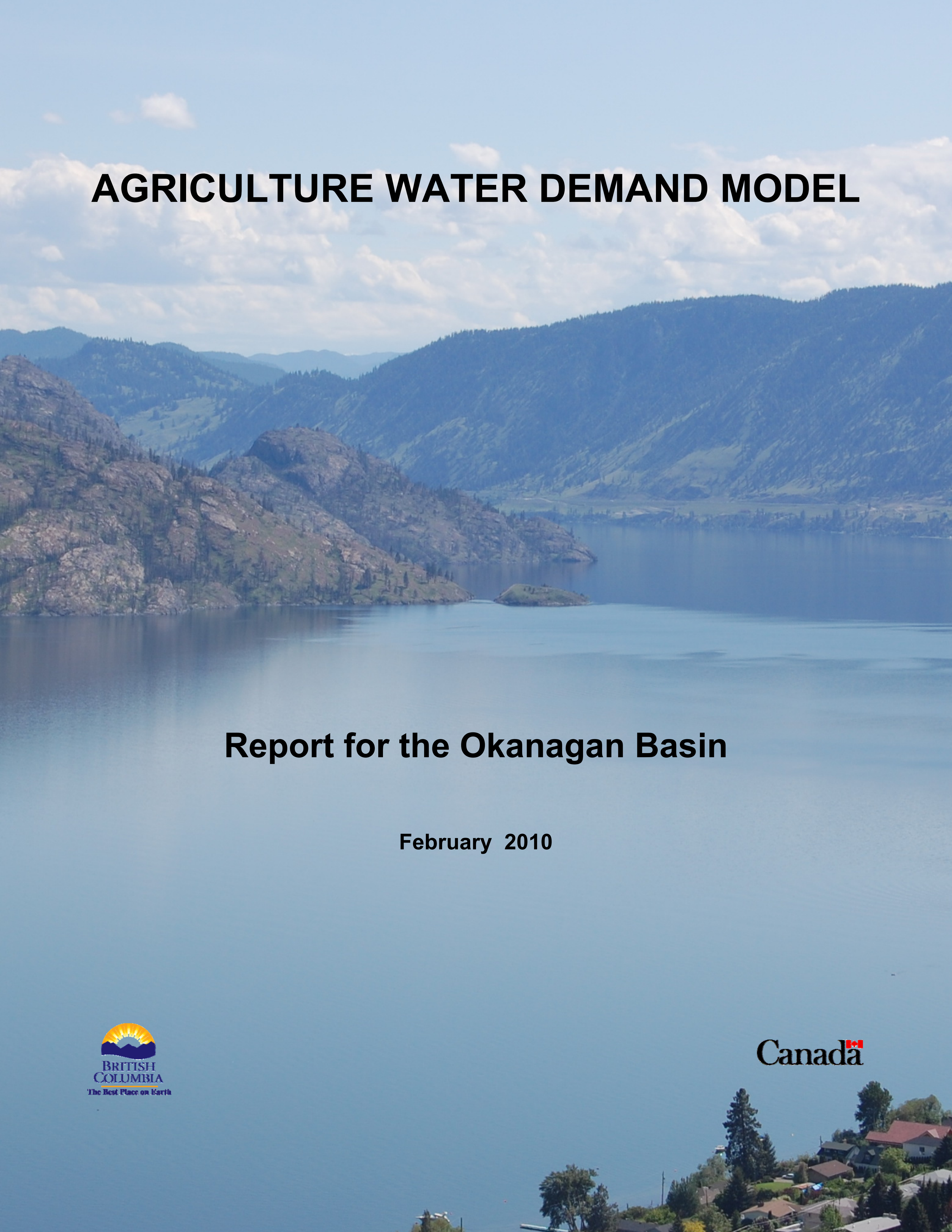
AGRICULTURE WATER DEMAND MODEL



Report for the Okanagan Basin

February 2010

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AGRICULTURE WATER DEMAND MODEL

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There are over thirty people that have been involved with the preparation and collection of data for the development of the Water Demand Model in the Okanagan. The authors wish to express appreciation to the following for their in-kind contribution for the tasks noted.

Grace Frank	Agriculture and Agri-food Canada	GIS data preparation
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Bill Taylor	Environment Canada	Climate data layer
Sam Lee	Ministry of Agriculture and Lands	GIS data preparation
Andrew Petersen	Ministry of Agriculture and Lands	Land Use Inventory
Stephanie Tam	Ministry of Agriculture and Lands	Model Development
Linda Hokanson	Ministry of Agriculture and Lands	Publication formatting

Background

An Okanagan Basin Water Strategy was initiated by Land and Water British Columbia (LWBC) in 2004 in response to significant pressures being exerted on the water resources in the basin. Rapid population growth, drought conditions from climate change, and the overall increased demand for water are driving this trend. Several recent studies have supported the scenario of a pending water crisis as Okanagan water resources are expected to be fully allocated in the next 15 – 20 years.

Climate change scenarios developed by UBC and the Pacific Agri-Food Research Centre (PARC) in Summerland predict that winter snow packs will decrease as the climate warms and the snow level moves higher up the mountains. Opportunities for storage will be limited if moisture is changed from snow to rainfall and the timing of precipitation also changes. Further, agricultural water demands are expected to increase as climate change creates hotter summers and longer growing seasons.

The Agricultural Water Demand Model was developed to provide current and future agriculture water demands for the Okanagan Basin. The intent of the model is to help fulfil the province's commitment under the Living Water Strategy to reserve water for agricultural lands. The model calculates water use on a property by property basis and sums each property to obtain a total for the entire basin or sub basins. Crop, irrigation system type, soils and climate data are used to calculate the water demand. Lands within the Agriculture Land Reserve, depicted in green in Figure 1 were included in the project.

The Ministry of Environment and the Okanagan Water Board are developing a water assessment model that will help to determine the water supply and demands in the basin for various scenarios. The model will be used to determine future water licencing in the Okanagan.

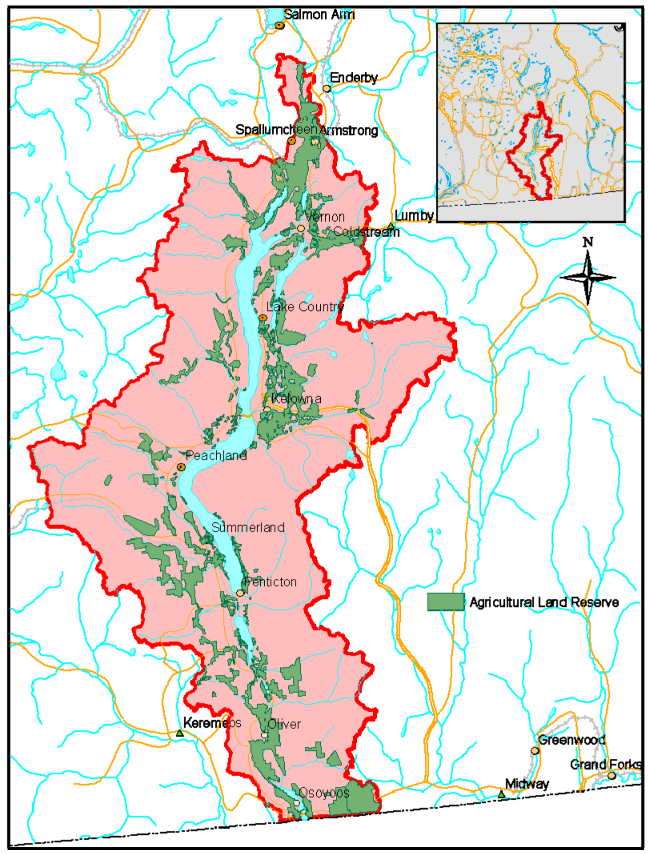

Figure 1 Map of Okanagan Basin

Methodology

The model is based on a GIS database that contains information on cropping, irrigation system type, soils type and climatic data. An explanation of how information was compiled for each is given below. The survey area included all properties within the Agricultural Land Reserve and those occurring outside the ALR where there is active agriculture. The inventory was undertaken by various teams using resources from local government, water purveyors and hiring local expertise with knowledge of agriculture in the Okanagan Valley.

Cadastre

Cadastre information was provided by the Regional Districts and other local governments in the Valley. A consultant was hired to unify all of the cadastral information into one seamless cover for the entire valley. This process allows the model to calculate water demand for each parcel and allows the model to report out on sub-basins, local governments, water purveyors or groundwater aquifers by summing the data for those areas. A GIS technician used aerial photographs to conduct an initial review of cropping information by cadastre and divided the cadastre into polygons that separated farmstead and driveways from cropping areas. This data was entered into a database that was used by the field teams to conduct and complete the land use survey.

Land Use Survey

The survey maps and database were created by Agriculture and Agri-food Canada and BCMAL for the survey crew to enter data about each property. The Okanagan Basin was divided into a number of regions and four survey crews were used to conduct the land use survey. Surveys were done through the summers of 2006 and 2007. The survey crew drove to each property where the team checked the data base for accuracy using visual observation and the aerial photography as provided on the survey maps. The technician verified the data in the database using a laptop computer and altered the appropriate codes if necessary. Corrections on the maps were made by hand. The map sheets were then sent back to the GIS lab to have the hand drawn lines digitized into the GIS system and have the additional polygons entered into the database.

Once acquired through the survey, the land use data was brought into a Geographic Information System (GIS) to facilitate analysis and produce maps. Digital data, in the form of a database and GIS shapefiles (for maps), is available upon request through a data sharing agreement with the Ministry of Agriculture and Lands.

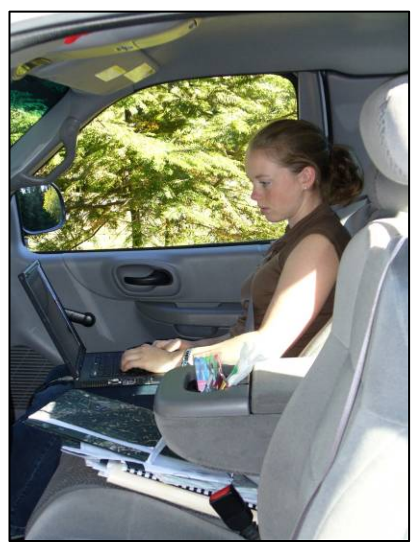

Figure 2 Land Use Survey

Figure 3 provides an example of a map sheet. The Okanagan Basin was divided into 398 map sheets. Each map sheet also had a key map to indicate where it was located in the basin.

