2.6 million. Reid Crowther (2000) estimated the cost of an Okanagan Lake booster station for the Lakeview Irrigation District at $2.5 million.

Many areas at low elevations near Okanagan Lake within the TLU already obtain water from the lake (Section 7.0). Based on the surface area and volume of the lake (3.44×10^8 m^2 and 2.59×10^{10} m^3, respectively), there appears to be substantial potential to make additional use of Okanagan Lake. The total annual water use in the TLU (about 25 million m^3) represents a depth of approximately 7 cm on the lake. However, a large proportion of this water returns to the lake via the wastewater treatment plant and septic systems. Therefore the net withdrawal from the lake is substantially less than 7 cm. Assuming that 50%-75% of the water withdrawn from all sources (surface sources, groundwater, and Okanagan Lake) returns to the lake, and 25%-50% is lost through evapotranspiration, the net effect on the lake at present is about 2-4 cm. Increases in demand from all sectors will increase this value. Population changes alone will nearly triple the value by 2050 and climate change will more than triple it. Regardless of what sources are utilized to satisfy future water demands, the impact on the lake will increase. The lake is operated within a very narrow range (less than 1.2 m) so moving from a 2-4 cm net withdrawal today to a 6-12 cm net withdrawal in 2050 could have a impact on lake levels and the operation of the lake. This emphasizes the importance of demand-side measures (not only in the TLU, but throughout the Okanagan watershed).

The major water utilities in the TLU are examining Okanagan Lake supply options. Feasibility and costs are specific to each particular utility.

Increased use of groundwater:

As indicated in Section 6.0, groundwater use is not regulated in B.C. Existing knowledge of the locations, extent, and potential yield of aquifers in the TLU is therefore limited. Based on voluntarily submitted information, it is known that the maximum potential yield of all existing wells in the TLU is about 12.6 million cubic metres per year. This value is consistent with an estimate of the rate of precipitation-based groundwater recharge. The actual yield of existing wells is unknown, as is the maximum sustainable rate of groundwater withdrawal. However, considering that the actual yield of existing wells is likely much less than the maximum yields, it is likely that there is room for additional groundwater withdrawal. However, additional study is needed to outline aquifers, determine recharge rates to each aquifer, estimate current and maximum potential yields, and identify specific groundwater development opportunities and costs.

Approximate costs for well development are about $450 per metre for an 8 inch (20 cm) diameter well, and $1,000 per meter for a 16 inch (40 cm) diameter well. A 16 inch well would be preferable for a municipal supply. These estimates include costs for drilling, well screens, well development, a pump test, and installation of a downhole video.

Increased use of upstream storage:

Opportunities to increase upstream storage can take two forms:

- Increasing the storage capacity of existing reservoirs
- Identifying and constructing new reservoirs

Earth Tech (2003) identified the approximate costs of constructing new reservoirs in the Okanagan as ranging from $600 to $1,500 per acre-foot (including engineering, foundation preparation, berms, spillway, and release works). However, recognizing that many of the most cost-effective storage sites have already been developed, that report recommended using a cost of about $1,200 per acre-foot for budgeting purposes (about $1000 per dam^3). The Lakeview Irrigation District has estimated the cost to increase the height of Big Horn Dam as $360,000, and the cost to construct a new dam on Lambly Creek at $7.7 million.

Agencies with water management responsibilities in the TLU have expressed concerns about a potential plan by the province to sell Crown land around upland lakes and reservoirs to private interests. Privatization of Crown land could result in increased development pressures and water quality concerns, and restrict the ability of the water utilities to develop or enhance storage in future.

Increased use of tributary flow:

Analysis of water licence data and water use data in Section 8.0 (Table 8.12) indicates that the major water utilities in the TLU currently have sufficient licences to remove about twice the volume of water they presently remove. Therefore, within the scope of existing licences, it appears that is possible for the water utilities to obtain additional water to meet their demands. Note, however, as indicated in Section 14.0, that increased withdrawals from surface streams will cause significant conflicts at certain times in some locations, both now and in the future. Therefore it is recommended that water utilities not increase their withdrawal rates from surface streams without a corresponding increase in upstream storage. Although Peachland and Powers Creeks have sufficient storage to support existing offstream use, the scenario analyses summarized in Section 14.0 indicate that making additional withdrawals from these sources without developing supporting upstream storage is not recommended.

Interbasin diversions into the TLU:

Within the TLU, there is already a major diversion from Lambly to Powers Creek. Lambly Lake is situated near the divide between these two watersheds. Before the reservoir was constructed, Lambly Lake flowed down Lambly Creek (see Section 7.0). Now, however, it flows down Powers Creek. There is a total of 9.66 million m^3 of licensed storage on Lambly Lake, and the live storage is 6.17 million m^3.

In addition, there is a network of ditches that divert water from upper Lambly Creek into the Nicola River watershed, then capture part of the flow of the Nicola River and divert the combined flow into Tadpole Lake in the headwaters of Powers Creek.

Reid Crowther (2000) recommended to the Lakeview Irrigation District to divert Dunwater's Creek from the Shorts Creek watershed into the Lambly Creek watershed upstream of the Big Horn Reservoir in order to supplement supply in support of potential new development.

A “medium” priority was assigned to the work, and it was estimated to cost $170,000. This project would increase the effective drainage area of the Big Horn reservoir by 23%.

Notably, Lambly Creek has experienced flow reductions in order to increase storage and flow in Powers Creek, and now there is a recommendation to enhance Lambly Creek storage and flow by diverting water from Shorts Creek. However, interbasin diversions are not consistent with the goals of sustainable water management as expressed in the Okanagan Shuswap LRMP.

15.3 DEMAND-SIDE MANAGEMENT APPROACHES

15.3.1 Benefits

Management of water demand has significant potential to reduce peak and total water use, to delay and minimize water resource conflicts, and to delay and reduce the costs of water infrastructure. The City of Kelowna has estimated that simply reducing peak summer water use by 16% will save up to $16.5 million in infrastructure improvements over the next 20 years (City of Kelowna, 2003). Demand-side management has been shown to have the following benefits (Brandes and Ferguson (2003):

- To consumers (reduces costs for water, energy, and sewage);
- To communities (reducing and delaying capital expenditures for water supply and wastewater treatment);
- To utilities (reduces baseload and peak demands, delaying and reducing capital expenditures);
- To corporations (reduces operating costs);
- To the environment (reduces aquatic impacts); and
- To the economy (money not spent on excessive water frees capital for more productive uses).

15.3.2 Demand management categories

Brandes and Ferguson (2003) identify three general categories of demand-side management (Figure 15.2). Socio-political strategies are those that attempt to change consumers attitudes, and include such measures as education and regulation. Economic strategies involve financial incentives, which can be powerful motivators in reducing wasteful water use. Structural and operational strategies utilize technological measures, such as low flow fixtures, metering, and land-use changes such as xeriscaping.

Table 15.1 Water demand management measures.

General Category	Specific Examples
Socio-political	Information and education
	Water policy
	Water use permits
	Landscaping ordinances
	Water restrictions
	Plumbing codes for new structures
	Appliance standards
	Regulations and bylaws (e.g., turf limitation bylaws, once-through cooling system bans)
Economic strategies	Rebates for more efficient toilets, showers, faucets and appliances
	Tax credits for reduced use
	High consumption fines and penalties
	Pricing structures (seasonal rates, increasing block rates, marginal cost pricing, full cost-recovery policies, daily peak hour rates, sewer charges)
Structural-operational	Landscape efficiency (soil moisture sensors, watering timers, cisterns, rain sensors, efficient irrigation systems, soaker hoses)
	Metering
	Lead detection and repair
	Water audits
	Pressure reduction
	System rehabilitation
	Efficient technology (dual flush toilets, low flow faucets, efficient appliances)
	Recycling and reuse (e.g. reuse of cooling and process water, using grey water for toilets and irrigation, wastewater reclamation)

From Figure 5.8 of Brandes and Ferguson (2003)

15.3.3 Experience with demand management in B.C. and elsewhere

Urban Systems (2001) reviewed demand-side approaches that have been implemented in 17 municipalities in B.C., as well as six other cities in Canada (Toronto, Kingston, Brockville, Leamington, Lethbridge and Winnipeg), and five cities in the U.S. (Phoenix, Los Angeles, Lompoc, St. Petersburg, and Albuquerque). These programs have each involved some of the elements listed in Table 15.1. Some relevant initiatives from the 17 B.C. communities include:

- Universal metering in Chilliwack, Nanaimo, Vernon, and Kelowna;
- Partial metering in Kamloops, Prince George, Vanderhoof, Qualicum Beach, Parksville, and Port Alberni (e.g. residential and commercial metering only, or commercial and industrial only);
- Water audits, leak detection programs, and water use restrictions in several communities;
- Full-cost recovery pricing strategy in Kelowna;
- Media programs, community events, information with utility billing, informational publications, outdoor advertizing, xeriscaping demonstrations, water conservation poster and essay contests, and website-based information in many of the 17 communities; and
- Sponsorship of voluntary low flow fixtures and voluntary use restrictions in many of the communities.

The South-East Kelowna Irrigation District (SEKID) examined demand-side alternatives in a pilot study (Nyvall and Van der Gulik, 2000). The pilot study involved metering of 421 agricultural irrigators, irrigation scheduling, and development of a data management system. Results indicated that water savings due to metering and irrigation scheduling ranged between 5% and 23% (an average of 13%). Drought-year peak demands were 10% smaller than the design drought year requirements. However, the additional awareness and education related to water use was seen to be the largest overall benefit of the pilot program. The authors conclude that an effective demand-side management approach involves at least three components:

- Metering;
- Public education; and
- Financial incentives (such as a water rate structure that rewards conservation).