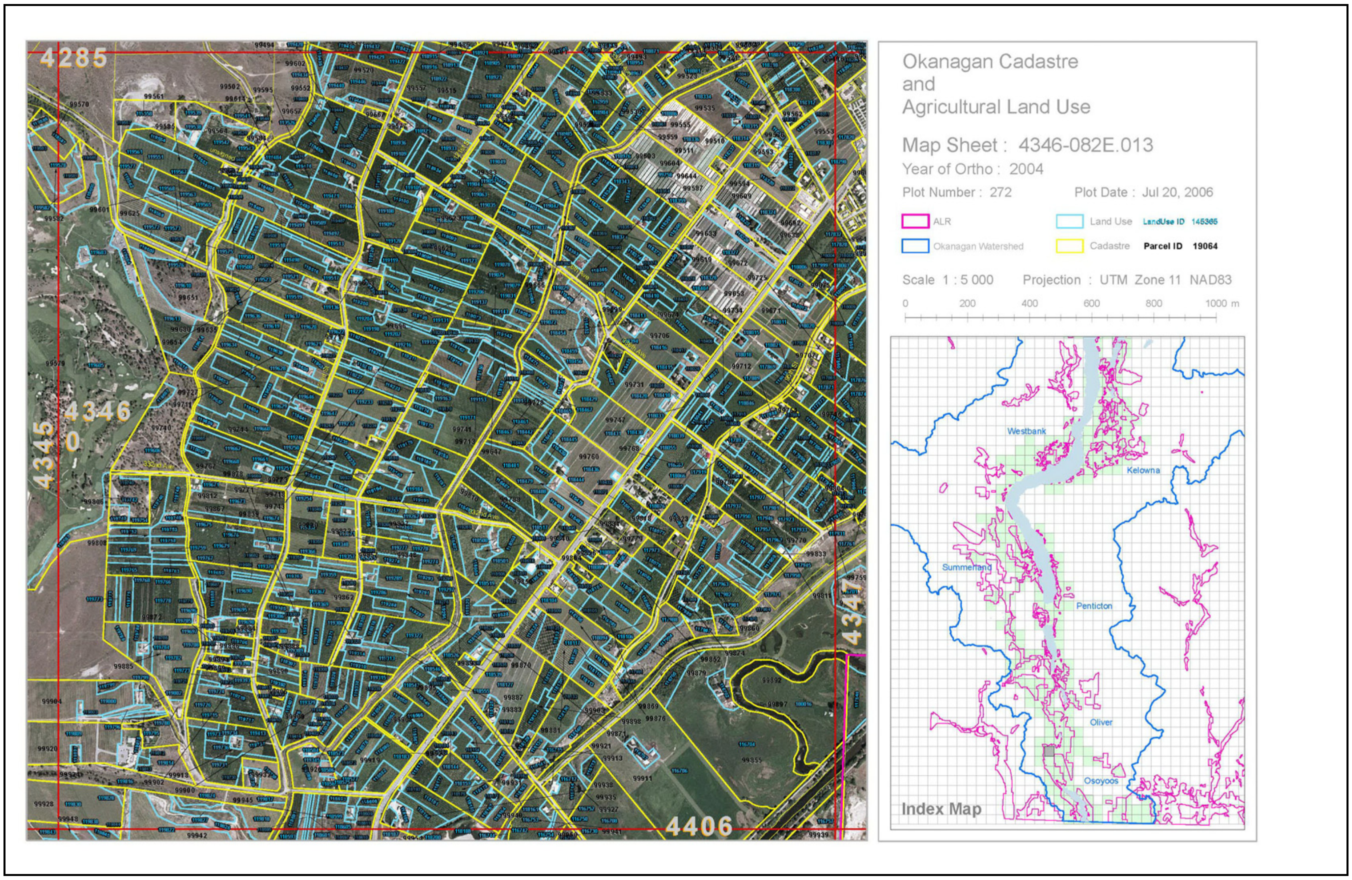

Figure 3 GIS Map Sheet

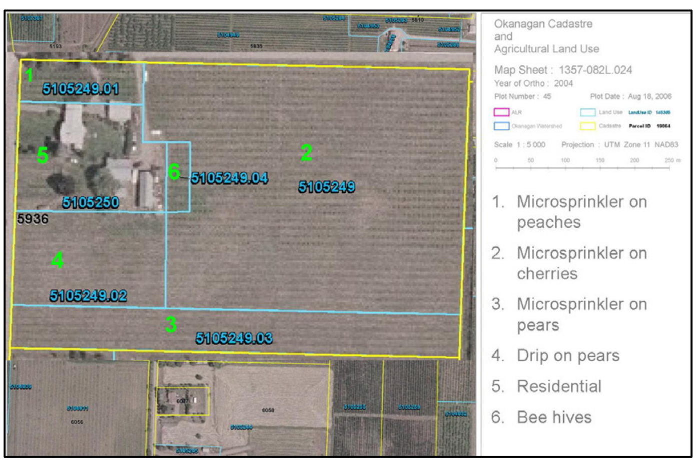

Figure 4 Land Use Designation

The smallest unit for which water use will be calculated will be the polygons within each cadastre. A polygon is determined by a change in land use or irrigation system within a cadastre. Polygons are designated as blue lines within each cadastre as show in Figure 3. A total of 126,419 polygons were generated for the Okanagan Basin for this project. Figure 4 provides an enhanced view of a cadastre containing six polygons. Each cadastre has a unique identifier as does each polygon. The polygon identifier is acknowledged by PolygonID. This allows the survey team to call up the cadastre in the database, review the number of polygons within the cadastre and ensure the land use is coded accurately for each polygon.

Soil Information

Soil information was obtained digitally from the Ministry of Environment's Terrain and Soils Information System. The Computer Assisted Planning and Map Production application (CAPAMP) provided detailed (1:20,000 scale) soils surveys that were conducted in the Lower Mainland, on Southeast Vancouver Island, and in the Okanagan-Similkameen areas during the early 1980s. Products developed include soil survey reports, maps, agriculture capability and other related themes. Soils Information required for this project was the soil texture (loam etc) and the available water storage capacity and peak infiltration rate for each texture type.

The intersection of soil boundaries with the cadastre and land use polygons creates additional polygons that the model uses to calculate water demand. Figure 5 shows how the land use information is divided into additional polygons using the soil boundaries. As discussed in the next section, the climate grid does not develop additional polygons. Each cadastre is assigned to a climate grid.

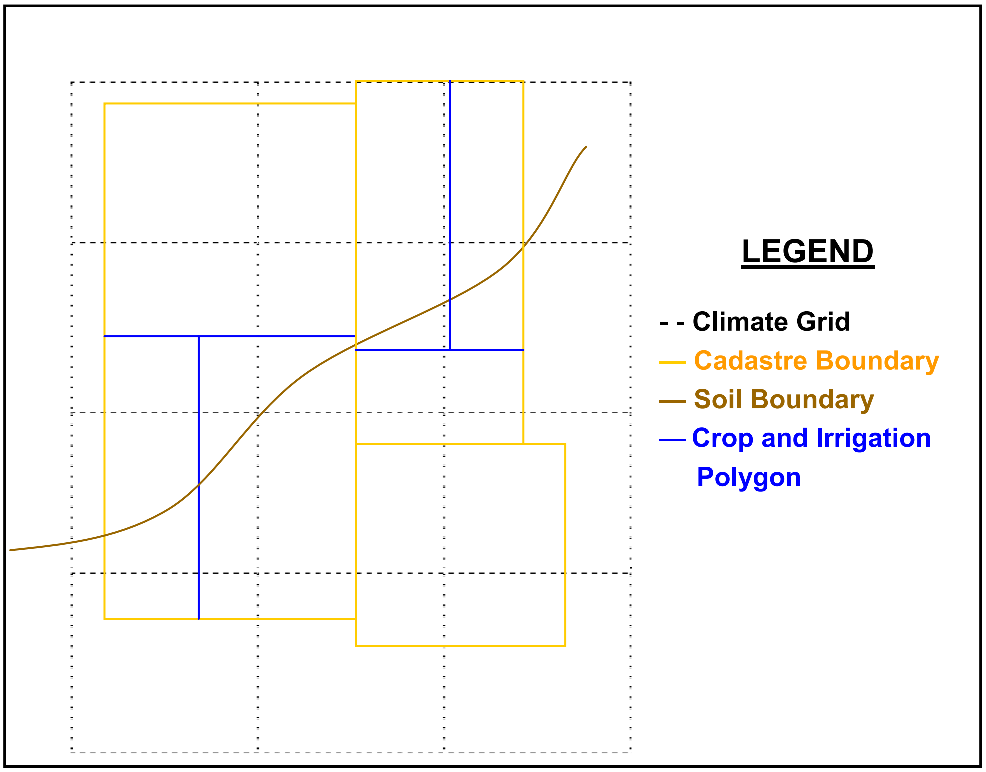

Figure 5 GIS Model Graphic

Climate Information

Historical Climate

The agricultural water demand is calculated using climate, crop, irrigation system and soil information data. The Okanagan region's climate is quite diverse. The climate generally gets cooler and wetter from south to north and as elevation increases. To incorporate the climatic diversity, climate layers were developed for the entire basin on a 500 m grid. Each grid cell contains daily climate data, maximum and minimum temperature (Tmax and Tmin) and precipitation which allows the model to calculate a daily reference evapotranspiration rate (ETo) value. A range of agro-climatic indices such as growing degree days, corn heat units, frost free days and Tsum can also be calculated for each grid cell based on temperature data. These values are used to determine seeding dates and the length of the growing season in the water demand model.

The climate data set has been developed by using existing data from climate stations in and around the Okanagan Basin from 1961-2006. This climate data set was then interpolated to provide a climate data layer for the entire Okanagan Basin on the 500 m grid. Since the Okanagan Basin is a little over 8,000 square kms there are a total of 32,000 grid cells populated with daily data. A detailed description of the model can be found in Neilsen et al. (2010).

Existing climate stations that were used to determine the climate coverage are shown in Figure 6. The attributes attached to each climate grid cell include:

- Latitude
- Longitude
- Elevation
- Aspect
- Slope
- Daily Precipitation,
- Daily Tmax, and Tmin

A climate database contains Tmin, Tmax, Tmean and Precip for each day of the year from 1961 until 2006.

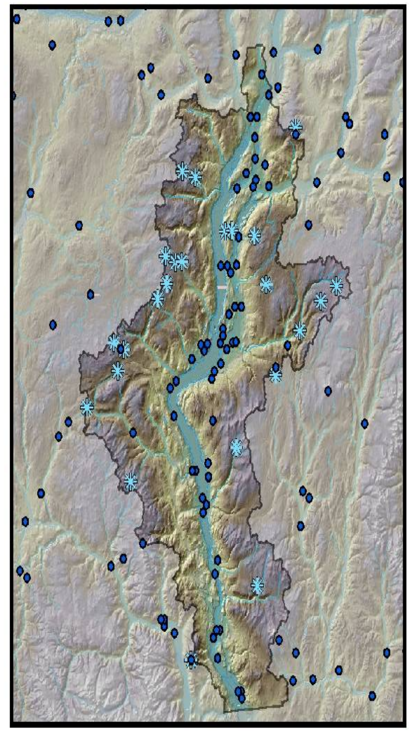

Figure 6 Okanagan Climate Stations

The indices that need to be selected, calculated and stored within the model are evapotranspiration (ETo), effective precipitation (EP), frost free days, growing degree days (base 5 and base 10), corn heat units and first frost date. This information is used to determine the growing season length as well as the beginning and end of the growing season. The model calculates the length of the growing season using the climate and crop information. The beginning and end of the growing season is also calculated and stored by Julian day.

Figure 7 graphically shows an example of the daily variation in climate data for the Okanagan.

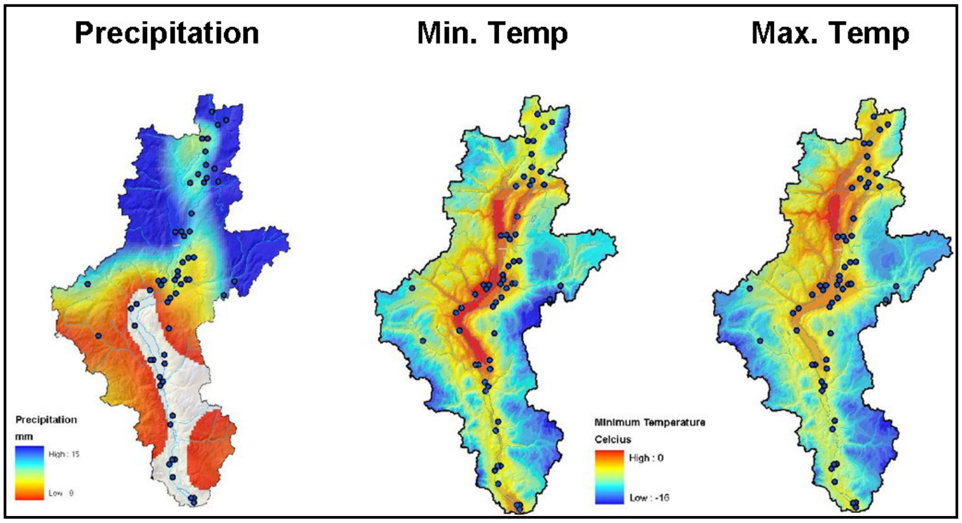

Figure 7 Climate Data

Future Climates

Future daily temperature and precipitation surfaces were developed using multiple Global Climate Models (GCMs) and 3 IPCC greenhouse gas emissions scenarios (SRES). The six GCMs used were CGCM2, CGCM3, CM2.1, ECHAM5, HadCM3, PCM1. The SRES scenarios included A2 which describes a very heterogeneous world with high population growth, slow economic development and slow technological change; B1 which describes a world with a global population that peaks in mid-century with rapid changes in economic structures toward a service and information economy and B2 which describes a world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability. No likelihood has been attached to any of the SRES scenarios (IPCC, 2008). Data form the GCMs were downscaled to 500 x 500m grid cells using TreeGen (Cannon, 2008) a model which combines a synoptic variable classification scheme (Cannon et al., 2002) with a weather generator.

Observed mean annual temperature, averaged across the Okanagan basin, showed a gradual increase over the 1961 to 2006 (Figure 8). Inter-annual variation was large with temperatures fluctuating between 2.2 and 6.4 °C. GCM temperatures also increased over this time period, but with far less inter-annual variation. Mean daily precipitation also showed an upward trend in the observed data, which was not matched by trends in the GCM simulations. The effects of these trends are more obvious when the GCM simulations were extended out to the end of the current century (Figure 9). The differences among models are quite distinct, indicating a range of plausible future climate scenarios. After 2040, the effects of the low and high emissions scenarios on temperature increases become evident. Canadian models CGCM2_A2 and CGCM3_A2 and the Hadley centre model HadCM3_A2 all demonstrate high temperature increases. In contrast, the EC model, both the ECHAM_A2 and ECHAM_B1 scenarios indicate very small changes in mean annual temperature between 2000 and 2100. Projected changes in precipitation over the same time period do not show similar trends, although the outcomes from all of the GCM scenarios indicate considerable inter-annual variation. This wide range of scenarios gives the opportunity to examine a number of possible impacts of climate change on water demand.

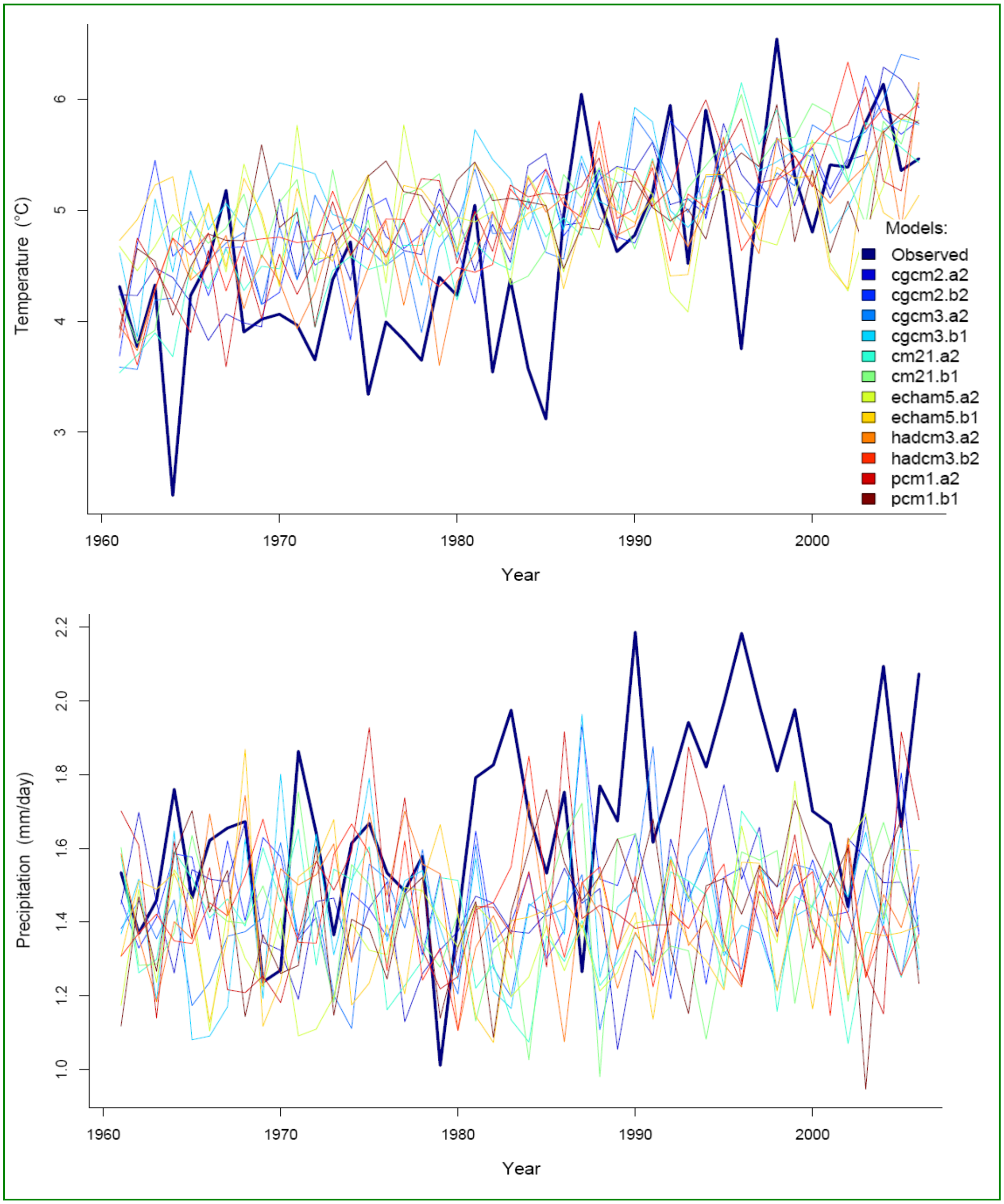

Figure 8 Mean annual temperature and precipitation from observations and downscaled GCMs during 1961-2006.

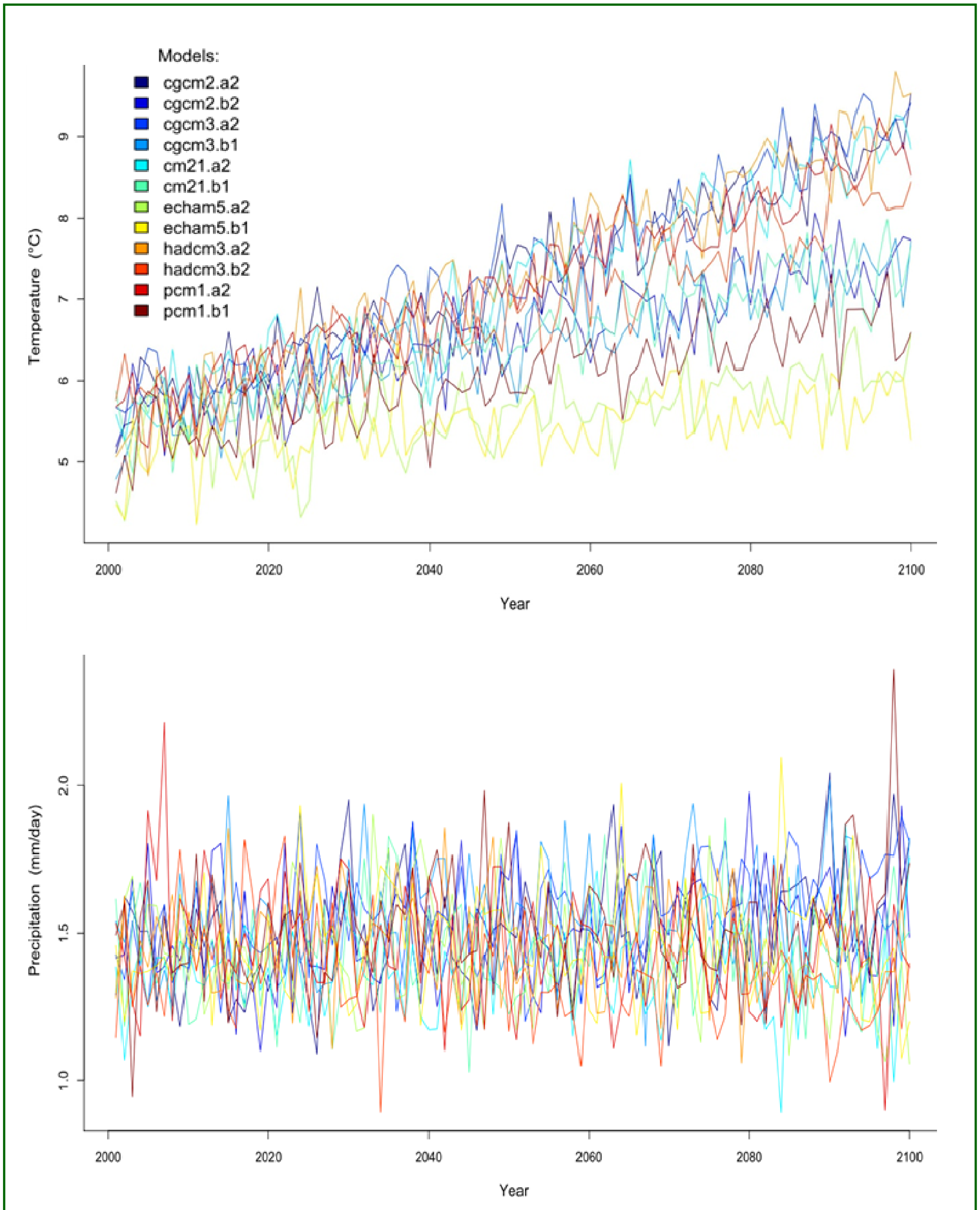

Figure 9 Mean annual temperature and precipitation from downscaled GCMs between 2000 and 2100.

Model Calculations

The model calculates the water demand for each polygon by using crop, irrigation, soil and climate parameters as explained below. Each polygon has been assigned an ID number as mentioned previously.

Crop

The CropID is an attribute of the PolygonID as each polygon will contain a single crop. The crop information (observed during 2005 – 2007) has been collected and stored with PolygonID as part of the land use survey. CropID will provide cropping attributes to the model for calculating water use for each polygon. CropID along with the climate data will also be used to calculate the growing season length and the beginning and end of the growing season. The attributes for CropID include rooting depth, availability coefficient, crop coefficient and a drip factor.

Rooting depth is the rooting depth for a mature crop in a deep soil.

An availability coefficient is assigned to each crop. The availability coefficient is used with the IrrigID to determine the soil moisture available to the crop for each PolygonID.

The crop coefficient adjusts the calculated ETo for the stages of crop growth during the growing season. Crop coefficient curves have been developed for every crop. The crop coefficient curve allows the model to calculate water demand with an adjusted daily ETo value throughout the growing season.

The drip factor is used in the water use calculation for polygons where drip irrigation systems are used. Since the model calculates water use by area, the drip factor adjusts the percentage of area irrigated by the drip system for that crop.

Irrigation

The IrrigID is an attribute of the PolygonID as each polygon will have a single irrigation system type operating. The irrigation information has been collected and stored as observed during 2005 – 2007 with the land use data. The land use survey determined if a polygon had an irrigation system operating, what the system type was and if the system was being used. The IrrigID has an irrigation efficiency listed as an attribute.

Two of the IrrigID, Overtreedrip and Overtreemicro are polygons that have two systems in place. In this case the efficiencies used in the model are the drip and microsprinkler efficiencies.

Soil

The soils layer is from CAPAMP data provided by the Ministry of Energy, Mines and Petroleum Resources. The attributes attached to the SoilID is the Available Water Storage Capacity (AWSC) which is calculated using the soil texture and crop rooting depth.

The Maximum Soil Water Deficit (MSWD) is calculated to determine the parameters for the algorithm that is used to determine the Irrigation Requirement (IR). Soil Moisture Deficit at the beginning of the season is calculated using the same terms as the MSWD.

Climate

The climate data in the model is used to calculate a daily reference evapotranspiration rate (ETo) for each climate grid cell. The data that is required to calculate this value are:

Elevation, metres (m)
Latitude, degrees (^{o})
Minimum Temperature, degree Celsius (^{o} C)
Maximum Temperature, degree Celsius (^{o} C)
Classification as Coastal or Interior
Classification as Arid or Humid
Julian day

Data that is assumed or are constants in this calculation are:

Wind speed	2 m/s
Albedo or canopy reflection coefficient,	0.23
Solar constant, G_{sc}	0.082 $MJ^{-2}min^{-1}$
Interior and Coastal coefficients, K_{Rs}	0.16 for interior locations 0.19 for coastal locations
Humid and arid region coefficients, K_o	0 °C for humid / sub-humid climates 2 °C for arid / semi-arid climates

Irrigation Water Demand Equation

The Irrigation Water Demand (IWD) is calculated for each polygon. The polygons are then summed to determine the IWD for each cadastre. The cadastre water demand values are summed to determine IWD for the basin, sub basin, water purveyor or local government. The following steps provide the process used by the model to calculate Irrigation Water Demand. Detailed information is available in the Technical Description provided by RHF Systems.

1. *Annual Soil Moisture Deficit*

The annual Soil Moisture Deficit represents the amount of water that has to be added to the soil at the beginning of the growing season in order to start off with a full soil reservoir.

- For each crop type the start of the growing season is determined.
- Start the initial storedMoisture depth on January 1 at the soil's maximum evaporation depth
- For each day between the beginning of the calendar year and the crop's growing season start, calculate a new stored moisture from:
  - the evapotranspiration (ETo)
  - the effective precipitation:
    EP = actual precipitation * early Evaporation Factor
  - daily Climate Moisture Deficit (CMD) = ET0 – EP
  - stored Moisture = previous day's stored Moisture – CMD

A negative daily CMD (precipitation in excess of the day's evapotranspiration) adds to the stored moisture level while a positive climate moisture deficit reduces the amount in the stored moisture reservoir. The stored moisture balance is capped at 0 on the low end and the maximum evaporation depth (maxEvaporation) at the other end on a daily basis; if there is enough precipitation to fill the reservoir beyond the maximum evaporation level, that extra moisture is ignored.

On the day before the start of each crop's growing season, the annual SMD value is finalized as the difference between the stored moisture at that time and the maximum evaporation:

SMD = maxEvaporation – storedMoisture

2. *Crop Evapotranspiration Rate (Etc)*

The reference evapotranspiration rate (ETo) is calculated for each climate grid cell for the years selected by the model using a modified Penman Montieth equation that uses daily Tmin and Tmax. The evapotranspiration for each crop (ETc) is calculated as the reference evapotranspiration ETo multiplied by the crop coefficient Kc:

ETc = ETo * Kc

The crop coefficients are based on crop-specific polynomial equations accounting for the plant growth and ground coverage stages. For alfalfa crops there is a set of equations corresponding to different cuttings throughout the growing season.

3. *Climatic Moisture Deficit (CMD)*

The CMD is stored with the PolygonID. The CMD is calculated daily but summarized for the length of the growing season (or a specified time period as selected for the case study) that has been determined for the crop that is resident on the polygon.

During the growing season, the daily Climate Moisture Deficit is calculated as the crop evapotranspiration (ETc) less the Effective Precipitation (EP); the effective precipitation is 75% of 5mm less than the actual precipitation (anything less than 5mm of rainfall is considered to evaporate without providing any irrigation benefit):

EP = (precip – 5) * 0.75
CMD = ETc – EP

If the precipitation is 5mm or less, then the effective precip is 0.

During each crop's growing season, a stored moisture reservoir methodology is used that's similar to the calculation of the annual Soil Moisture Deficit. At the beginning of the growing season, the starting point for the stored moisture is the maximum stored moisture depth under the assumption that any soil moisture deficit has been satisfied. Then, on a daily basis, the stored moisture level is used towards satisfying the climate moisture deficit to produce an *adjusted Climate Moisture Deficit* (CMDa):

CMDa = CMD – storedMoisture

If the storedMoisture level exceeds the day's CMD, then the CMDa = 0 and the stored moisture level is reduced by the CMD amount. If the CMD is greater than the stored moisture, then all of the stored moisture is used (storedMoisture is set to 0) and the adjusted CMD creates an irrigation requirement.

The upper limit for the storedMoisture level during the growing season is the maximum stored moisture setting (maxStoredMoisture).