The City of Kelowna has taken a multi-tiered approach to water conservation, involving regulation of water use, metering, effective pricing, and education (City of Kelowna, 2003):

- In 1993, the City passed a bylaw requiring water-conserving fixtures in all new construction.
- In 1994, the City passed a bylaw requiring all new service connections to install a water meter.
- In 1996, the City implemented a public education program. The program is intended to teach efficient use of water and targets three sectors of the community – residential, commercial and institutional (schools).
- In 1998, the City began to use water meters for billing purposes.

The Ministry of Water Land and Air Protection recently (November 26, 2003) held a one-day workshop in the Okanagan on demand-side management approaches. The workshop was intended to initiate development of a "Water Save Tool Kit". The Tool Kit is intended to evaluate conservation efforts in B.C. and highlight success stories, identify barriers, gaps and opportunities for water conservation, and identify practical measures that can be taken by individuals and communities to conserve water. Workshop participants addressed several topics:

- Water conservation challenges and solutions (what are the challenges and solutions to water conservation?);
- Water sustainability action plan (WSAP) (to introduce the WSAP – a partnership involving the Ministry of Water, Land, and Air Protection and others);
- Water Save Tool Kit (to discuss how to obtain maximum information for the conservation evaluation initiative, and how to publicize results); and
- Water conservation considerations (to discuss benefits, barriers, tools and support mechanisms for achieving reduced water use for a variety of supply-side and demand-side approaches - e.g. metering, pricing, regulation, education, and others).

15.3.4 Opportunity for demand-side management in the TLU

Because of the fact that TLU residents use more water per capita and pay less per unit of water than citizens of nearly every other location in the world, there appears to be substantial opportunity to reduce water use in the TLU. In addition, the TLU is a relatively water short area, yet the population has grown substantially over the past 30 years and is projected to continue growing at a rapid rate over the next 20 years. Demand-side measures can substantially improve the outlook for continued economic growth and environmental sustainability. In addition, it is important to realize that a portion of the water removed for use is permanently lost to the atmosphere and to the hydrologic system of the Okanagan River watershed via the processes of evaporation and evapotranspiration. At present, the effect of this permanent water loss in the TLU is likely equivalent to a depth of about 2-4 cm on Okanagan Lake each year. However, increases in demand from the TLU alone (about 10% of the total area of the Okanagan watershed) could increase this value to 6-12 cm by 2050 (without adoption of water conservation measures), which could have an impact on lake levels and the operation of the lake.

The strong seasonal patterns of water use in the TLU suggest that reductions in water use are likely achievable, since much of the summer use occurs in the elastic portion of the demand curve, in the area where effective pricing strategies can have an impact on use (Section 11.0).

Whereas water use by commercial and industrial users likely has a limited seasonal component (except for those industries which involve irrigation, such as nurseries and golf courses), residential and agricultural users require much more water in the summer months. Many studies done for southern interior communities (including within the TLU) have shown that residential water use follows a “hydrograph” shape - rising from a steady winter baseline (representing indoor use only) beginning in March to reach a peak in July and August, then decreasing again back to the winter baseline by November. Agricultural use follows the same pattern, rising from zero in March to reach a peak in mid-summer, and continuing through September, sometimes even into October, before dropping to zero again in October.

While average usage rates are important, the size of the peak use is also important from an economic perspective. Since water supply systems must be sized to handle the peak demand, reductions in peak use are important in terms of avoiding shortages, and also in reducing the cost of future system improvements.

Based on the scenario outputs reported in Section 14.0 (including the effects of 10%, 20%, and 30% reductions in demand), and based on the above-noted demand-management approaches and experience in other communities in B.C., it is recommended that demand-side measures be implemented in the TLU. The first step is for all relevant agencies (e.g. RDCO and the water utilities) to agree on a minimum water conservation target. Different targets could be set for different user categories, or a common target could be set for all categories; and a schedule for achieving the target would be agreed on. Demand-side measures for the TLU would then be focussed on achieving this target. Measures should include at least the following four approaches:

- Public education programs (to promote water conservation and to encourage changes such as xeriscaping and improvements in irrigation application techniques and irrigation scheduling);
- Universal metering;
- Financial incentives (use of a volume-based rate system and potentially other incentives) and
- Regulations (including requiring water conserving fixtures, restrictions on water use in peak periods).

Urban Systems (2001) recommended that the District of Peachland adopt three of these four approaches (all except financial incentives). Earth Tech (2003) estimates that with the use of meters, effective pricing, and an education program, overall water savings of 20% to 25% can be achieved. Urban Systems (2001) indicates that universal metering alone will result in a 25% reduction in peak demand. With additional savings due to enactment of effective regulations, a 30% saving in total water use should be attainable in the TLU with these four approaches.

Once metering is in place, secondary measures can be implemented, including:

- a leak detection program;
- water auditing;
- improvements in irrigation application techniques; and

- irrigation scheduling.

Each of these measures relies on metering of flow, so they can be effectively applied only after meters are in place. Beyond these measures, there are even more opportunities for saving water:

- promotion of land use changes, crop selection, and xeriscaping;
- recycling and reuse; and
- combining water systems.

Participants in the SDRI workshop held in Westbank on December 9, 2003 considered several of these alternatives (see Section 15.1). Despite differences in perceived social and political acceptability and applicable legal frameworks, the approaches considered were all judged to be feasible.

The approaches recommended for the TLU are described below.

Public education:

Earth Tech (2003) and Nyvall and Van der Gulik (2000) concluded that public education is an essential component of a demand-management approach. Approaches include use of television, radio, and newspapers, public forums, printed material, including flyers with utility bills, placing information on websites, demonstration projects, and school programs. The nature of the program depends on the mix of customers. Agricultural customers use more water per connection, so the potential savings in actual water use is greater, which may justify a more personal approach.

Earth Tech (2003) estimates that a long-term 10% reduction in water use can be achieved through public education. Annual program costs vary and are higher for smaller utilities due to economies of scale, but were estimated at about $10 per connection per year for a typical education program.

Metering:

Meters are one of the most effective tools for influencing water use. As indicated in Section 11.0, Urban Systems (2001) reported that water use in five selected metered communities in Canada averaged 500 L per person per day, as compared with 805 L in 6 un-metered communities (a difference of 305 L per person per day, or 38%). In Kelowna, daily per capita residential use dropped from 775 L to 570 L (a 25% saving) after the introduction of meters. In Vernon, daily per capita residential use dropped from 700 L to 590 L after the introduction of meters (a 16% reduction). In Calgary, usage dropped from 562 L to 498 L (a reduction of 11%).

Metering advantages include:

- The user pays for what is used;
- Better water use records are obtained (enabling leak detection and further improvements to water management);
- Awareness and education occur, which reduces water use, particularly in peak times

Meter installation costs include supply and installation of the meters in new homes, and retrofitting existing homes. Approximate costs range from $350 per connection for a utility with less than 1,000 connections to $275 per connection for a utility with more than 1,000 connections. Irrigation connection costs range from about $1,500 per connection to $2,000 per connection for a system including tensiometers for irrigation scheduling and a database management system. Automated meter reading equipment and software adds about $50,000.

Pricing:

Combined with metering, effective pricing is one of the best ways to influence water use. Pricing is inelastic over the first increment of water use, but becomes elastic for the less essential water uses, such as lawn watering. Several pricing methods were outlined in Section 11.0. Even with a constant unit rate method, there is an incentive to use water wisely, as a cost is attached to each unit that is used. More direct incentives to reduce water use are provided by increasing block rate structures, higher peak hour rates, marginal cost pricing, full cost-recovery policies, summer use charges, and sewer charges.

Environment Canada (2001) showed that across Canada, volume-based residential customers use an average of 269 L per capita per day, compared with 457 L for flat-rate systems. Since volume-based pricing cannot occur without meters, this saving is due to the combined benefits of meters and the pricing structure. Earth Tech (2003) indicates that, along with metering, water use reductions of 20% to 25% can be expected using an incentive-based pricing approach.

Regulations:

Municipal bylaws can be enacted to require low flush toilets, water-saving showerheads, and other efficiencies. Municipalities can also provide water conservation kits that include low flow shower heads, faucet aerators, flow restrictors, and dye to check if toilets are leaking. Municipalities can offer rebates to local plumbers for installing water-saving fixtures. Finally, municipalities can enact and enforce water rationing during peak summer use or if storage depletion is imminent.

Leak detection:

Earth Tech (2003) estimates that distribution system leakage is typically 10%-15% of total water use. In section 6.0, we estimated the average leakage in TLU water systems at 5% - which provided a good match between supply-based calculations of water use and demand-based calculations of water use. The Earth Tech report indicates that there are several methods of detecting leakage, and that leakage not only wastes water, but costs the utility in terms of lost revenue. However, there is a cost to detect and repair leaks. Estimated repair costs for small watermains (diameters less than 300 mm) are estimated to be about $2,500 per day, and estimated costs for larger diameter mains range form $5,000 to $7,000 per day.

Water Auditing:

Water auditing is a method of determining exactly how much water is used at all locations in a water system. It can only be accomplished with end-user meters, and provides the information needed to identify water use by individual users and by categories of users, and to identify leakage locations. It provides information needed to effectively improve system management.

Water application techniques:

The means by which irrigation water is applied to the soil has a significant bearing on the efficiency of the application. Open ditches lose much more water than closed pipes. Overhead sprinklers are considered to be 50%-60% efficient, micro-jet systems are approximately 75% efficient, and trickle systems are approximately 80%-90% efficient. Thus, moving from an overhead to a micro-jet system can result in water savings of 20%, and moving from an overhead to a trickle irrigation system can save 30%. Costs of conversion of overhead to alternative systems ranges from $1,200 to $1,500 per acre.

Irrigation scheduling:

Irrigation scheduling refers to the use of scientific methods based on measurement of soil moisture to determine when the soil requires water, then applying only the minimum necessary. This method requires the use of a tensiometer (or alternative instrument) for monitoring soil moisture. Irrigators often operate at design capacity all season long, including during the spring when soil moisture is naturally high and crop water demands are low. Accordingly, savings are typically realized in the early part of the irrigation season. These programs are relatively inexpensive to operate, but have the potential to save substantial volumes of water.