4. Crop Water Requirement (CWR)

The Crop Water Requirement is calculated as the adjusted Climate Moisture Deficit multiplied by the soil water factor and any stress factor (used primarily for grass crops):

CWR = CMDa * swFactor * stressFactor

5. Irrigation Requirement (IR)

The IR is stored with the PolygonID. The irrigation requirement is determined from the crop water requirement CWR, a factor that adjusts for the area irrigated by a drip system (Drip Irrigation Factor (Df)) and the Irrigation System Efficiency (Ie). The Drip Factor (Df) is only used when a drip irrigation system is used in the polygon. The Df defaults to 1.0 if a drip irrigation system is not used.

The Irrigation Requirement is therefore calculated as:

IR = CWR * Df / Ie

6. The Irrigation Water Demand (IWDperc and IWD)

The portion of the Irrigation Water Demand lost to deep percolation is the Irrigation Requirement multiplied by the percolation factor:

IWDperc = IR * soilPercFactor

The final Irrigation Water Demand is then the Irrigation Requirement plus the loss to percolation:

IWD = IR + IWDperc

Calculation of Individual Terms used in the Irrigation Water Demand Equation

Growing Season Boundaries

There are three sets of considerations used in calculating the start and end of the irrigation season for each crop:

- temperature-based derivations, generally using TSUM or Growing Degree Day accumulations
- the growing seasons overrides table
- irrigation overrides

These form an order of precedence with later considerations potentially overriding the dates established for the previous rules. For example, the temperature-based rules might yield a season start date of day 90 for a given crop in a mild year. To avoid unrealistic irrigation starts, the season overrides table might enforce a minimum start day of 100 for that crop; at that point, the season start would be set to day 100. At the same time, a Water Purveyor might not turn on the water supply until day 105; specifying that as the Irrigation start day on the User Interface form would override both of the other dates, resulting in a final season start of day 105.

The use of the growing season overrides table and the Irrigation overrides are outlined in the IWDM User's Guide. This section describes the rules used to establish growing season boundaries based on the internal calculations of the model. These rules have changed significantly over those listed in the RFP, many moving to a TSUM (summed temperature) accumulation methodology. The GDD and TSUM Day calculations are described in separate sections.

The *standard end of season* specified for several crops is the earlier of the Growing Degree 5 end date or the first frost.

Corn (silage corn)

- uses the corn_start and the minimum of the killing frost or Corn Heat Unit 2700 day for the season boundaries

Sweetcorn, Potato, Tomato, Pepper, Strawberry, Vegetable

- corn_start date for the season start
- corn start plus 110 days for the season end

Cereal

- GDD5 start for the season start and the GDD5 start plus 130 days for the season end

AppleHD, AppleMD, AppleLD, Asparagus, Berry, Blueberry, Ginseng, Nuts, Raspberry, Sourcherry, Nursery

- season start: (0.8447 * tsum600_day) + 18.877
- standard end of season

Pumpkin

- corn_start date, standard end of season

Apricot

- season start: (0.9153 * tsum400_day) + 5.5809
- standard end of season

CherryHD, CherryMD, CherryLD

- season start: (0.7992 * tsum450_day) + 24.878
- standard end of season

Grape

- season start: (0.8447 * tsum600_day) + 18.877
- standard end of season

Peach, Nectarine

- season start: (0.8438 * tsum450_day) + 19.68
- standard end of season

Plum

- season start: (0.7982 * tsum500_day) + 25.417
- standard end of season

Pear

- season start: (0.8249 * tsum600_day) + 17.14
- standard end of season

Grass, Forage, Alfalfa, Golf, TurfFarm

- season start: later of the GDD5 start and the tsum300_day
- standard end of season

Domestic, Yard, TurfPark

- season start: later of the GDD5 start and the tsum400_day
- standard end of season

Greenhouse

- fixed season of February 1 – October 31

Availability Coefficient (AC)

The availability coefficient is taken directly from the crop factors table (*crop_factors*) based on the cropId value.

Rooting Depth (RD)

Read directly from the crop factors table.

Stress Factor

Read directly from the crop factors table.

Available Water Storage Capacity (AWSC)

The available water storage capacity is taken directly from the soil factors table (*soil_factors*).

Maximum Soil Water Deficit (MSWD)

The maximum soil water deficit is the product of the crop's availability coefficient, rooting depth, and the available water storage capacity of the soil:

$$MSWD = RD * AWSC * AC$$

Deep Percolation Factor (Soilpercfactor)

For the greenhouse "crop", the greenhouse leaching factor from the main application configuration table (*iwdm_configuration*) is used as the soil percolation factor. For other crops, the factor depends on the soil texture, the maximum soil water deficit, the irrigation system, and the Irrigation Management Practices code. The percolation factors table (*soil_percolation_factors*) is read to find the first row with the correct management practices, soil texture and irrigation system, and a maximum soil water deficit value that matches or exceeds the value calculated for the current landuse polygon.

If the calculated MSWD value is greater than the index value for all rows in the percolation factors table, then the highest MSWD factor is used. If there is no match based on the passed parameters, then a default value of 0.25 is applied.

For example, a calculated MSWD value of 82.5, a soil type of SL and an irrigation system of Ssovertree would retrieve the percolation factor associated with the MSWD index value of 75 in the current table (presently, there are rows for MSWD 50 and 75 for SL and Ssovertree).

Maximum Evaporation Factor (Maxevaporation)

Read directly from the soil factors table.

Irrigation Efficiency (IE)

Read directly from the irrigation factors table (*irrigation_factors*).

Maximum Stored Moisture Depth (Maxstoredmoisture)

The maximum stored moisture value is set as one half of the maximum soil water deficit (MSWD).

Soil Water Factor (SWFactor)

For the greenhouse "crop", the soil water factor is set to 1. For other crops, it's interpolated from a table (*soil_water_factors*) based on the maximum soil water deficit (MSWD). For Nurseries, the highest soil water factor (lowest MSWD index) in the table is used; otherwise, the two rows whose maximumSoilWaterDeficit values bound the calculated MSWD are located and a soil water factor interpolated according to where the passed MSDW value lies between those bounds.

For example, using the current table with rows giving soil water factors of 0.95 and 0.9 for MSWD index values of 75 and 100 mm respectively, a calculated MSWD value of 82.5 would return a soil water factor of

$$0.95 + ((82.5 – 75) / (100 – 75) * (0.9 – 0.95)) = 0.935$$

If the calculated MSWD value is higher or lower than the index values for all of the rows in the table, then the factor associated with the highest or lowest MSWD index is used.

Early Season Evaporation Factor (earlyevaporationfactor)

Taken from the main application configuration table (*iwdm_configuration*).

Crop Coefficient (Kc)

The crop coefficient is calculated from a set of fourth degree polynomial equations representing the crop's ground coverage throughout its growing season. The coefficients for each term are read from the crop factors table based on the crop type, with the variable equaling the number of days since the start of the crop's growing season. For example, the crop coefficient for Grape on day 35 of the growing season would be calculated as:

Kc =(0.0000000031 * 35^4) + (-0.0000013775 * 35^3) + (0.0001634536 * 35^2) + (-0.0011179845 * 35) + 0.2399004137
= 0.346593241

Many of the coefficients have been modified from the values listed in the RFP. See the crop factors table for the current values.

Alfalfa crops have an additional consideration. More than one cutting of alfalfa can be harvested over the course of the growing season, and the terms used for the crop coefficient equation changes for the different cuttings. For alfalfa, the alfalfa cuttings table is first used to determine which cutting period the day belongs to (first, intermediate or last), and after that the associated record in the crop factors table is accessed to determine the terms.

Growing Degree Days

The Growing Degree Day calculations are much the same as those outlined in the RFP, but there have been changes to the tests that reset the searches for the start and end of the GDD accumulations.

Start of GDD Accumulation

For each base temperature (bases 5 and 10 are always calculated, other base temperature can be derived), the start of the accumulation is defined as occurring after 5 consecutive days of mean temperatures matching or exceeding the base temperature. This is a slightly different test than outlined in the RFP where the mean temperature has to strictly exceed the base temperature for 5 days. The search for the start day gets reset if a killing frost (< -2 degrees C) occurs, even after the accumulation has started. The search also restarts if there are 2 or more consecutive days of minimum temperatures

<= 0 C. The GDD start is limited to julian days 1 – 210; if the accumulation hasn't started by that point, then it's unlikely to produce a reasonable starting point for any crop.

End of GDD accumulation

The search for the end of the GDD accumulation begins 50 days after its start. The accumulation ends on the earlier of 5 consecutive days where the mean temperature fails to reach the base temperature (strict *less than* test) or the first killing frost (-2 C).

During the GDD accumulation period, the daily contribution is the difference between the day's mean temperature and the base temperature, as long as the mean temperature isn't less than the base temperature:

GDD = Tmean – BaseT; 0 if negative

Frost Indices

Three frost indices are tracked for each year:

- the last spring frost is the latest day in the first 180 days of the year with a minimum temperature of 0 degrees or less
- the first fall frost is the first day between days 240 and the and of the year where the minimum temperature drops to 0 degrees or less
- the killing frost is the first day on or after the first fall frost where the temperature drops to or below –2 C.

Corn Heat Units

The Corn Heat units calculation is slightly different than the RFP description in that each of the 2 terms (Tmax and Tmin) in the numerator of the equation gets set to 0 individually if the term is negative, which can be different than evaluating the whole equation and then setting it to 0 if negative:

term1 = (3.33 * (tmax - 10)) - (0.084 * (tmax - 10) * (tmax - 10)); 0 if negative
term2 = 1.8 * (tmin - 4.44); 0 if negative
CHU = (term1 + term2) / 2

Corn Season Start and End

The corn season boundary derivations are similar to the Growing Degree Day determinations. The start day is established by 3 consecutive days where the mean temperature is 11.2 degrees or warmer. As in the case of the GDD calculations, the search for the corn season start day gets reset if the minimum temperature drops to –2 or less or if there are 2 or more consecutive days of minimum temperatures between –2 and 0 C.

For silage corn, the season ends at the earlier of the killing frost (-2 C) and the date when 2700 Corn Heat Units have been accumulated.

The end of the sweet corn season is defined as 110 days after the season start.

TSUM Indices

The TSUM day for a given number is defined as the day that the sum of the positive mean daily temperatures reaches that number. For example, the TSUM400 day is the day where the sum of the positive mean temperatures starting at January 1 sum to 400 units or greater.

Days where the mean temperature falls below 0 are simply not counted – they don't restart the accumulation sequence.

Land Use Results

A summary of the Okanagan Basin's land area and the ALR area are shown in Table 1. Figures 10, 11 and 12 show the areas of water, ALR land and land parcels in the basin graphically.

Table 1 Overview of Okanagan Basin's Land and ALR area

	Area		**Number of parcels**
Total Area of Basin	797,375 ha	-	-
Area of Water Feature in Basin	47,708 ha	-	-
Area of Land in Basin (excluding water feature)	749,667 ha	-	-
Area of Land Parcels in Basin	255, 499 ha	Number of Parcels in Basin	103,181
Area of Land Parcels in Okanagan Basin (excluding transportation and water land use)	255, 317 ha	Number of Parcels in Okanagan Basin (excluding transportation and water land use)	103,078
ALR area	99,078 ha	Number of Parcels in ALR	16, 237
Area of First Nations Reserve in Basin	31,463 ha	Number of Parcels of First Nations Reserve in Basin	56
Area of First Nations Reserve in ALR	6,524 ha	Number of Parcels of First Nations Reserve in ALR	17

Figure 10 Area of Water in Basin (47,708 ha)

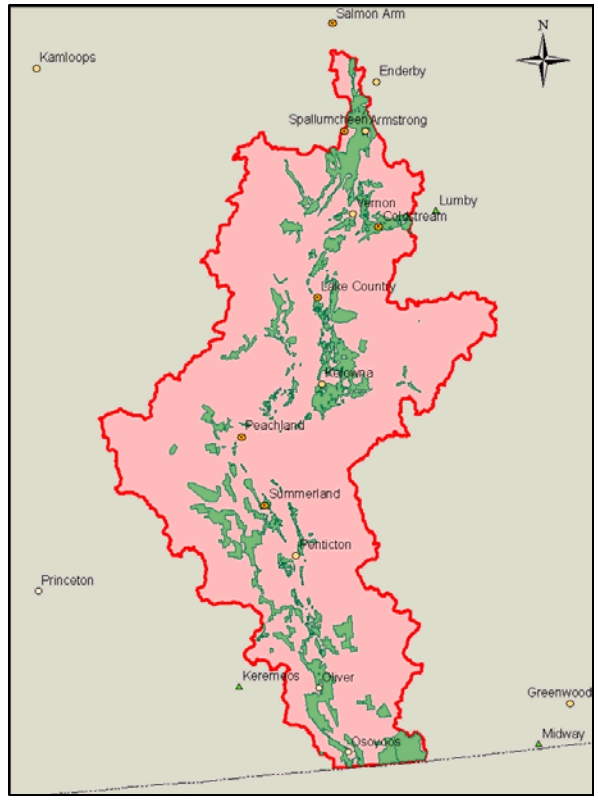

Figure 11 Land area in ALR (99,078 ha)

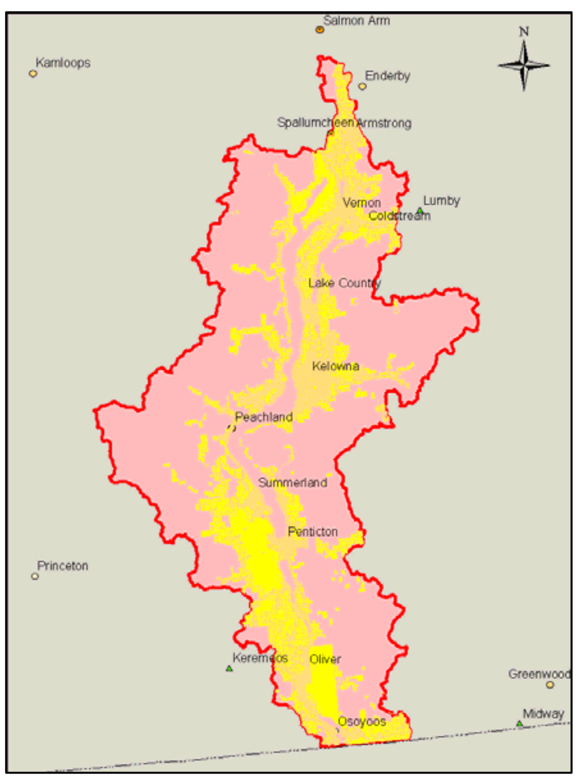

Figure 12 Area of Land Parcels in Basin (255, 499 ha)

Table 2 Summary of primary agricultural activities within the ALR where primary land use is agriculture

Primary agriculture activity	Number of parcels	Total ALR area (ha)	Percent of parcels	Mean parcel size (ha)
Agri-tourism	2	12	<1	6.3
Beef Cattle Farm	224	4,193	4	20.6
Berry Farm	22	64	<1	2.9
Christmas Tree Farm	7	29	<1	4.1
Commercial Pet Kennel	1	11	<1	10.6
Cultivated Land	12	125	<1	12.3
Dairy Farm	12	66	<1	5.5
Equestrian Facility	16	98	<1	6.3
Field Flower Farm	1	3	<1	2.5
Field Vegetable Farm	104	643	2	6.3
Forage Operation	1,171	11,626	23	10.4
Ginseng Farm	5	39	<1	7.8
Grain Production	2	42	<1	21.9
Greenhouse Operation	11	77	<1	7.6
Horse Farm	237	662	5	2.8
Livestock Operation - Type Unknown	17	56	<1	3.4
Llama/Alpaca Farm	8	15	<1	1.8
Mushroom Farm	1	3	<1	3.1
Nursery	50	217	<1	4.4
Nursery (incl. Polyhouses)	3	6	<1	2.2
Nut Farm	5	17	<1	3.6
Orchard	1,982	7,898	38	4.1
Other	98	501	2	5.2
Pasture	582	4,714	11	8.5
Poultry (backyard flock or free range)	2	5	<1	2.3
Poultry Farm	14	49	<1	3.9
Preparation/Processing	1	2	<1	2.3
Range	20	641	<1	38.2
Sheep/Goat Farm	5	11	<1	2.2
Specialty Crop Production	1	22	<1	22.3
Tree Farm	43	311	<1	7.2
Turf Farm	8	104	<1	13.1
Veterinary Clinic	1	8	<1	8.1
Vineyard	476	2,595	9	5.6
Winery	1	4	<1	4.5
Unknown	22	81	<1	3.7
Total	**5,167**	**34,951**	**100**	**7.1**

Agricultural Water Demand Results

The model has a reporting feature that can save and generate reports for the scenarios that have been developed. A summary of the data that can be generated by the model can be found in Appendix A. Climate data from 1997, 2003 and 2006 were chosen as they represent a relatively wet year, dry year and average year respectively. Most tables use 2003 data since the maximum current demand can then be reported.

Annual Crop Water Demand - 2003

Table A1 provides the annual water demand for current crop and irrigation systems used for the year 2003 using average irrigation management. The total outdoor demand (irrigation) in the Okanagan Valley for 2003 is 206,974,538 m^3. Agricultural crops alone are 131,819,533 m^3 or approximately 64% of the outdoor water use in the basin. This does not include a significant number of farms that may have an irrigation system and are entitled to water, but are currently not using their system. This information has been captured by the model and will be reported out later.

The total agricultural area irrigated in the basin is 18416 hectares. In the Okanagan 13,790 agricultural hectares or 75% is supplied by surface water sources which includes both private licences and water purveyors. A total of 739 hectares is irrigated with reclaimed water and the remaining 3887 hectares, 21%, is irrigated from groundwater.

Forage crops including alfalfa, corn and grass combined are 7937 hectares, 43% of the irrigated acreage in the Okanagan. Apples, berries, cherries, fruits, vegetables and grapes combine to make up 9595 hectares, 52% of the irrigated area. Forage grass which makes up 27.5% of the irrigated area has 35% of the water demand in the basin.

Annual Water Demand by Irrigation System - 2003

The crop irrigation demand can also be reported by irrigation system type as shown in Table A2. The total area that is currently irrigated by efficient irrigation systems; drip, microspray and microsprinkler systems for the horticulture sector is 3787 hectares or 20%. However 52% of the agricultural irrigated acreage, predominantly fruits and vegetables, can use more efficient irrigation systems than are currently being used.

Annual Water Demand by Soil Type - 2003

Table A3 provides the annual water demand by soil type. The sandy loam category shows a higher than normal value as all regions where a soil type could not be identified were defaulted to sandy loam. All outdoor domestic irrigated areas were also assumed to use sandy loam.

Water Purveyor Demand - 2003

The model calculates water demand on a property by property basis and can summarize the data for each water purveyor in the Okanagan Basin. Table A4 provides an estimated outdoor water demand for each purveyor including domestic, park area and agricultural areas. The bottom of the table shows the private irrigated area – this is included as a check to allow the total numbers to be compared against the other tables.

Local Government Demand - 2003

The estimated outdoor water demand by Local Government is shown in Table A5. All jurisdictions are included. Of interest is that the water demands for Kelowna, RDOS and NORD are almost identical.

Yearly Water Demand Comparison

Table A6 provides an estimate of total water demand in the basin for 1997, 2003 and 2006 using an average management factor. The range is quite large with 1997 considered to be a wetter year and 2003 considered to be one of the hottest years on record. Water demand in 1997 is only 73% of 2003.

Irrigation Management Factors

The model can estimate water demand based on poor, average and good irrigation management factors. This is accomplished by developing an irrigation management factor for each crop, soil and irrigation system combination. For each polygon, a maximum soil water deficit (MSWD) is calculated based on the soil type and crop rooting depth within the polygon. For each soil class and irrigation system combination a range of four MSWD are provided. An irrigation management factor is established for each of the MSWD ranges for each soil type and irrigation system combination. The management factor is based on irrigation expertise as to how the various irrigation systems operate. There are a total of 5292 irrigation management factors established for the 21 different soil types and 21 different irrigation systems used in the model. To provide an idea of the matrix developed, Table 3 gives an example of the irrigation management factors used for sandy loam and loam soils and solid set sprinkler and drip systems.

Table 3 Irrigation Management Factors

Soil Class	MSWD	SS Overtree Good	SS Overtree Average	SS Overtree Poor	Drip Good	Drip Average	Drip Poor
Loam	38	0.1	0.15	0.2	0.05	0.1	0.15
	50	0.05	0.1	0.15	0.05	0.075	0.1
	75	0.05	0.1	0.15	0.05	0.075	0.1
	100	0.05	0.075	0.1	0.05	0.075	0.1
Sandy loam	25	0.2	0.225	0.25	0.1	0.15	0.2
	38	0.1	0.15	0.2	0.1	0.125	0.15
	50	0.05	0.1	0.15	0.05	0.1	0.1
	75	0.05	0.1	0.15	0.05	0.075	0.1

The management factors increase as the MSWD decreases as there is less soil storage potential in the crop rooting depth. For irrigation systems such as guns, operating on a pasture which has a shallow rooting depth, on a sandy soil which cannot store much water, the poor irrigation management factor may be as high as 0.5.

The management factor used in the model assumes all losses are deep percolation while it is likely that some losses will occur as runoff as well.

Table A6 provides the results of the different management factors for 2003 data.

Percolation Rates

The percolation rates vary by crop, irrigation system type, soil and the management factor used. Table A7 provides a breakdown by irrigation system type and shows percolation volumes based on poor, average and good management. The last column provides a good indication of the average percolation per hectare for the various irrigation system types. For example, drip irrigation systems have only 18 – 20% of the percolation rates of gun systems. Landscape systems have a high percolation rate predominantly because application rates are high and the crop rooting depth is quite shallow.

On a basin wide scale, percolation rates for poor management are 150% higher than for good management. For 2003 climate data the percolation rate of the entire basin for poor irrigation management is estimated to be 33,881,882 m^3 and 24,154,584 m^3 for good irrigation management.

All Existing Irrigation Systems Using Water

There are a number of existing irrigation systems that are currently not being used for a variety of reasons. The grower may have retired, crops could have been removed and nothing planted or the property may be inactive as it is for sale. If these properties are included, the irrigated acreage increases from 25,993 hectares to 27,075 hectares. Adding the inactive category shown in Table A1, the actual increased acreage is 1295 hectares.

Where a crop was not established, the acreage was assigned a forage crop so that the model could determine a water demand. The majority of the increased acreage is therefore forage if comparing Tables A1 and A8. Comparing Tables A2 and A9, it will be noted that almost all irrigation systems have some increase in acreage, but the sprinkler systems have the highest percentage increase. Table A10 provides a quick reference summary of the changes in crops and irrigation systems.

The increase in water demand by using all the irrigation systems in 2003 is 6%, from 206,974,538 m^3 to 219,134,002 m^3, an increase of 12,159,464 m^3.

Outdoor Domestic Demand

The process to classify residential land cover used a combination of ortho-rectified air photos (orthos), captured in 2004 at a resolution of 1.0m for most of the basin, and in 2007 at a resolution of 0.5m for the Vernon, Kelowna and W. Kelowna areas. Land use in the images was classified based on the colour and shape of objects. The first major sub-division was into pervious and impervious surfaces, which were then categorized into 5 pervious classes and 6 impervious classes (Table 4).

Land was assigned to cover categories using Feature Analyst an extension used with ArcGIS®. Features were first defined by creating training samples for each ortho which captured 30-40 sample polygons in each category. After the training set was characterized, features to be excluded from the analysis were masked out. These included roads, non-residential areas (e.g. agriculture, parks, ICI, natural landscapes etc). (Figure 13).

Table 4 Classes of Land Cover in Residential Areas

Pervious surfaces	Impervious surfaces	Irrigated
Yard (green)		Yes
Yard (brown)		No
Treeshade		Yes
Natural vegetation		No
Bare soil		No
	Pool	No
	Roofs (white, red, grey, tan)	No
	Driveways	No

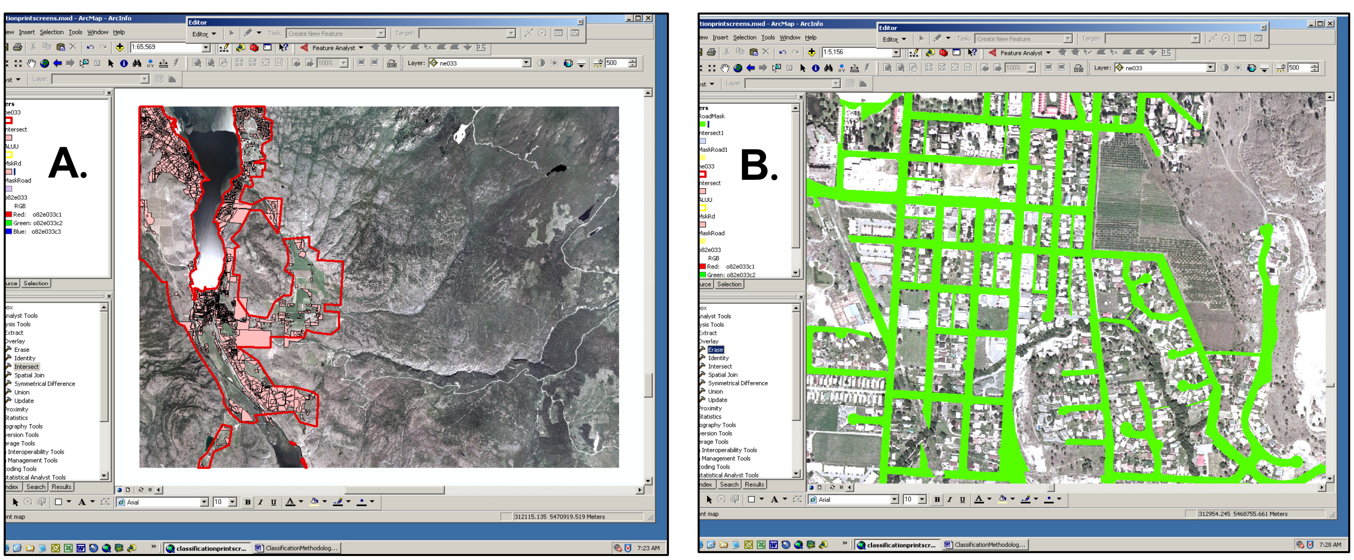

Figure 13 A. Preliminary identification of residential areas; B. identification of roads

Features within the residential area were then classified according to the training set parameters to produce an image that identified irrigated areas that would be included in the water demand model (Figure 14).

Figure 14 Example of classified air photograph

Green areas in Figure 14 would be included in the water demand model as domestic irrigation.