Promotion of land use changes, crop selection, and xeriscaping:

Municipalities can promote water-efficient landscaping around commercial, industrial, and institutional developments, and agricultural agencies can promote more water-efficient crops (see examples in Section 11.0). Municipalities can provide incentives and education to developers and residents on xeriscaping and use of native plant species as alternatives to traditional landscaping materials. Brandes and Ferguson (2003) report that a xeriscaped yard typically uses 30% to 80% less water than a conventional yard (and usually saves on fertilizer and herbicides as well). High-density development greatly reduces the need for lawn watering and improves the efficiency of service delivery. Improved pedestrian orientation in developments reduces the need for road pavement. "Low impact development" approaches reduce stormwater runoff volumes, improve runoff quality, recharge aquifers, and reduce servicing costs compared to conventional designs. These measures, taken together, can substantially reduce water demand for domestic use, which is the largest (and growing) component of water use in the TLU.

Recycling and reuse:

Other communities in the Okanagan have implemented water recycling and reuse programs. The City of Vernon recycles all its treated wastewater (it is used for irrigation), and the City of Penticton recycles some of its treated wastewater. Specific industrial and institutional water users that require cooling water may have substantial opportunity to implement water recycling. Many applications, such as irrigation of golf courses, do not require high quality treated water. The Vernon Golf Club uses recycled wastewater for all its irrigation needs. However, opportunities within the TLU should be assessed on a site-specific basis.

Combining water systems:

Water supply systems in the North Okanagan have recently gone through two rounds of amalgamation. In 1995, several local utilities were merged to form the North Okanagan Water Authority (NOWA). In 2003, the City of Vernon and the District of Coldstream were added and a new larger body known as Greater Vernon Water was formed to govern the supply and distribution of water throughout the Greater Vernon area. It is possible that some efficiencies in managing storage and distribution could be achieved in the TLU with a similar approach. The potential for achieving such efficiencies within the TLU should be investigated.

In total, it is estimated that implementation of the first four approaches outlined above (education, meters, effective pricing, and some regulation) could result in 30% overall savings in water use. A residential water use reduction of 30% would reduce per capita usage rates to the equivalent of those in Kelowna and Vernon. Implementation of the other conservation measures recommended above is likely to result in additional savings, potentially reaching 50%. A 50% residential reduction would reduce per capita water usage to about the B.C. average, although it would still exceed the Canadian average.

15.3.5 Improved management activities already underway in the TLU

Some of the large water utilities in the TLU have already initiated studies of their water supply systems, in order to ensure that they can continue to deliver high quality water to their customers well into the future. The Westbank Irrigation District is presently conducting a detailed assessment of both supply-side and demand-side approaches specific to its system. This study is not yet ready for release.

In a previous study conducted for the Lakeview Irrigation District (LID), Reid Crowther (2000) made several recommendations, including:

- raising Big Horn Dam (medium priority),
- constructing the Dunwater's Creek diversion (an interbasin diversion into the Lambly Creek watershed) (medium priority),
- constructing a new dam on Lambly Creek (low priority),
- constructing a booster station on Okanagan Lake (low priority),
- developing and implementing a water efficiency program (meters) (low priority); and
- raising water rates to keep up with inflation (no rating).

It is noteworthy that the metering recommendation was given a low priority, and the recommendation regarding water rates did not include moving to a unit rate based on actual usage. In addition, the price increase recommendation was limited to inflation, despite the fact that LID's rates are among the lowest in British Columbia (and Canada and the world).

Urban Systems (2001) analyzed supply-side and demand-side management approaches for the District of Peachland. As noted above, that report recommended three demand-side approaches be adopted in Peachland:

- education;
- regulations; and

- metering.

In addition, that report recommended several supply-side improvements, notably the interconnection of the three separate water supply systems presently serving the District.

16.0 CONCLUSIONS, RECOMMENDATIONS, AND NEXT STEPS

Phase 1 studies of current conditions have been summarized in Section 12.0, and Phase 2 studies of future conditions have been summarized in Section 14.0. Opportunities for demand-side and supply-side management approaches to deal with existing and future water resource pressures have been outlined in Section 15.0. Conclusions and recommendations for improved water management in the TLU are presented in Section 16.0.

16.1 CONCLUSIONS

On the basis of the analysis of current conditions and of the future pressures on water in the Trepanier Landscape Unit, the following conclusions are drawn:

1. Water agencies and stakeholders have identified many water-related issues in the TLU, which are currently being managed under a wide variety of regulations, goals, objectives, and policies. Analyses of water licences, land use, flows, water quality, and fisheries information confirm that water resources are presently under pressure in the TLU and that there are several barriers to more effective water resource management in the TLU.
2. There are data gaps that should be filled to fully understand water resources and water use in the TLU. Streamflow data is only collected on an ongoing basis on two of the five major streams in the TLU, water licence information is maintained in a complex format that is difficult to use and the data are difficult to interpret, there is virtually no information on rates of groundwater supply or demand or on groundwater quality, and fish conservation flows in some streams may be set unrealistically high because of a lack of actual data on natural historic flows.
3. Flows in the five major streams of the TLU have already been reduced due to offstream withdrawals, by an average of 13%. Streamflows are highly variable from year to year. A 5-year drought year has only 67% of the streamflow of an average year in the Okanagan.
4. Water quality generally meets water quality guidelines (or water quality objectives where they have been set) although exceedances for turbidity, colour, and coliform bacteria (raw water) are not uncommon. However, water quality conditions are such that all major utilities chlorinate their water. There are existing and future threats to water

quality, including recreational use of upland lakes, motorized recreational vehicle impacts on streams, and livestock access to surface water bodies. Though poorly studied in the TLU, experience from other locations suggests that residential, agricultural, and commercial development could affect water quality in stream reaches downstream of the major water supply intakes. These activities could contribute to pollution loads of groundwater and low-elevation stream reaches.

5. Downstream of the major water intakes, streamflows in summer and fall are often lower than recommended “fisheries conservation flows”, suggesting that fisheries impacts have occurred and/or that these conservation flows may be set too high.
6. Total annual offstream water use in the TLU is 24.554 million cubic metres (66% from surface sources, 30% from Okanagan Lake, and 4% from groundwater). Water use is distributed as follows: residential - 41% (36,366 population); agriculture (including golf courses) - 34%; commercial/industrial - 20%, and leakage - 5%. Actual water withdrawn from surface sources is 46% of the total amount licensed for withdrawal. In three of the five principal streams (Lambly, McDougall, Trepanier), neither licensed offstream use nor actual offstream use is fully supported by storage, but in Peachland and Powers Creeks, both licensed and actual offstream use are fully supported by storage.
7. Rates of water use in the TLU are high (residential use averages 789 L/person per day on a year-round basis – about double the B.C. average) and prices are relatively low (residential rates average about 25 cents per cubic metre – less than half the B.C. average). Agricultural and commercial/industrial rates are even cheaper. Effective conservation measures could reduce water use by 30% to 50%.
8. Population in the TLU is forecast to grow from 36,336 in 2001 to 59,937 in 2020 and 97,201 in 2050. Water use in the TLU is expected to grow by 41% by 2020 and 91% by 2050, if it is assumed that the climate does not change over that time period. However, if the effects of climate change currently predicted by computer models are accounted for, total water use in the TLU will increase by 55% by 2020 and 128% by 2050, relative to 2003.
9. In addition to affecting water demand, climate change will also reduce streamflows throughout the TLU. Based on three representative climate models and the UBC Watershed Model (as calibrated for the five major tributary streams of the TLU),

naturalized streamflows will become an average of 15% smaller by 2020, and 35% smaller by 2050.

Specific predictions of the effects of population growth and climate change on streamflows in the five principal streams of the TLU for the years 2020 and 2050 have been made. These predictions make many assumptions, including that future demand is satisfied entirely from tributary sources, and that no changes in management to prevent conflicts takes place. On this basis, the following conclusions are drawn:

10. If potential climate changes are ignored, streamflows in 2020 will be smaller than today due simply to population and economic growth, but the predicted flow reductions will be relatively small. Nevertheless, the flow allocation, fish habitat, and water quality issues that are experienced now will intensify. Conservation flows will not be met in Powers Creek. Streamflows in 2050 will decrease further, resulting in more substantial flow reductions and associated water quality and fisheries impacts, which will be concentrated in Lambly, McDougall, and Powers Creeks.
11. If climate change is accounted for, significant streamflow reductions are expected in all five major creeks by 2020 (averaging 25%) due both to increased demand and reduced supply, resulting in zero flow at some locations for parts of the year in an average year. An average year will be like a 5-year drought year today, and a 5-year drought year will be like a 20-year drought year today. Current licences will not be sufficient to satisfy demand on Powers Creek.
12. These impacts will be even more severe by 2050, when annual flows will be reduced by an average of 56%, resulting in conservation flows not being met at many locations, and zero flow in all creeks for parts of the year. An average year will be like a 20-year drought year today, and a 5-year drought year in 2050 will be like a 50-year drought year today. Current licences will not be sufficient to satisfy demand on Powers and Lambly Creeks.
13. Streamflow impacts will be more severe below than above the intakes of the major water purveyors.
14. If future demands are satisfied from sources other than tributary streams, the predicted impacts on the tributaries will be smaller than indicated here. For example, if

groundwater were developed to its currently estimated capacity, increased use of tributaries and Okanagan Lake could be avoided until about 2020.

15. If the climate does not change, demand management alone to 2020 would allow future demand to be satisfied from tributaries alone, and permit population and economic growth to occur without streamflow reductions relative to 2003, and the associated water quality and fisheries impacts.
16. However, by 2050 (even without climate change), both demand management and alternate supplies will be needed to prevent streamflow reductions and associated environmental impacts.
17. If the climate does change as predicted, augmentation of the water supply will be needed (along with demand management) to prevent streamflow reductions and associated environmental impacts by 2020.

16.2 RECOMMENDATIONS

16.2.1 Relation to Accepted Water Management Goals and Policies

The recommendations presented in this report follow from the analyses and conclusions presented in preceding sections. They are consistent with the goals for water management expressed in the Okanagan Shuswap LRMP, and in the four Official Community Plans that have been developed for TLU communities. For reference, the OSLRMP water-related goals (Section 5.0) are repeated here:

- Manage consumptive and instream uses of the surface and groundwater resource on a sustainable basis;
- Ensure instream flows for fish, fish habitat, and aquatic ecosystems are considered when making water allocations;
- Maintain the integrity of the hydrometric inventory system;
- Achieve and maintain properly functioning conditions of streams including the timing and magnitude of flows;
- Manage for good water quality as indicated by levels of turbidity, temperature, sediments, and contaminants;

- Minimize risk to life and property from floods, erosion, mass wasting, and debris torrents; and
- Maintain the quality and quantity of groundwater.

There are several water management goals expressed in the four OCPs (Section 5.0). These goals have evolved in response to RDCO's Regional Growth Strategy, and relate to:

- Ensuring sustainable water supplies for current and future levels of development;
- Maintenance of water quality in both surface water and groundwater;
- Protecting aquatic habitat in watercourses and riparian areas;
- Regulation of development on floodplains, along watercourses, and in riparian areas;
- Stormwater management; and
- Water conservation.

This report's recommendations are also consistent with the policies relating to water that are contained in the Okanagan Shuswap LRMP and the four OCPs. Tables 5.2 through 5.7 in this report list 74 such policies. Recommendations have not been made in response to each goal or policy. Rather, specific recommendations have been made with respect to the key issues facing the TLU.

Implementation of these recommendations will help the agencies with responsibility for water management in the TLU to implement the goals and policies of the LRMP. They provide a link between the Okanagan-wide policies and goals of the LRMP and the specific conditions of the TLU. They also provide guidance to the OCP process, enabling OCP planners to develop appropriate policies for water management.

It is important to note that recommendations are made at the scale of a "landscape-level" plan. The scope of the plan did not permit analysis at a finer scale of resolution, such as the scale required to examine details of the supply and distribution systems of particular utilities.

16.2.2 Recommendations for Improved Water Management

The following recommendations are made to promote long-term economic and environmental sustainability in the TLU, consistent with existing OCP and LRMP goals and policies. The recommendations are approximately prioritized from high to low, although all of them should be implemented.

Recommendation #1: Demand management

Preamble:

Research conducted during this project has shown that rates of water use greatly exceed the B.C. and National averages, and prices are much lower than elsewhere in B.C. and Canada. There is substantial scope for reducing per capita water use in the TLU. Water conservation makes more efficient use of existing infrastructure and resources, has been shown to be highly cost-effective, and typically reduces environmental impacts associated with securing additional water supply. Demand reduction is recommended as the primary method of meeting future water needs in the TLU.

Recommendations:

Demand-side management approaches for the TLU should be adopted and implemented before 2010. Measures should include at least the following approaches, as described in Section 15.0:

- A minimum water use reduction target should be set;
- Public education programs (to promote water conservation and to encourage changes such as xeriscaping and improvements in irrigation application techniques and irrigation scheduling);
- Universal metering;
- Financial incentives (use of a volume-based rate system and potentially other incentives);
- Ensuring full cost-recovery pricing; and
- Regulations (including requiring water conserving fixtures, restrictions on water use in peak periods).

It is expected that 30% reductions in water demand, which would reduce per capita water use to similar levels to those in Kelowna and Vernon, are attainable in the TLU with these basic approaches. It is recommended that as soon as metering is in place, additional measures (that depend on meters) be implemented:

- Utilities should implement a leak detection program;
- Utilities should conduct water audits to determine locations and amounts of water use and leakage;
- Improvements in irrigation application techniques should continue to be made; and
- A program of irrigation scheduling should be implemented.

Finally, the following measures that do not depend on meters should be implemented:

- Promotion of land use changes. Local governments should encourage developments with lower per capita water use such as multi-family residential vs. large single-family lots, and low impact development designs including xeriscaping and onsite retention and infiltration of stormwater runoff. The low density of development in the TLU, combined with substantial future development potential, provides opportunities for significantly affecting water use and quality through urban design;
- Promotion of crops that require less irrigation, considering the economic implications of this action within and beyond the TLU;
- Implementation of recycling and reuse of wastewater by businesses and jurisdictions; and
- The potential for achieving water supply and distribution efficiencies through combining water systems should be investigated.

Although realizing the benefits of these actions may take years, they can generate substantial reductions in water use. Regardless of the return period, however, such actions should be implemented as soon as possible, and before 2010. Some of the planning changes (such as changes in urban form) generate other secondary benefits, such as reduced vehicle use and road area, and more efficient servicing patterns (for water, power, sewer, drainage, and transportation). Low impact development techniques often accompany new urban forms, reducing runoff peaks and improving the quality of stormwater runoff.

Adoption of all of these conservation measures could result in total water savings near 50%. It is recommended that all of these demand-side approaches be applied throughout the TLU, and adjusted to reflect local conditions and the potential benefit of implementing the identified opportunities.

Recommendation #2: Supply Side Management

Preamble:

Analyses indicate that both supply-side and demand-side management approaches will be needed in the TLU in future to ensure long-term economic development and to maintain streamflows near present levels. Supply-side approaches to water management recommended for the TLU have been outlined in Section 15.0.

Recommendation:

- In order to prevent exacerbation of present-day water management issues and conflicts, development of additional water supplies will likely be necessary by 2020 if climate change is accounted for, and by 2050 if only projected population changes are considered. Since it is likely that the climate is changing, it is recommended that all utilities that rely on surface water sources develop additional water supplies before 2020.

Supply-side management strategies recommended for the TLU include (in approximate chronological order):

- Operational improvements, including achieving operational efficiencies, leakage reduction in the primary conveyance systems, and reductions in system pressure;
- Additions to or development of new upstream storage;
- Pumping from Okanagan Lake; and
- Increased use of groundwater.

Although a great deal of upland storage has already been developed and licensed, there is likely some remaining opportunity to increase storage in upland areas. An assessment of the potential for increases in storage is beyond the scope of this report. Each water utility should evaluate the extent to which additional storage can be developed in the areas under their management. In the short term, increased storage is likely to be the most cost-effective approach to increasing supply. In the longer term, however, tributary storage will become more difficult and costly to develop, and there is a limit to the availability of water from this source.

It is recommended that the province carefully consider any proposed sale of Crown land around upland lakes or storage reservoirs, because private shoreline ownership could constrain the development of increased storage.

Because of limits to the availability of new upland storage, it is recommended that investigation and development of Okanagan Lake and groundwater become higher priorities than they have been in the past. However, current knowledge of groundwater is limited, so large-scale groundwater development should not occur before the resource has been properly evaluated (see Recommendation 8). It is noteworthy that while the use of Okanagan Lake and groundwater to service future demands represents a medium to long-term solution, there is a limit to the use of these alternative supplies. Groundwater-surface water interactions could cause reductions in baseflows in surface streams if groundwater is overused. Also, water use from Okanagan Lake will eventually become significant enough to affect lake levels, which has negative implications for lake water quality and downstream flows. Already it is estimated that consumptive water use (i.e. water that is permanently lost) from the TLU alone represents 2 to 4 cm lost annually from the lake, and with continued economic growth, this figure will rise.

Increased use of tributary flow without upstream storage development, and inter-basin diversions into the TLU are two supply-side options that are not consistent with the goals and policies for water management contained in the Okanagan-Shuswap LRMP, and are thus not recommended for the TLU. Even though Powers and Peachland Creeks may have sufficient storage to support existing offstream use, the detailed scenario output summarized in Section 14.0 indicates that increased withdrawals without additional supporting storage are not recommended on these creeks.

Prior to embarking on supply augmentation programs, it is recommended that each of the three major water utilities in the TLU that obtain water from surface sources conduct detailed analyses, specific to their particular water supply system, of future supply-side and demand-side management options, including analyses of costs and benefits, and determine which of the demand or supply options described in this report are most appropriate for implementation.

It is recommended that RDCO assist the smaller water utilities with similar utility-specific analyses to determine the optimal adaptation approach in each case. Many of these smaller utilities obtain water directly from Okanagan Lake, so detailed analyses of alternative sources of supply is not likely necessary. However, analyses of demand reduction strategies will be relevant to these utilities. Utilities using lake water may need to be convinced of the merits of demand reduction.

In summary, the technical analyses presented in this report indicate that both augmentation of water supply and reduction in water demand will be needed in order to ensure economic development and maintenance of environmental quality in the Trepanier Landscape Unit in the future. Demand management should be the first priority. If it is assumed that the climate is not changing, both approaches will be needed by 2050. If it is assumed that the climate is changing, both approaches will be needed by 2020. <u>We recommend that demand management be implemented by 2010, and that additional water supplies be developed as a second priority by 2020.</u>

<u>Recommendation #3: Surface Water Allocation</u>

Recommendation:

If current licences for offstream use were fully utilized, water withdrawals from surface sources would exceed those in Scenario 2.2 (year 2050, assuming climate change takes place) by 10.2 million m^3 per year, or 18%. Therefore, it is recommended that, despite the fact that there is room available within the scope of existing licences for additional withdrawals from the major tributaries, no increases to offstream withdrawals should be made without an equivalent increase in upstream storage to support the withdrawal.

It is recommended that future requests for surface water licences be considered in light of the detailed analyses presented in this report for each of the five major tributaries. In particular, it is recommended that no additional licences for water withdrawal from these watersheds be issued without an accompanying licence for upstream storage development, consistent with current practice. Applications for water licences from any surface stream in the TLU should be accompanied by proof that all reasonable alternatives have been pursued for obtaining water from already licensed sources, and that demand management measures are incapable of meeting the water requirements of the applicant.