The results from the model show that the total landscape area irrigated is 7577 hectares of which 1061 hectares (14%) is comprised of golf courses; 607 hectares (8%) is landscape turf which includes parks, school grounds etc; and 5,910 hectares (78%) are private lots. The landscape turf area obtains 81% of the water supply from surface water sources, 15% from groundwater and 4% from reclaimed water, primarily golf courses.

The domestic outdoor demand as calculated by the model for 2003 is 58,567,260 m^3. The domestic outdoor water use was captured by using image analysis to determine the landscapes that were being irrigated for each cadastre or property. What the model is not able to do is determine the level of irrigation being used on each property. For example some yards look greenish but are obviously not irrigated to the same extent as other lawns. Another limitation of this method is that the image analysis has inherent errors due to tree or building shade that may reduce the irrigated area.

A survey conducted in the Kelowna area during the summer of 2009 indicated that approximately 35% of the properties were not irrigated or were partially irrigated. The model's water demand results also exceeded the actual use as determined by meters in this area by 30%. Reducing the model's domestic outdoor demand by 30% may therefore be warranted. A value of 40,997,082 may be more in line.

If these adjusted values are used then the agricultural water demand is 69.6% of the total outdoor water use in the valley.

Crop and Irrigation System Change Scenarios

The model is capable of doing 'what if' scenarios such as "What if all of the apples grown south of Kelowna that are on a sandy soil were converted to grapes and irrigated with drip systems?". A few scenarios have been run to provide some basic information for the Okanagan Basin.

Agricultural Acreage Expansion and Domestic Buildout to 2040

This scenario increases the agricultural irrigated area and the domestic outdoor irrigated area.

The increase in agricultural area was based on the following criteria being matched. The scenario does not take into account if there is sufficient water available to irrigate, but does provide an estimate of the additional water that may be required if lands in the ALR close to a water supply were to be irrigated. The rules applied to the scenarios are:

- The additional lands must be within the ALR and must be within 2 km of a water purveyor or within 5 km of a major lake or the Okanagan River.
- The land must be under 750 m elevation.
- The soil's agriculture capability class must be less than 4 in the north part of the basin and less than 5 in the south part of the basin. The split between north and south occurs between Peachland and Summerland
- For lands south of Lake Country, additional irrigated land will be cropped with apples using a microsprinkler system. Lands located north of Lake Country will be cropped with alfalfa and will use a sprinkler system.

There are many options of crops and irrigation systems that could have been chosen, but forage and apples were selected for this scenario to keep the report simple. Table A10 provides a summary of the increase in cropped acreage and the increase in irrigation systems used. The increased acreage for apples is 3811 hectares and 3359 hectares for alfalfa.

The total increase in domestic outdoor irrigation is 268 hectares. This number may be lower than expected due to domestic redevelopment and the developments being higher density.

The total increase in irrigated acreage for agriculture is 6617 hectares, comparing all properties with irrigation systems in 2006 with the growth scenario. Comparing previous tables to Table A11 indicates that the increase in water demand for the future build out scenario would be 37,679,878 m^3 for agriculture and 2,466,908 m^3 for outdoor domestic using a 2003 climate scenario. Table A13 provides similar information by irrigation system type. The domestic component is quite low due to the assumptions of higher density and redevelopment.

Table A12 shows that the total water demand using 2003 climate data for this scenario would be 259,280,786 m^3, using an average management factor. The number decreases to 252,949,425 m^3 using a good management factor. The management factor does not have as big an impact in this case as a large portion of the additional area is being irrigated with microsprinklers which are more efficient, have lower application rates and therefore reduce leaching.

Agricultural Water Demand – Horticulture Converted to Drip

Table A14 provides the results of a scenario with all of the horticultural crops with irrigation systems being converted to drip irrigation. Table A9 provided the water demand prior to the conversion to drip systems. The water demand for 19,649 hectares of agricultural land prior to conversion was 145,400,008 m^3 and after the conversion to drip, the water demand for the agriculture sector dropped to 124,227,696 m^3 using 2003 climate data and average management. Improving the irrigation management to good reduces the demand to 121,496,351 m^3.

The savings obtained by installing drip systems on all horticultural crops and improving the irrigation management to good for 2003 climate data is 23,903,657 m^3 or 16.5%.

Agricultural Water Demand – Half of Tree Fruits Converted to Grape

The past few years have seen a large conversion of apple crops to grapes in the Okanagan. Grapes use less water than apples, so a scenario was developed to determine the water savings that would occur if half of the existing apple crops were to be converted to grapes and all of the conversions were irrigated with drip systems. The conversions occurred on soils that were suited to grape crops, predominantly the lighter soils such as sandy loam.

Tables A15 and A8 provide the change in water demand that occurred, from 143,723,108 m^3 to 121,379,184 m^3, a saving of 22,343,924 m^3 for average management and using 2003 climate data. Table A16 provides similar data broken down by irrigation system type.

Agricultural Water Demand – Half of Forage Converted to Tree Fruits, Grapes and Vegetables

A lot of fields that are growing forage or grass have the potential of being farmed with higher value crops such as tree fruits, grapes or vegetables. This scenario determines the difference in water demand if half of the forage area were converted into these other crops, split evenly between the three, and if the converted area was irrigated with drip systems.

Comparing Table A8 with A17, apples have increased by 1048 hectares, grapes by 1036 hectares and vegetables by 1102 hectares. Comparing Table A9 and A18, drip has increased by 3194 hectares and other irrigation systems that were irrigating forage have decreased.

Crop water demand, using 2003 data, has gone from 143,723,108 m^3 to 126,063,104 m^3, a reduction of 17, 660,000 m^3 or 12%.

Future Demand

Future demand was calculated using climate data from the range of Global Climate Models (GCMs) described earlier. In all cases, the effects of future climates on irrigation water demand were compared to those modelled for the historic period (1961-2006).

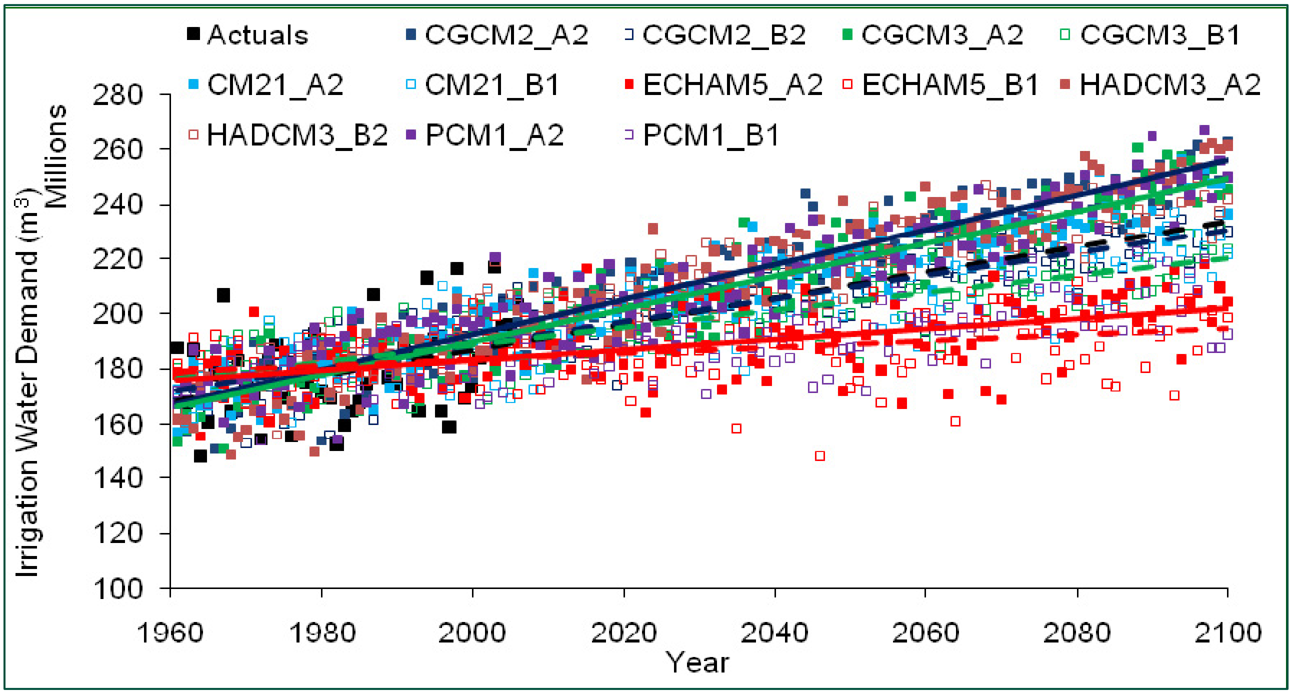

Figure15 Future irrigation demand for all outdoor uses in the Okanagan Basin in response to observed climate data (Actuals) and future climate data projected from a range of Global Climate Models.

The irrigation season in Figure 15 is not restricted for the GCM scenarios. All scenarios have moderate irrigation practice. Solid lines represent trends in A2 scenarios and dashed B1 or B2 scenarios (blue CGCM2; green CGCM3; red ECHAM5). The black dashed line is the trend in the actual water demand (1990 to 2006) extended to 2100.

Using the land use and irrigation system information for 2006-07 described previously, irrigation demand for all outdoor water uses (agriculture, parks, golf courses, private dwellings (domestic)) was simulated for observed climate data (Actuals) from 1961 to 2006 and for GCM climate data from 1961 to 2100. Water demand ranged from around 150 to 217 million cubic meters between 1961 and 2006 in response to observed climate data (Figure 13). The effect of the upward trend seen in the observed temperature data is evident in the 'actuals' water demand estimates in Figure 15. This trend carried out to 2010 (back dashed line), falls in the middle of the GCM based estimates which on average range between 192 and 256 million cubic meters by 2100 i.e. an increase of around 33%. The peak simulated demand over the time period 1961-2100 is 266 million cubic meters reached in the 2090s (PCM1_A2) and the lowest simulated demand is 148 million cubic meters in the 2040s (ECHAM_B1). Domestic household out-door water use comprises approximately 30% of total irrigation demand. Trends for all other uses (agriculture, parks and golf courses) follow the same pattern as total irrigation demand (Figure 14). The peak demand by 2100 is around 195 million cubic meters. The agricultural water demands modelled here are considerably lower than the the current water volume licensed to agriculture in the BCMOE water database (327 million cubic metres). Recorded water uses were higher than shown in Figure 14 in some agricultural regions in the period prior to 1991, but this was likely associated with less efficient irrigation systems than those simulated here (Neilsen et al., 2006). However, localized water shortages have occurred in the past when supply has not been sufficient to meet demand. In 1998 and 2003, high summer temperatures and low precipitation produced the highest simulated demands between 1961 and 2006. Recorded irrigation water use was also high in these years (Neilsen et al., 2006) and water shortages occurred in some jurisdictions in 2003 when stored water was insufficient to meet requirements, resulting in watering restrictions for all users. Conservative techniques including irrigation scheduling and the use of the most efficient irrigation technology for each type of crop production in agriculture and low water use landscaping for domestic users user will likely be required to ensure future adequate supply and to protect ecosystem requirements.

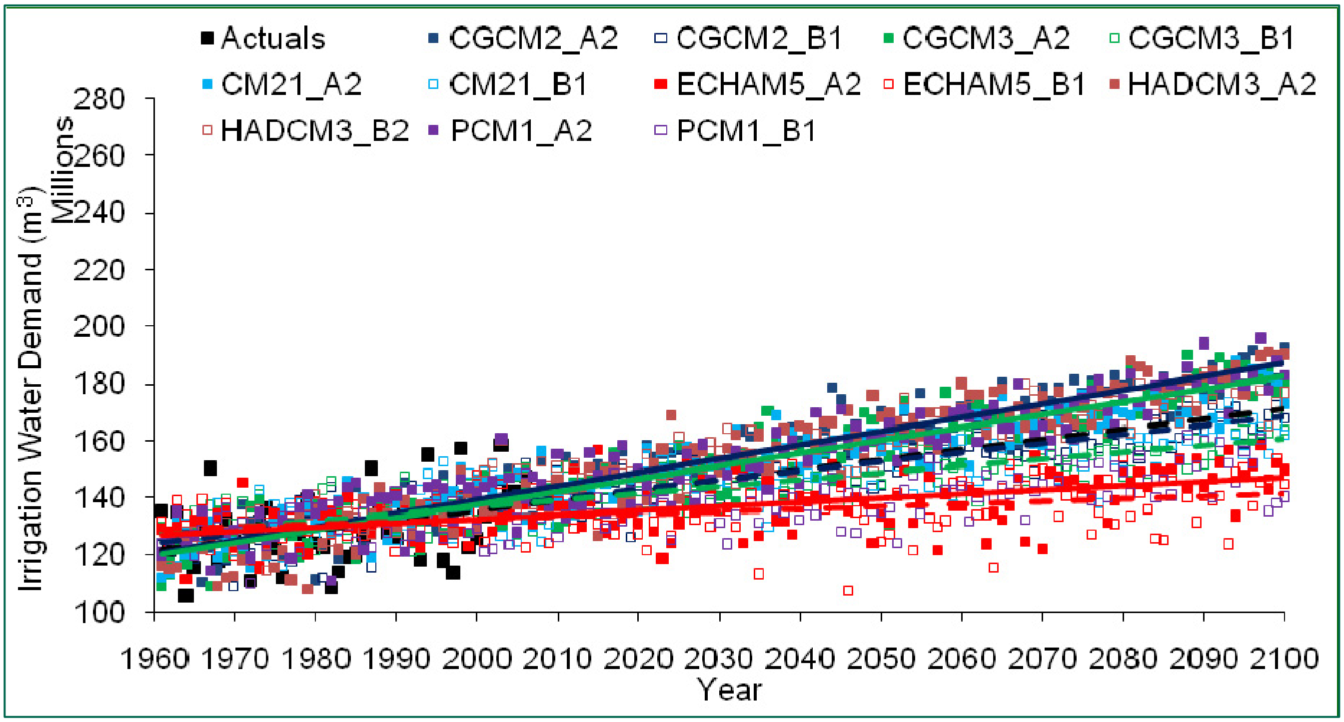

Figure 16 **Future irrigation demand for non- domestic outdoor uses in the Okanagan Basin in response to observed climate data (Actuals) and future climate data projected from a range of Global Climate Models.**

The irrigation season is not restricted for the GCM scenarios in Figure 16. All scenarios have moderate irrigation practice. Solid lines represent trends in A2 scenarios and dashed B1 or B2 scenarios (blue CGCM2; green CGCM3; red ECHAM5). The black dashed line is the trend in the actual water demand (1990 to 2006) extended to 2100.