Recommendation #4: Protection of Water Quality

Preamble:

The future changes in streamflows that are described in this report will have negative implications for water quality. In addition, there is concern about current plans by the province to sell Crown land along the shorelines of upland lakes and reservoirs, which could result in development pressures and associated water quality impacts. In urban areas, increased urbanization will have implications for hydrologic response and water quality.

Recommendation:

It is recommended that appropriate effort be directed at protecting water quality on both Crown Land and private land by the appropriate agencies. On Crown Land, this may take the form of source assessments under the *Drinking Water Protection Act*, potentially followed by Drinking Water Protection Plans. On private land, this could take the form of measures to control development in order to minimize development impacts on hydrologic response and water quality.

Recommendation #5: Protection of Streamside Corridors

Preamble:

The future changes in streamflows that are described in this report will result in additional impacts on aquatic ecosystems, including fish habitat. In order to prevent additional impacts related to disturbance of riparian and floodplain areas, it will become increasingly important that these areas be protected.

Recommendation:

It is recommended that the appropriate agencies ensure that sufficient protection is provided to streamside areas within the TLU to maintain the functioning of riparian and floodplain processes at adequate levels, and minimize the negative impacts to the aquatic ecosystem that will be associated with reduced future streamflows.

16.2.3 Recommendations for Information Needs

Each of the above water management recommendations should be implemented without waiting for additional data or information. However, there are several issues with respect to data and information in the TLU. In some cases, data gaps exist, and in some cases where data are available, the format of the data does not readily permit analysis. Relevant data exists in many locations, is held by many different agencies, and exists in a variety of formats. The following recommendations are made to improve the quality and quantity of the data available in the TLU for making water management decisions. They are organized approximately in order of priority. They are all important, and it is recommended that they all be implemented before 2010.

Recommendation #6: Water Licence Information System

Preamble:

Water licence data is currently maintained in a complex format that is often difficult to interpret, particularly where multiple licences or points-of-diversion are concerned. The method of querying licence data (particularly for large areas) is cumbersome, but it is currently available on-line or upon request from MSRM (Water Licence Information System output). Only the Water Licence Information System query has the ability to compile licences above a point within the stream network, however, it does not necessarily identify all licences (particularly those on springs). The online request cannot identify all licences upstream of a particular point.

Recommendation:

A thorough examination of the Water Licence Information System is recommended in order to identify improvements for access and querying. A map and database (GIS) approach should be pursued, in which a user could easily identify existing water licences upstream of a particular location on a stream network. In order to facilitate analysis, metric units should be adopted. At a minimum, metric units should be provided along with traditionally used (non-metric) units.

The Provincial government should become more proactive in cancelling licences that are no longer in use, so that water managers will be able to more easily identify currently active instream and offstream licences.

Recommendation #7: Measurement of Water Use

Preamble:

Records of actual volumes of water removed from surface sources, Okanagan Lake, and groundwater are either not available at all, or are not readily available. Only the major water utilities maintain records of their actual water withdrawals. Assumptions have been made in this report to estimate water use by the minor utilities. Therefore total water use in the TLU cannot be determined precisely. Second, because most TLU water customers are not metered, the water used by each customer is not known. Water meters would provide very useful information to confirm the assessment of water use presented in this report, and to support future water management planning decisions. Meters would have other benefits, including assisting with future conservation initiatives, as described in Section 15.0.

Recommendations:

- It is recommended that all water utilities in the TLU measure their rate of water withdrawal from primary sources (surface streams, Okanagan Lake, and groundwater).
- It is recommended that customers of each of the water utilities in the TLU be metered, whether the water source is tributaries, groundwater, or Okanagan Lake. Meters are most urgent where customers are supplied from tributary sources.

- It is recommended that water utilities conduct an audit or survey of water withdrawal rates, and indoor and outdoor use among their residential and commercial customers after a one or two year period. Such information can guide conservation programs, water pricing decisions, and public education messages. This information can also be used to update the estimates of water use and other analyses presented in this report.

Recommendation #8: Groundwater

Preamble:

There is no legislation or policy relating to groundwater use in British Columbia. Consequently, there is very little reliable information on groundwater quantity and quality in the TLU. The groundwater use and extraction information reported herein has been inferred based on a variety of sources of unknown accuracy. Although the groundwater resource appears to be under utilized, further examination of groundwater conditions is recommended prior to significant additional groundwater development.

Recommendations:

The following recommendations are made:

- Improvements in groundwater management depend on obtaining improved groundwater inventory and use information. It is recommended that the Provincial government enact legislation to regulate groundwater use in British Columbia – including establishing standards for well construction, and requiring reporting of relevant information, including yields;
- It is recommended that (even in the absence of provincial legislation) RDCO, Peachland, and the Westbank First Nation implement a program of voluntary provision of groundwater information. Owners of selected properties in the TLU would be asked to allow monitoring of well yields, water table depth, water use, and water quality. The costs of such a program could be covered by the provincial government, and the results would be used to better understand and assess groundwater resources and use in the TLU.
- Aquifer mapping, based on surficial geology mapping, anecdotal evidence and limited field mapping, should be considered for the upland areas of the TLU;

- Detailed hydrogeological data and information should be generated for the six identified aquifers so detailed assessments of aquifer yield and sustainability can be completed. Information for this task would be obtained from the voluntary monitoring program and from other sources;
- Detailed aquifer vulnerability mapping that considers land use, zoning and levels and types of development should be considered for the six identified aquifers; and
- The need for wellhead protection plans and groundwater protection areas should be assessed, based on the results of the updated vulnerability mapping and the monitoring program.

Recommendation #9: Streamflow Inventory

Preamble:

Currently only two hydrometric stations are active in the TLU. Given the increasing demand for water in the TLU, it is becoming increasingly important to have access to the best possible hydrologic data to support operational water management. The flow estimates presented in this report have made use of some assumptions and approximations made necessary because of a lack of current stream-specific data.

Recommendations:

- In order to reduce reliance on regional flow estimation, it is recommended that hydrometric stations be re-established in all five major watersheds of the TLU, at least near the mouths of each stream, and also preferably above major intake locations and below major storage reservoirs.
- Ensure flows in all significant municipal and irrigation diversions are monitored - at least those of the Westbank and Lakeview Irrigation Districts and the District Municipality of Peachland;
- All data collection in the TLU should be managed by a single agency, which would disseminate the information to all stakeholders.

Recommendation #10: Water Quality

Preamble:

Although considerable water quality data has been collected in the TLU since the 1970s, not all of it has been entered into the provincial EMS database or another central database. This makes it difficult to assess how frequently and how severely either natural or human-caused processes have compromised water quality. MWLAP is, however, expected to produce water quality assessment and objectives reports on Trepanier, Lambly, Powers, and Peachland Creeks in 2004, which should help to clarify the status of water quality in the TLU.

The inventory program that compiled the data for the forthcoming MWLAP reports is no longer operating. With the proclamation of the *Drinking Water Protection Act* and Regulation in 2003 the water purveyors in the TLU are required to monitor water quality and report the results to the public on an annual basis. The *Act*, however, only requires that they sample for total coliform bacteria and fecal coliform bacteria (*E. coli*.). The Drinking Water Officer may require that other parameters also be monitored. In the case of the TLU, data for other water quality parameters are needed to interpret the coliform data (e.g. questions about the relation between high bacteria counts and high turbidity) and to assess potential effects of land use on water quality. In addition, the monitoring programs must be carefully designed to ensure that the data can be used to evaluate trends, assess impacts of existing or new land uses or point-sources, and/or determine compliance with legislation or water quality objectives.

Recommendations:

The following recommendations are made to further the existing understanding of water quality and to provide the information needed to manage water sources in the future:

- RDCO, water utilities, and other water agencies and stakeholders should review the forthcoming water quality assessment reports from MWLAP, including the basis for any new Water Quality Objectives that are set;
- MWLAP should update the EMS database to include the recent MWLAP data and any other available data (e.g. data collected by water purveyors, Noranda, or Riverside);

- Water quality monitoring should continue in all the water supply watersheds, and the list of monitoring parameters should be expanded beyond the minimum requirements in the *Drinking Water Protection Act*. The list and sampling schedule should be customized for each stream depending on uses (e.g. drinking water or aquatic life), but should include at least turbidity and/or total suspended solids, total dissolved solids, pH, water temperature, and true colour (or another measure of organic carbon). Sampling for metals, nutrients, parasites (e.g. *Cryptospridium parvum*), trihalomethanes, or other parameters will be of value at some sites.
- The monitoring should take place at the water intakes (in addition to whatever sampling within the system that the water utilities conduct). If additional sampling sites are considered beneficial they would ideally be located at the sites of any new hydrometric stations because flow data assists in data interpretation.
- Future water quality monitoring programs should be designed carefully to ensure that the goals of the program are well understood and can be achieved. A specialist in statistical study design should be consulted early in the design process.
- Opportunities for cost sharing of the monitoring should be explored among the water utilities, forest licensees, RDCO, Interior Health Authority, and other stakeholders, and all stakeholders should be involved in development of the study design.

Recommendation #11: Fish Conservation Flows

Preamble:

Flows necessary to sustain fish populations in TLU streams have been evaluated and discussed by a variety of stakeholders in recent years.

Recommendations:

The following recommendations are made to advance the process of setting conservation flows in TLU tributaries:

- Consider adopting conservation flows that vary depending on the naturalized flows (i.e., flows without water storage, release, or diversion) in any given year, i.e. are not intended to preserve "optimal" conditions at all times. In particular, during low-flow periods, conservation flows should be no greater than the total naturalized flows available.

Sufficient information should be collected on habitat-flow relationships to enable explicit evaluation of the implications of managing flow on this basis.

However, if an approach based on preserving "optimal" conditions for fish is selected:

- Complete field assessments of fish habitat-flow relationships in order to calibrate the conservation flow recommendations. The assessments should concentrate on the nature of the relationship at flows near the range of reasonable conservation flows, as determining the shape of the curve in this flow range is critical.
- Determine whether conservation flows in those sections of channel not containing kokanee can reasonably be reduced during the fall/winter months from the proposed universal conservation flows, keeping in mind that rainbow trout require sufficient flows for over-wintering.
- Careful consideration should be given to determining which life history stage is most limiting to each fish population, then structuring conservation flows accordingly. Additionally, it should be confirmed that flow is the primary controlling factor for each population, as opposed to temperature or another factor that may be beyond the influence of water managers.
- Incorporate water temperature moderation into future conservation flows, if there is evidence that this is a key fish production bottleneck in the streams of interest.
- Finally, it is recommended that once conservation flow discussions have been concluded, instream licences should be issued for these amounts, to ensure that instream uses are legally protected. Even though these licences will rank low in terms of priority, they will provide more protection than if there was no licence in place. In addition, such licences could facilitate use of the Fish Protection Act to ensure conservation flows are maintained.

Recommendation #12: Water Information Accessibility

Preamble:

Review of the above-noted recommendations suggests a need for improved access to water-related technical information. The first comprehensive water management study conducted in the Okanagan (the Okanagan Basin Study) recommended establishing a central data clearing house. A more recent study (Summit, 2000) recommended the same thing - an "information clearinghouse" for Okanagan water-related data. Although little was done about the 1974 recommendations, the B.C. Freshwater Institute at Okanagan University College has recently begun to develop a system for making Okanagan water-related data more readily available to researchers, agencies, and the public.

Recommendation:

It is recommended that an Okanagan water information clearinghouse be developed, and that local and provincial agencies with water-related mandates in the TLU support such an initiative.

16.3 NEXT STEPS

The analyses conducted in support of the Trepanier Landscape Unit water management plan indicate very specifically where and by how much streamflows in the TLU will be affected in future. Recommendations have been made to mitigate these impacts, beginning with substantial reductions in water demand beginning before 2010, and including development of alternative water sources beginning before 2020. Failure to change rates of water use or seek alternative water sources will either constrain economic growth or impair environmental resource values, or both.

The recommended next steps are as follows:

- creation of a leadership group that will champion the cause of improved water management and encourage adoption and implementation of the recommendations presented in this report;
- holding stakeholder and public consultations to agree on goals, strategies, and action items, using the recommendations of this report as a starting point;
- creation of a water management implementation plan; and
- implementation of improved water management actions using a variety of existing mechanisms.

These points are outlined in more detail below.

1: Establish a leadership group

It is recommended that a Water Management Advancement Team be established as a strategic alliance of key stakeholders to administer the water management plan and champion improved water management in the TLU. The group could be lead by RDCO or another of the members of the Steering Committee created for the present plan, or another body, and would consist of a cross-section of agencies with a mandate to manage water in the TLU. The Water Management Advancement Team could be formally established under an existing mechanism (such as RDCO or the Okanagan Basin Water Board). It would work to improve water management in the TLU, foster the development of partnerships as needed to implement recommendations, seek funding to complete technical studies, oversee technical studies, conduct monitoring and data management, ensure access to data, and coordinate educational programs.

2: Hold stakeholder and public consultations and develop an implementation plan

It is recommended that the recommendations contained herein be used as a basis for development of a water management implementation plan for the TLU. The implementation plan would include broader stakeholder consultation than has been possible in the course of the present project, and seek agreement on key goals for water management in the TLU among key stakeholders. The water management implementation plan should contain, at a minimum:

- water management goals and policies;
- priorities among action items;
- targets for water conservation and quality;
- assigned responsibilities for implementing plan elements;
- schedules to ensure timely attainment of targets and implementation of identified actions; and
- budgets for action items, including statements of cost-effectiveness and identification of sources of funding.

3: Implement improved water management

Once a water management implementation plan has been adopted for the TLU, it is recommended that management recommendations be adopted as appropriate into Official Community Plans and servicing bylaws, Water Use Plans, Drinking Water Protection Plans, and specific management objectives for community watersheds under the Forest and Range Practices Act.

Firm commitments need to be gained for the water management implementation plan and its elements in associated plans and bylaws. Once committed, the responsible agencies need to be accountable for implementation. The Water Management Advancement Team can aid in plan implementation and finding solutions that are acceptable to water managers, purveyors, and users.

17.0 REFERENCES

Agriculture and Agri-Food Canada. 2003a. Digital map coverage of current agriculture by crop type. Provided by G. Frank (Summerland Research Station) on July 31, 2003.

Agriculture and Agri-Food Canada. 2003b. Digital files presenting water demand by crop for the Okanagan. Provided by W. Koch (Summerland Research Station) in December 2003.

Brandes, O.M. and K. Ferguson. 2003. Flushing the Future? Examining urban water use in Canada. A report by the POLIS Project on Ecological Governance, University of Victoria, Victoria, B.C.

Bender, J. 2004. Personal communication with P. Rotheisler of Summit on June 14, 2004. Technical Officer, Land and Water B.C., Penticton.

City of Kelowna. 2003. Environmental Indicators – Monitoring Trends in the City of Kelowna. City of Kelowna website: www.city.kelowna.bc.ca. Viewed October 6, 2003.

Canada – British Columbia Okanagan Basis Agreement. 1974. Fisheries and Wildlife in the Okanagan Basin – Technical Supplement IX to the Final Report. Office of the Study Director, March 1974.

Casa Loma Water Utilities (Casa Loma). 2003. Information Sheet on Casa Loma Water Utilities Management.

Cohen, S. and Kulkarni, T. (editors). 2001. Water Management and Climate Change in the Okanagan Basin. Environment Canada and University of British Columbia, 75 p.

Cohen, S. and Neale, T. (editors). 2003. Expanding the Dialogue on Climate Change & Water Management in the Okanagan Basin, British Columbia, Interim Report, 150 p.

Coulson, C.H. and W. Obedkoff. 1998. British Columbia Streamflow Inventory. Water Inventory Section. Resource Inventory Branch. Ministry of Environment, Lands and Parks. March 1998.

Curran, D. 2003a. A Case for Smart Growth. West Coast Environmental Law Foundation. Vancouver, B.C.

Curran, D. 2003b. Smart Bylaws - Summary. West Coast Environmental Law Foundation. Vancouver, B.C.

Dalhuisen, deGroot, and Nijkamp. 2001. Thematic Report on the Economics of Water in Metropolitan Areas, April 2001.

District of Peachland. 2003. Water Rates Bylaw #1669. Feb. 11, 2003.

Dobson Engineering Ltd. (Dobson). 1990a. Lambly (Bear) Creek – Assessment of alternatives to enhance Okanagan Lake fishery. Consultant's report prepared for Ministry of Environment, Penticton, B.C.

Dobson Engineering Ltd. (Dobson). 1990b. Powers Creek – Assessment of alternatives to enhance Okanagan Lake fishery. Consultant's report prepared for Ministry of Environment, Penticton, B.C.

Dobson Engineering Ltd. (Dobson). 1990c. Trepanier Creek – Assessment of alternatives to enhance Okanagan Lake fishery. Consultant's report prepared for Ministry of Environment, Penticton, B.C.

Dobson Engineering Ltd. (Dobson). 1998. Watershed Assessment Report for the Trepanier Creek Watershed. Prepared for Gorman Brothers Lumber Ltd.

Dobson Engineering Ltd. (Dobson). 1999. Interior Watershed Assessment for the Peachland Creek watershed (Penticton Forest District). Prepared for Riverside Forest Products Ltd. (Kelowna Division)

Dobson Engineering Ltd. (Dobson). 2001a. 2001 Interior Watershed Assessment Update for the Lambly Creek Watershed (Penticton Forest District). Prepared for Riverside Forest Products Ltd. and the Small Business Forest Enterprise Program (Penticton).

Dobson Engineering Ltd. (Dobson). 2001b. 2001 Interior Watershed Assessment Update for the Powers Creek Watershed (Penticton Forest District). Prepared for Riverside Forest Products Ltd, the Small Business Forest Enterprise Program (Penticton), and Gorman Brothers Lumber Ltd.

Dobson Engineering Ltd. (Dobson). 2002. Westbank Irrigation District Dam Manuals.

EBA Engineering Ltd. (EBA) 2000. Central Okanagan Growth Management Strategy Aggregate Supply and Demand Study. Prepared for RDCO, District of Lake Country, District of Peachland, and City of Kelowna.

Earth Tech Canada Inc. 2003. Letter report to District of Summerland re Environment Canada Conservation Research Report. January 8, 2003.

Economic Development Commission. 2000. Peachland Economic Profile 2000. Volume 3. Issue 2. Kelowna, B.C.

Economic Development Commission (EDC), Regional District of the Central Okanagan. 2003. Population Projections for the Central Okanagan. http://www.edccord.com/economic/pop_proj.htm.

Einarson, D. 2003. Personal communication. Impact Assessment Biologist, Ministry of Water, Land & Air Protection. Kamloops. December 11, 2003.

Environment Canada. 1977. Temperature observations at Station 08NM157 (Powers Creek at the Mouth).

Environment Canada. 2001. Municipal Water Pricing 1991-1999. Environmental Economics Branch. Ottawa.

Environment Canada. 2003. Climate normals for 1971-2000. Online data at http://www.msc-smc.ec.gc.ca/climate/climate_normals_1990/index_e.cfm

Environment Canada. 2004. Threats to Water Availability in Canada. NWRI Scientific Assessment Report Series No. 3 and ACSD Science Assessment Series No. 1. National Water Research Institute. Burlington, Ontario. 128p.

Frank, G. 2003. Agricultural land use in the Trepanier Creek area. Digital shape file provided by e-mail on July 29, 2003. Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, B.C.

Galbraith, D.M. and G.D. Taylor. 1969. Fish habitat survey: Okanagan tributary streams, 1969. Unpublished manuscripts. Fish and Wildlife Branch, Victoria, B.C. 190 p.

Gleik, P. 2000. The Changing Water Paradigm A Look at Twenty-First Century Water Resource Development. International Water Resources Association, 25 (1), p. 129.