Examples from the water demand model used to simulate the effects of changing management practices are given in Figures 17 and 18. These particular scenarios apply only to the agricultural sector, and are meant to illustrate the scope of the water demand model. This is by no means an exhaustive exploration of potential responses to water management issues and many other scenarios including all users are currently being developed. For the historic period, with observed climate data, removing restrictions on the irrigation season had the greatest effect on total water use, closely followed by poor water management techniques, e.g. not scheduling irrigation to meet plant water demands (Figure 17). The average management practice line is the same as the 'Actuals' data plotted on Figures 16 and 15. Good management practice, i.e. paying careful attention to irrigation scheduling reduced overall demand, but the largest water savings potentially occurred by improving irrigation system efficiency – in this example by changing horticultural crops to drip irrigation.

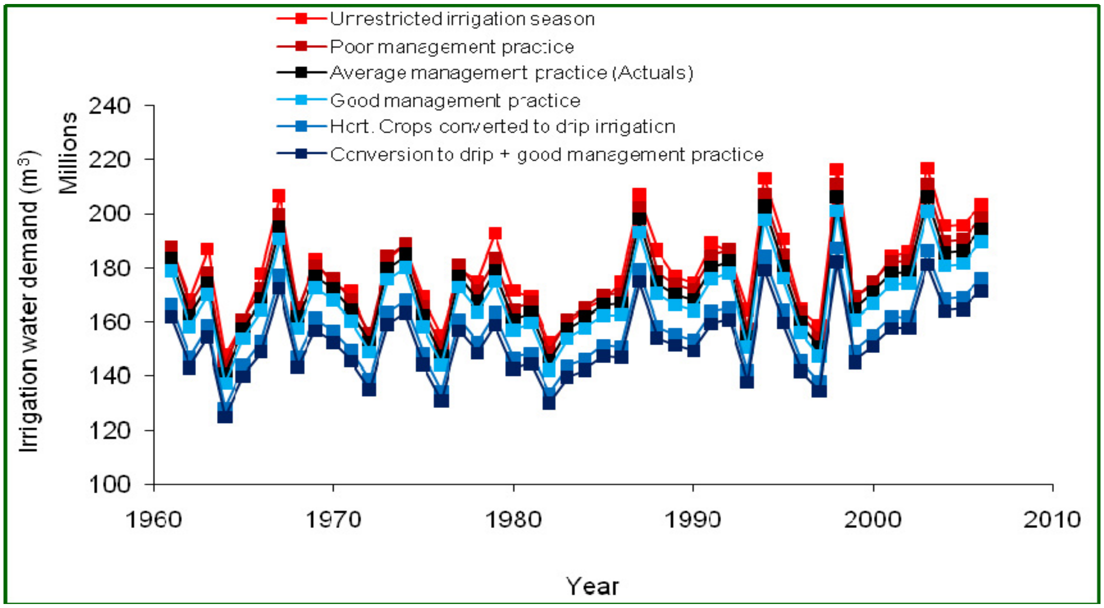

Figure 17 Simulated irrigation water demand for historic climate data under a range of management practices.

The effects of changing management practices under three GCM climate scenarios are illustrated in Figure 18. CGCM2_A2 provides a high water use scenario, CGCM2_B2 is a moderate water use scenario, which appears to mimic the observed water use pattern, and ECHAM5_B1 is a low water use scenario, which appears less likely to occur when considering historic water use patterns. In the most extreme climate scenario (CGCM2_A2), restricting the growing season and applying good irrigation practice similarly reduce water demand by around 5% by the 2100. Using more efficient irrigation systems reduces water use by 14%, even with an unrestricted irrigation season, which brings demand back into the range observed for the end of the historic period 1990-2006. It appears that the effects of changes in climate on irrigation demand can likely be mitigated by changes in irrigation management. However, previous studies have shown that the effects of climate change and variability on supply may be sufficiently high to prevent demand being met in some years (Neilsen et al., 2006; Merritt et al., 2006). These issues are currently being addressed in the Okanagan Water Supply Demand Study (http://www.obwb.ca/water_supply_demand/).

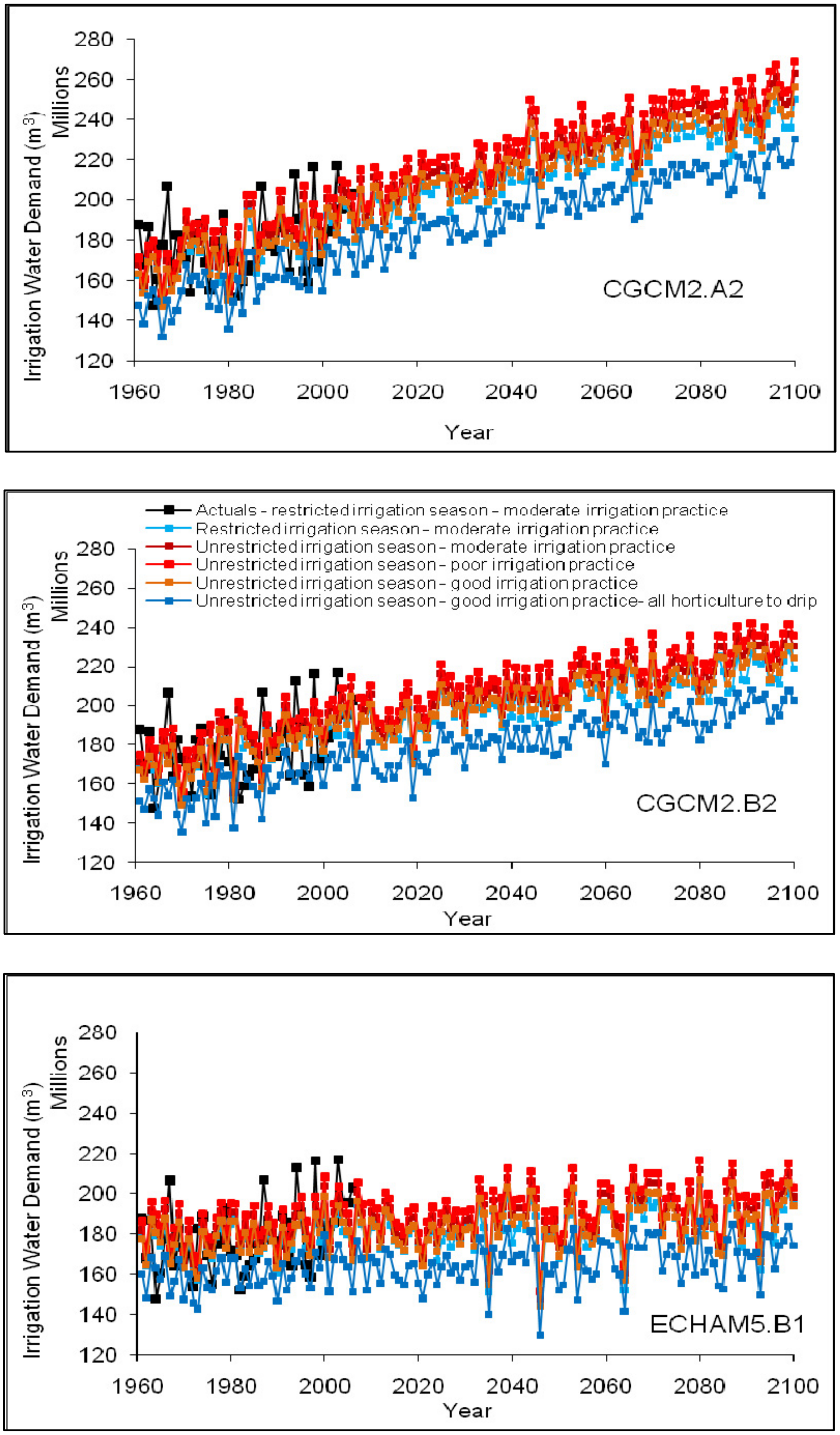

Figure18 Simulated irrigation water demand for GCM climate data under a range of management practices using high (CGCM2_A2), moderate (CGCM2_B2) and low (ECHAM5_B1) temperature scenarios

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Appendix A

Table 5 Summary of Appendix A Tables		
Scenario	**Reporting**	**Year**
Table A1 Water Demand - Crops currently irrigated	By Crop – Average Management	2003
Table A2 Water Demand - Irrigation systems used	By Irrigation System – Average Management	2003
Table A3 Water Demand - Soils irrigated	By Soil Type – Average Management	2003
Table A4 Water Demand – Water purveyors	By Water purveyor - Average Management	2003
Table A5 Water Demand – Local Government	By Local Government - Average Management	2003
Table A6 Water Demand – Management Factors	By Poor, Average and Good Management	1997, 2003, 2006
Table A7 Percolation Rates	By Irrigation System	2003
Table A8 Current Demand – Systems currently used and not used	By Crop – Average Management	2003
Table A9 Current Demand – Systems currently used and not used	By Irrigation System – Average Management	2003
Table A10 Crop and Irrigation System Comparison – all irrigation systems being used	Comparison of acreage increase when all current irrigation systems are being used	2003
Table A11 Future Increased Irrigated Acreage - Crop	By Crop – Average management - 2040	2003
Table A12 Future Increase Irrigated Acreage – Management Factors	By Average and Good Management - 2040	2003
Table A13 Future Increased Irrigated Acreage-Irrigation System	By Irrigation System – 2040	2003
Table A14 Irrigation Demand – Horticulture Converted to Drip	By Irrigation Systems Type, Average and Good Management	2003
Table 15 Water Demand – Half Tree fruits Converted to Grape using only drip systems	By Crop – Average Management	2003
Table A16 Water demand – Half Tree Fruits Converted to Grape using only drip systems	By Irrigation System – Average Management	2003
Table A17 Water Demand – Half of Forage Converted to Tree Fruits, Grapes and Vegetables	By Crop – Average Management – converted crops are drip irrigated	2003
Table A18 Water Demand – Half of Forage Converted to Tree Fruits, Grapes and Vegetables	By Irrigation System - Average Management – converted crops are drip irrigated	2003

Table A1 Crop Water Demand 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Crop Group**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Alfalfa	1,275	9,010,934	707	96	647,964	677	852	5,767,594	677	2,222	**15,426,491**	694
Apple	4,070	29,174,202	717	-	-	-	211	1,511,750	717	4,281	**30,685,952**	717
Berry	44	291,916	672	-	-	-	18	110,656	603	62	**402,572**	651
Cherry	1,074	8,120,474	756	-	-	-	45	367,359	819	1,119	**8,487,833**	759
Corn	409	1,956,321	479	23	120,830	525	189	821,606	436	620	**2,898,757**	468
Forage	2,964	27,446,657	926	429	4,132,948	964	1,703	13,877,787	815	5,096	**45,457,392**	892
Fruit	792	6,576,735	830	-	-	-	102	771,618	759	894	**7,348,354**	822
Grape	2,290	9,780,281	427	6	15,923	250	436	1,863,362	427	2,733	**11,659,566**	427
Nursery	253	2,543,339	1,006	185	1,263,641	684	127	1,047,376	823	565	**4,854,356**	859
Turf Farm	60	606,512	1,008	-	-	-	46	414,190	911	106	**1,020,702**	966
Vegetable	370	2,732,012	739	-	-	-	137	845,546	618	507	**3,577,558**	706
Inactive	190	-	-	0	-	-	23	-	-	213	**-**	-
	13,790	98,239,383		739	6,181,306		3,887	27,398,844		18,416	**131,819,533**	
Turf												
Golf	446	4,471,113	1,002	298	3,095,884	1,041	317	3,095,360	977	1,061	**10,662,357**	1,005
Landscape Turf	488	4,779,235	980	17	172,714	1,004	101	973,438	960	607	**5,925,388**	977
Domestic Outdoor	5,169	50,987,109	986	0	1,312	1,006	741	7,578,839	1,023	5,910	**58,567,260**	991
	6,104	60,237,457		315	3,269,910		1,159	11,647,637		7,577	**75,155,005**	
Total	**19,893**	**158,476,840**	**797**	**1,054**	**9,451,216**	**897**	**5,046**	**39,046,481**	**774**	**25,993**	**206,974,538**	796