Golder Associated Ltd. (Golder). 1992. Final Report to Central Okanagan Regional District c/o Urban Systems Ltd. on Glenrosa Drainage Study, Westbank, B.C. July 3, 1992.

Hamlet, A.F. and Lettenmaier, D.P. 1999. Effects of climate change on hydrology and water resources in the Columbia River Basin. Journal of the American Water Resources Association. 35: 1597-1624.

Inkster, G. 1992. Habitat inventory of McDougall Creek. Natural Resources Team, Westbank Indian Band. Prepared for Westbank Indian Band, Ministry of Environment, Lands and Parks, and Ministry of Aboriginal Affairs.

Jamieson, B. 2003a. Personal communication between B.Jamieson, Manager of Westbank Irrigation District, and D. Hayward of Summit. February 11, 2003.

Jamieson, B. 2003b. Personal communication between B. Jamieson, Manager of Westbank Irrigation District, and L. Uunila of Summit. September 2003.

Jamieson, B. 2003c. Personal communication between B. Jamieson, Manager of Westbank Irrigation District, and B. Guy of Summit. September 2003.

Jarman, P. 1999. Setting site-specific receiving water quality standards for molybdenum at Brenda Mine. In: Molybdenum Issues in Reclamation. W. Price, B. Hart, and C. Howell (eds.) Proceedings of the 1999 Workshop. B.C. Committee on Molybdenum Issues in Reclamation and B.C. Technical & Research Committee on Reclamation. Kamloops, p. 108-119.

Jeffery, T. 2003a. Water use records, Lakeview Irrigation District, Administrator.

Jeffery, T. 2003b. Personal communication with B. Guy of Summit on October 17, 2003. Lakeview Irrigation District Administrator.

Jenkins, M., J. Lund and R. Howitt. 2001. Economic Losses for Urban Water Scarcity in California.

Jensen, V. 1999. Trends in nutrients, water clarity, and phytoplankton in Okanagan and Kalamalka Lakes, 1969-1998. In: Okanagan Lake Action Plan Year 3 (1998) Report. Fisheries Project Report #RD 78. Ministry of Fisheries. p. 127-160.

J. Paul and Associates et. al. 1998. Okanagan-Shuswap LRMP Area Socio-economic and Environmental Profile Draft. Prepared for the Okanagan-Shuswap LRMP Planning Table. (J. Paul and Associates Inc.; Robinson Consulting Associates Ltd.; Keystone Wildlife Research; The ARA Consulting Group Inc.; Economics Branch, Ministry of Employment and Investment; OSLRMP Interagency Support Team; OSLRMP Process Support Team).

Kellow, R. 1970. The Study of Water Use in Single Dwelling Residences in the City of Calgary, Alberta. Edmonton: University of Alberta, Department of Economics and Rural Sociology. Unpublished Master's Thesis.

Kirk, R.J. 2000. Physical and chemical limnology. Okanagan Lake. In: Okanagan Lake Action Plan Year 4 (1999) Report. Fisheries Project Report #RD 83. Ministry of Fisheries. p. 80-104.

Knight and Piesold Ltd. 1981. Westside Water Committee report on Development of an overall water supply plan for the Westside area. Prepared for the Westbank Irrigation District. February 1981.

Koch, W. 2003. Okanagan crop water demand model data. Digital copy of spreadsheet provided by e-mail on December 17, 2003. Agriculture and Agri-Food Canada, Pacific Agri-Food Research Centre, Summerland, B.C.

Koshinsky, G.D. and T.J. Willcocks. 1973. Fishery Potentials in the Okanagan Basin – Task 66D, Canada-BC Okanagan Basin Agreement. Report prepared by Environment Canada, Fisheries Service, Winnipeg for Okanagan Study Commission, Penticton. 198 p.

Land and Water B.C. Inc. (LWBC). 2002. Information Sheet: Water Rights in British Columbia. June 27, 2002.

Letvak, D.B. 1980. Annual runoff estimates for west side of Okanagan Valley. Memo to File 0256957. Ministry of Environment, Lands and Parks. July 21, 1980.

Maas, T. 2003. What the Experts Think: Understanding Urban Water Demand Management in Canada. POLIS Project on Ecological Governance. Victoria, B.C. December 2003.

Mallow, Travis. Email on water consumption. MAFF (Ministry of Agriculture, Food and Fisheries). 2003.

Miles, E.L., Hamlet, A.F., Snover, A.K., Callahan, B., and Fluharty, D. 2000. Pacific Northwest regional assessment: the impacts of climate variability and climate change on the water resources of the Columbia River Basin. Journal of the American Water Resources Association. 36: 399-420.

Ministry of Environment, Lands and Parks. 1998. Hydrologic zones of B.C. Map.

Ministry of Sustainable Resource Management (MSRM). 2003a. Database of licensed withdrawals from points of diversion in the TLU.

Mote, P. et. al. 1999. Impacts of Climate Variability and Change – Pacific Northwest. A report of the Pacific Northwest regional assessment group for the U.S. Global Change Research Program. The JISAO/SMA Climate Impacts Group, JISAO Contribution #715, University of Washington, Seattle, 109 p.

Neilsen, D., Smith, S., Koch, W., Frank, G., Hall, J., and Parchomchuck, P. 2001. Impact of climate change on crop water demand and crop suitability in the Okanagan Valley, B.C. Technical Bulletin 01-15. Pacific Agri-food Research Centre, Summerland, B.C. 32 p.

Northwest Hydraulic Consultants (NHC). 2003a. Lambly Creek Stream Summary (draft). Prepared for B.C. Fisheries (Fisheries Management Branch).

Northwest Hydraulic Consultants (NHC). 2003b. Powers Creek Stream Summary (draft). Prepared for B.C. Fisheries (Fisheries Management Branch).

Northwest Hydraulic Consultants (NHC). 2003c. Trepanier Creek Stream Summary (draft). Prepared for B.C. Fisheries (Fisheries Management Branch).

Northwest Hydraulic Consultants (NHC). 2003d. Peachland Creek Stream Summary (draft). Prepared for B.C. Fisheries (Fisheries Management Branch).

Nyvall, T.J. and T. Van der Gulik. 2000. The South-East Kelowna Irrigation District Demand Management Project. Report prepared for B.C. Ministry of Agriculture, Food, and Fisheries, Resource Management Branch. June 2000.

Obedkoff, W. 1998. Streamflow in the Southern Interior Region. Water Inventory Section. Resource Inventory Branch. Ministry of Environment, Lands and Parks. December 1998.

Obedkoff, W. 2000. Interior Community Watershed Streamflow Inventory. Water Inventory Section, Resources Inventory Branch, Ministry of Environment, Lands and Parks. March 2000.

Phippen, Burke. 2001. The effects of recreation on drinking water quality within the Lambly, Kelowna and Mission Creek watersheds, Kelowna, British Columbia 2000. BWP Consulting, Prepared for British Columbia Ministry of Environment, Lands and Parks by BWP Consulting. May 2001.

Reid Crowther and Partners Ltd. 2000. Lakeview Irrigation District – 2000 Capital Expenditure Charge Bylaw Update. Report prepared for the Lakeview Irrigation District. February 2000.

Regional District of Central Okanagan (RDCO). 2003a. Information sheets on the Westbank First Nation Water System; Killiney Beach Water System; Pritchard Water System; West Kelowna Estates Water System; Star Place Water System; and Westshore Water System.

Regional District of Central Okanagan (RDCO). 2003b. Digital files summarizing community populations within the Trepanier Landscape Unit (based on various sources). June 2003.

Rescan Consultants Inc. 1992. Assessment of rainbow trout populations in the lower reaches of Peachland and Trepanier Creeks. Consultants report prepared for Brenda Mines Ltd., Peachland, B.C.

Roach, R., V. Huynh, and S. Dobson. 2004. Drop by Drop – Urban Water Conservation Practices in Western Canada. Western Cities Report #29. Canada West Foundation. February 2004.

Rood, K. 2001. Hydrology, water use and conservation flows for kokanee salmon and rainbow trout in the Okanagan Lake basin, B.C. Prepared for B.C Fisheries (Fisheries Management Branch). August 2001.

Rouck, K. 2003. Email from K. Rouck of Gorman Bros. Ltd. to B. Guy of Summit Environmental Consultants Ltd. dated December 18, 2003.

Shepherd, B.G. and R. Ptolemy. 1999. Flows for fish: Requirements of Okanagan Lake Tributaries. Ministry of Environment, Lands and Parks and Ministry of Fisheries. Draft Fisheries Project Report.

Stroiazzo, J. 1999. Molybdenum treatment and water management at Brenda Mines. In: Molybdenum Issues in Reclamation. W. Price, B. Hart, and C. Howell (eds.) Proceedings of the 1999 Workshop. B.C. Committee on Molybdenum Issues in Reclamation and B.C. Technical & Research Committee on Reclamation. Kamloops, p. 96-107.

Summit Environmental Consultants Ltd. (Summit). 1996. Final Report Watershed Restoration Program McDougall Creek Watershed Assessment. Prepared for Heartland Economics Ltd. and Westbank First Nation.

Summit Environmental Consultants Ltd. (Summit). 2000. Review of Water Stewardship in the Okanagan Valley. Report prepared for the Okanagan Basin Water Board. February 2000.

Swain, L. 1990. Water Quality Assessment and Objectives, Okanagan Area, tributaries to Okanagan Lake (Peachland, Trepanier, Westbank, Faulkner, and Lambly Creeks). Technical Appendix. Water Management Branch, Ministry of Environment. Victoria.

Swain, L. 1992. Ambient Water Quality Objectives for the tributaries to Okanagan Lake neat Westbank: Overview Report. Water Management Branch, Ministry of Environment, Lands & Parks. Victoria.

Tate, D. and D. Lacelle. 1995. Municipal Water Rates in Canada: Current Practices and Prices, 1991. Prepared Social Science Series No. 30.

Tempelman-Kluit, D.J. 1989. Geology, Penticton, British Columbia; Geological Survey of Canada, Map 1736A, scale 1:250,000.

Grant Thornton. 2003. Central Okanagan Crown Land Tourism and Commercial Recreation Opportunity Study. Prepared for the Central Okanagan Regional District and the Province of British Columbia.

Tredger, C.D. 1987. Investigation of kokanee enhancement opportunities in Okanagan Lake tributary streams. Ministry of Environment and Parks, Recreational Fisheries Branch, Victoria, B.C. 81 p.

Tredger, C.D. 1988. Okanagan Lake tributary assessment: progress in 1987. Fisheries Project Report No. FAIU-10. Ministry of Environment, Recreational Fisheries Branch, Victoria, B.C.

Tredger, C.D. 1989. Okanagan Lake tributary assessment: progress in 1988. Fisheries Project Report No. FAIU-15. Ministry of Environment, Recreational Fisheries Branch, Victoria, B.C.

Tredger, C.D. and J.C. Wightman. 1988. Assessment of Powers Creek rainbow trout carrying capacity (August 1979). Fisheries Assessment and Improvement Unit, Recreational Fisheries Branch, Ministry of Environment and Parks, Victoria, B.C.

University of British Columbia (UBC). 1997. Integrated watershed management. Institute for Resources and the Environment, in collaboration with the Centre for Continuing Studies. Vancouver, B.C.

UMA Engineering (UMA). 1992. Lakeview Irrigation District - Big Horn Dam Site Selection Studies. Prepared for Lakeview Irrigation District.

Urban Systems Ltd. 1999. Regional District of Central Okanagan Population and Employment Projections – 2018. Prepared for the Regional District of Central Okanagan. July 1999.

Urban Systems Ltd. 2001. Water Supply and Demand Review, District of Peachland. March 2001.

Urban Systems Ltd. 2002. Regional District of Central Okanagan Development Cost Charge Analysis Draft Report – August 2002. Prepared for the Regional District of Central Okanagan.

Valentine, K.W.G., P.N. Sprout, T.E. Baker, and L.M. Lavkulich. 1981. The Soil Landscapes of British Columbia. Agriculture Canada and B.C. Ministry of Environment.

Westbank First Nation (WFN). 2003. Summary of water supply system for I.R. #9 and #10. August 6, 2003.

Westbank Irrigation District. (WID). 2002. Drinking Water Quality Program Annual Report.

Westbank Irrigation District. 2003a. Frequently asked questions about water quality issues. Westbank.

Westbank Irrigation District. 2003b. Drinking Water Quality Program: Annual Report 2002. Westbank.

Wightman, J.C. and G.D. Taylor. 1978. Overview and rating of production capabilities and enhancement opportunities for rainbow trout and kokanee in tributaries to upper Okanagan basin lakes. Fish Habitat improvement Section, Fish and Wildlife Branch, Ministry of Recreation and Conservation, Victoria, B.C.

18.0 GLOSSARY AND ACRONYMS

Active floodplain	Any level area with alluvial soils, adjacent to a stream, which is flooded by water on a periodic basis (more frequently than one year in 5).
Acre-foot	A unit of volume with dimensions of one acre by one foot.
Actual offstream use	The rate of actual water withdrawal for offstream purposes.
Actual evapotranspiration	See *Potential evapotranspiration*.
Agricultural Land Reserve (ALR)	Areas of the province where soils have moderate and high capability to support agricultural production, and have been formally classified as such, and are formally protected from other forms of land use.
Alluvial	Adjective used to describe sediments that have been transported by water.
Alluvial material	Material transported and deposited by running water.
Anadromous fish	Fish that are hatched in freshwater, grow to maturity at sea and then return to their natal stream to spawn.
Annual maximum daily discharge	The highest daily discharge in a stream recorded over a period of one year.
Anthropogenic	Adjective describing actions caused by human activity.
Biogeoclimatic zone	A geographic area having characteristic vegetation with associated climate, soils and animals. In British Columbia, each forested zone occurs under a broadly similar macro-climate and is usually named by one or more of the dominant tree species which are capable of self-regeneration on most of the zone's habitats (e.g., Coastal Western Hemlock, Interior Douglas fir). In B.C., the biogeoclimatic zones are further subdivided into sub-zones, variants, and phases.
Coefficient of variation	Standard deviation divided by the mean
Conservation flow	The rate of flow required for the protection of aquatic resources.
Cubic metres per second	The units used to report streamflow, which is a term that has the dimensions of volume per unit of time
Cubic decameter	A unit of volume with dimensions 10 m by 10 m by 10 m.
DFO	Fisheries and Oceans Canada
Discharge	Rate of fluid flow expressed as a volume per unit of time (e.g. cubic metres per second)
Distribution system losses	The difference between the quantity of water withdrawn from a source to the quantity that actually reaches end users, caused by leakage in the water distribution network.
Domestic water use	See Residential Water Use.

ECA	Equivalent Clear-cut Area. The total area clearcut reduced by an amount that accounts for the hydrologic effects of forest regrowth.
Evaporation	The process by which liquid water is converted to water vapour.
Evapotranspiration	The combined processes of evaporation and transpiration. They are frequently combined since it is difficult to sort them out in a field situation.
Fish stream	A stream or portion of a stream that is frequented by any life stage of anadromous salmonids, game fish, identified threatened or endangered fish, or regionally important fish as determined by authorized MOF or MOELP personnel.
Fisheries-sensitive zone	Includes side and back channels, ponds, swamps, seasonally flooded depressions, lake littoral zones, and estuaries that are seasonally occupied by over-wintering fish.
Geographic information system (GIS)	A computer system used to store, manipulate, and map spatially-referenced data.
Glaciofluvial Deposit	Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces.
H_{60}	The elevation in a watershed above which lies 60% of the watershed area. Peak flows are thought to be more sensitive to forest harvest above H_{60}.
Instream licensed quantity	A rate of streamflow that is protected under licence for instream uses.
I.R.	Indian reserve
Irrigation water use	Water used for irrigation purposes, including but not limited to growing fruit, crops, pasture, and vineyards.
IWAP	Interior Watershed Assessment Procedure: a process for assessing the risk that prior harvesting-related activities have impacted a watershed; outlined in a guidebook developed (currently under revision) by Ministry of Forests.
LWBC	Land and Water B.C.
Lake	A body of water greater than 2 m deep.
Licensed storage	A volume of water licensed to be stored behind a dam for subsequent use.
Mean	The average value. Equals the sum of individual observations divided by the number of observations.
Mean annual discharge (MAD)	The average rate of flow in a stream over an annual period.
mg/L	Milligrams per litre
MSRM	Ministry of Sustainable Resource Management
MWLAP	Ministry of Water, Land, and Air Protection
Naturalized flow	Natural flows estimated by adjusting measurements of managed flows

	to account for the effects of upstream storage and withdrawals. They are called naturalized as opposed to natural because they have been estimated rather than measured.
Net flow	Managed streamflows, i.e. naturalized flows plus releases from storage, or naturalized flows minus additions to storage or withdrawals from the stream
Offstream licensed quantity	A volume or rate of flow licenced to be withdrawn from a stream for a human use.
Pesticide	A material that is used to prevent, destroy, repel, attract or reduce pest organisms such as insecticide, herbicide, and plant defoliants.
Population	An aggregate of individuals of a species within a specified location in space and time.
Potential Evapotranspiration	The total amount if water that would be lost by evapotranspiration if there was an unlimited supply of water. *Actual evapotranspiration* is the amount of water actually lost, if there is less available water than the potential evapotranspiration demands (e.g., a desert has a high PET rate, but a low AET rate).
ppm	Parts per million.
RDCO	Regional District of Central Okanagan
Residential water use	Water used for residential purposes, both indoor and outdoor.
Riparian area	The area adjacent to a stream, lake or wetland that is wet enough or flooded frequently enough to develop and support natural vegetative cover that is distinct from vegetation in neighbouring freely drained upland sites.
ROW	Right-of-way
Standard deviation	A measure of the variability in a set of data, equal to the square root of the variance (see *mean, coefficient of variation*).
Stream	A stream is any reach; it must have a continuous channel bed; the bed or banks can be locally obscured; and the bed must be scoured by water or contain observable deposits of mineral alluvium.
Streamflow	Rate of flow in a stream, reported in units of volume per unit of time (cubic metres per second).
Stream reach	A relatively homogeneous section of a stream having a sequence of repeating structural characteristics (or processes) and fish habitat types. The key factors used to discriminate between reaches are discharge, sediment load, channel pattern, channel confinement, gradient, streambed material and bank material.
Stream width	The horizontal distance between rooted vegetation to rooted vegetation on opposite sides of a stream, measured at right angles to the general orientation of the banks.
Till	A compact, poorly-sorted sediment deposited by glacial ice. Typically contains a mix of particle sizes.
Toxic	When a substance is poisonous or injurious to plant or animal health it is considered to be toxic.

Total licensed quantity	The sum of instream and offstream licensed quantities.
Transpiration	The process by which plants transfer water vapour to the atmosphere. The water was originally taken up from the soil through the plant roots.
Water licence	All water in British Columbia is owned by the Crown. A water licence is a legal document issued by the Water Management Branch which specifies the terms and conditions under which the right to use water is granted (LWBC, 2002).
Water Quality Guideline (WQG)	A maximum and/or minimum value for a physical, chemical, or biological characteristic of water, biota, or sediment, applicable province-wide, which should not be exceeded to minimize the risk of specified detrimental effects from occurring to a water use, including aquatic life, under specified environmental conditions.
Water Quality Objective (WQO)	A water quality criterion adapted to protect the most sensitive designated use at a <u>specific location</u> with an adequate degree of safety, taking local circumstances into account.
Wetland	A swamp, marsh, bog, fen, shrub-carr or area of shallow open water that supports a natural vegetation distinct from adjacent upland areas. In a wetland the water table is at, near or above the surface, or soils are saturated for long enough to be the principal determinant of vegetation and soil development. Wetlands are characterized by hydrophytic vegetation and subhydric or hydric soils.