Table A2 Irrigation System Demand 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**
Irrigation Type	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**
	(ha)	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**
Drip	1,306	5,537,529	424	71	324,317	460	146	579,729	397	1,522	**6,441,575**	423
Gun	203	2,295,767	1,132	16	215,014	1,349	54	681,592	1,265	273	**3,192,373**	1,171
Handline	1,020	8,313,920	815	30	285,950	955	328	2,784,921	849	1,377	**11,384,792**	827
Microspray	437	2,956,805	677	-	-	-	29	196,382	685	465	**3,153,187**	678
Microsprinkler	1,467	10,246,902	698	-	-	-	90	590,922	659	1,557	**10,837,824**	696
Overtreedrip	193	900,760	468	6	34,952	588	27	100,511	369	226	**1,036,223**	459
Overtreemicro	17	125,182	757	-	-	-	-	-	-	17	**125,182**	757
Pivot	328	1,825,295	557	-	-	-	107	642,587	600	435	**2,467,882**	567
PivotLP	4	29,378	736	-	-	-	2	12,945	628	6	**42,324**	699
SDI	43	236,715	554	-	-	-	-	-	-	43	**236,715**	554
Sprinkler	2,469	19,717,409	799	125	944,397	755	1,361	9,553,260	702	3,955	**30,215,066**	764
Ssgun	18	99,128	548	-	-	-	-	-	-	18	**99,128**	548
Ssovertree	2,720	17,331,191	637	6	46,902	777	353	2,091,975	593	3,079	**19,470,068**	632
Sssprinkler	114	896,328	790	-	-	-	25	134,815	542	138	**1,031,143**	745
Ssundertree	1,711	14,159,404	828	47	347,444	739	76	593,545	782	1,834	**15,100,393**	823
Subirrig	67	464,008	697	-	-	-	131	734,616	559	198	**1,198,625**	606
Travgun	844	6,640,803	787	302	2,920,141	968	690	4,951,837	718	1,835	**14,512,782**	791
Wheelline	972	7,790,052	802	137	1,062,191	775	505	4,091,520	810	1,614	**12,943,762**	802
	13,928	99,566,576		739	6,181,308		3,924	27,741,157		18,591	**133,489,044**	
Turf												
GolfSprinkler	446	4,471,113	1,002	298	3,095,884	1,041	315	3,075,845	978	1,058	**10,642,842**	1,006
Landscapesprinkler	5,519	54,439,150	986	17	174,026	1,004	807	8,229,479	1,019	6,343	**62,842,655**	991
	5,965	58,910,263		315	3,269,910		1,122	11,305,324		7,402	**73,485,497**	
Total	**19,893**	**158,476,839**	**797**	**1,054**	**9,451,218**	**897**	**5,046**	**39,046,481**	**774**	**25,993**	**206,974,541**	796

Table A3 Water Demand by Soil Type 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Soil Texture**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Clay	721	5,278,724	732	198	1,396,695	705	823	4,993,684	607	1,742	**11,669,103**	670
Fine Sandy Loam	27	229,852	840	4	20,886	507	17	143,318	845	48	**394,056**	813
Heavy Clay	682	4,645,941	681	-	-	-	27	219,986	824	709	**4,865,928**	686
Loam	1,516	11,505,279	759	54	555,109	1,023	496	3,910,127	788	2,067	**15,970,516**	773
Loamy Sand	2,525	21,407,685	848	60	624,505	1,050	447	3,690,046	826	3,031	**25,722,236**	849
Organic	173	1,375,843	797	-	-	-	152	1,079,831	709	325	**2,455,674**	756
Sand	28	281,947	998	-	3,956	1,063	1	11,071	1,078	30	**296,973**	1,002
Sandy Clay Loam	23	214,146	947	-	-	-	-	895	932	23	**215,041**	947
Sandy Loam	8,983	70,575,938	786	411	3,735,339	909	1,848	15,914,753	861	11,242	**90,226,029**	803
Sandy Loam (defaulted)	2,985	27,549,689	923	276	2,698,392	978	541	4,392,925	812	3,801	**34,641,005**	911
Silt Loam	1,337	9,434,579	706	12	94,582	763	320	2,291,181	715	1,669	**11,820,342**	708
Silty Clay	66	557,876	852	35	296,177	858	196	1,186,278	606	296	**2,040,331**	690
Silty Clay Loam	547	3,647,836	667	4	25,577	652	136	984,145	723	687	**4,657,558**	678
Very Coarse Sandy Loam	1	6,539	1,056	-	-	-	-	-	-	1	**6,539**	1,056
Very Fine Sandy Loam	281	1,764,965	629	-	-	-	43	228,243	536	323	**1,993,208**	616
Total	**19,894**	**158,476,839**	**797**	**1,054**	**9,451,218**	**897**	**5,046**	**39,046,483**	**774**	**25,993**	**206,974,539**	**796**

Table A4 - Water Demand by Purveyor 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**
Purveyor	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**
	(ha)	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**
Alto Utility	12	124,892	1,029	-	-	-	19	190,536	1,031	31	**315,427**	1,030
Antler Beach	-	-	-	-	-	-	1	9,504	954	1	**9,504**	954
Black Mountain Irrigation District	1,214	9,641,438	795	-	-	-	183	1,530,482	838	1,396	**11,171,920**	800
Boundary Line Irrigation District	35	266,339	771	-	-	-	-	-	-	35	**266,339**	771
Bylaw 1083 - Sunnyside	83	338,928	409	-	-	-	14	116,675	835	97	**455,603**	471
Bylaw 434 - Killiney Beach	72	695,330	970	-	-	-	-	-	-	72	**695,330**	970
Bylaw 571 - Dietrich (Star Place)	3	32,080	932	-	-	-	-	-	-	3	**32,080**	932
Bylaw 597 - West Kelowna Estates	37	371,815	1,002	-	-	-	0	1,140	969	37	**372,955**	1,002
Bylaw 695 - Westshore Estates	22	219,024	990	0	1,216	1,003	14	143,286	996	37	**363,526**	992
Bylaw 793 - Pritchard/Shanboolard	27	224,234	843	-	-	-	-	-	-	27	**224,234**	843
City of Armstrong	10	98,074	954	77	464,786	605	121	1,135,063	936	208	**1,697,923**	815
City of Kelowna	813	8,239,054	1,014	-	-	-	-	-	-	813	**8,239,054**	1,014
City of Penticton	884	6,643,002	752	34	359,707	1,074	-	-	-	918	**7,002,709**	763
Corp. of the District of	1,331	10,741,233	807	-	-	-	-	322	1,081	1,332	**10,741,555**	807
Eagle Rock Waterworks District	12	119,634	1,002	-	-	-	56	536,746	953	68	**656,380**	961
Eastside Utility Ltd.	104	857,906	822	-	-	-	-	-	-	104	**857,906**	822
Edgewater Pines	-	-	-	-	-	-	1	6,620	947	1	**6,620**	947
Faulder Comunity System	57	535,650	941	-	-	-	4	36,135	907	61	**571,785**	938
Former Naramata Irrigation District	322	2,105,389	654	-	-	-	-	-	-	322	**2,105,389**	654
Future BMID	43	358,842	832	-	-	-	-	-	-	43	**358,842**	832
Future City of Kelowna	138	939,567	683	-	-	-	-	-	-	138	**939,567**	683
Future GEID	74	548,093	740	-	-	-	-	-	-	74	**548,093**	740
Future SEKID	4	38,701	1,010	-	-	-	3	28,336	1,071	7	**67,037**	1,035
Glenmore Ellison Improvement	989	7,278,133	736	-	-	-	40	327,842	818	1,029	**7,605,975**	739
Golder Arrow Trailer Park	-	-	-	-	-	-	1	8,515	1,108	1	**8,515**	1,108
Grandview Waterworks District	55	525,053	954	-	-	-	169	1,281,809	757	224	**1,806,863**	805
Greater Vernon Water Utility	3,054	26,334,237	862	747	6,874,234	921	339	2,869,546	847	4,139	**36,078,016**	872
Greystokes	-	-	-	-	-	-	2	12,945	628	2	**12,945**	628
Idle-O-Apartments	-	-	-	-	-	-	1	12,228	1,151	1	**12,228**	1,151
Jennens	0	2,997	1,014	-	-	-	11	84,884	789	11	**87,881**	795
Kaleden Irrigation District	127	947,801	747	-	-	-	-	-	-	127	**947,801**	747
Lakeshore Waterworks District	-	-	-	-	-	-	22	222,268	1,034	22	**222,268**	1,034

Table A4 continued - Water Demand by Purveyor 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	Water Licence			Reclaimed Water			Groundwater			Total		
Agriculture	Irrigated	Irrigation	Average	Irrigated	Irrigation	Average	Irrigated	Irrigation	Average	Irrigated	Irrigation	Average
Purveyor	Area	Demand	Req.	Area	Demand	Req.	Area	Demand	Req.	Area	Demand	Req.
	(ha)	(m3)	(mm)	(ha)	(m3)	(mm)	(ha)	(m3)	(mm)	(ha)	(m3)	(mm)
Lakeview Irrigation District	278	2,326,300	838	-	-	-	0	2,601	997	278	**2,328,901**	838
Larkin Waterworks District	165	1,415,226	856	76	434,557	571	248	1,323,698	533	490	**3,173,481**	648
Lower Nipit Improvement District	26	216,984	825	-	-	-	-	-	-	26	**216,984**	825
Meadow Valley Irrigation District	109	960,488	885	-	-	-	-	-	-	109	**960,488**	885
Municipality of Lake Country	1,898	15,649,953	825	-	-	-	1	8,969	1,023	1,899	**15,658,922**	825
Municipality of Peachland	231	2,022,068	874	-	-	-	-	-	-	231	**2,022,068**	874
Okanagan Falls Irrigation District	0	2,658	1,103	-	-	-	46	453,945	990	46	**456,603**	990
Okanagan Landing Utilities	-	-	-	-	-	-	-	437	1,002	-	**437**	1,002
Osoyoos Irrigation District	148	1,085,224	735	-	-	-	-	-	-	148	**1,085,224**	735
Peachland Ponderosa	-	-	-	-	-	-	20	182,852	940	20	**182,852**	940
Rolling Hills Water Works District	-	-	-	-	-	-	17	70,568	428	17	**70,568**	428
Rutland Water Works	3	28,594	1,062	-	-	-	164	1,763,486	1,075	167	**1,792,080**	1,075
Sage Mesa Water System	40	402,515	1,007	-	-	-	5	46,549	986	45	**449,064**	1,004
Shuttleworth Creek Irrigation	4	27,710	732	-	-	-	-	-	-	4	**27,710**	732
Skaha Estates Improvement	13	131,050	1,051	-	-	-	-	-	-	13	**131,050**	1,051
South East Kelowna Irrigation	1,564	12,183,577	779	-	-	-	0	4,147	1,095	1,564	**12,187,724**	779
South Okanagan Mission	24	142,264	584	-	-	-	26	167,479	639	51	**309,743**	613
St Andrews Utility	-	-	-	-	-	-	15	161,805	1,088	15	**161,805**	1,088
Steele Springs Waterworks	90	929,795	1,032	-	-	-	2	22,260	1,055	92	**952,055**	1,032
Sun Valley Improvement District	4	48,062	1,102	-	-	-	32	144,042	456	36	**192,103**	534
Town of Oliver	65	515,779	795	50	500,355	998	57	639,298	1,119	172	**1,655,433**	962
Town of Oliver Water Works	1,146	8,811,153	769	-	-	-	11	91,068	832	1,157	**8,902,221**	770
Town of Osoyoos	98	868,413	889	71	816,362	1,153	46	529,532	1,144	215	**2,214,307**	1,031
Town of Osoyoos Water Works	502	4,186,531	833	-	-	-	15	162,654	1,092	517	**4,349,186**	841
Twin Lakes Water Utility	-	-	-	-	-	-	39	372,986	967	39	**372,986**	967
Vaseux Lake Imrovement District	-	-	-	-	-	-	2	16,335	1,058	2	**16,335**	1,058
Weeping Willow Mobile Home	-	-	-	-	-	-	1	7,226	1,123	1	**7,226**	**1,123**
West Bench Irrigation District	83	753,432	905	-	-	-	-	-	-	83	**753,432**	**905**
Westbank Irrigation District	394	3,364,777	854	-	-	-	1	6,311	1,014	395	**3,371,088**	854
Whitewood Neighborhood	-	-	-	-	-	-	3	29,538	921	3	**29,538**	921
Willow Beach Utility	-	-	-	-	-	-	2	24,448	1,164	2	**24,448**	1,164
Purveyor Total	**16,406**	**134,299,999**	**819**	**1,054**	**9,451,217**	**897**	**1,751**	**14,787,116**	**845**	**19,211**	**158,538,332**	**825**

Table A4 continued - Water Demand by Purveyor 2003

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	Water Licence			Reclaimed Water			Groundwater			Total		
Agriculture / First Nations	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)
Okanagan Indian Band Reserve 1	-	-	-	-	-	-	89	847,283	948	89	**847,283**	948
Osoyoos Indian Band	699	4,149,517	594	-	-	-	-	-	-	699	**4,149,517**	594
Penticton Indian Band Reserve 1	76	663,677	870	-	-	-	21	213,476	1,024	97	**877,152**	903
Westbank First Nation	27	248,444	924	-	-	-	-	-	-	27	**248,444**	924
First Nations Total	**802**	**5,061,638**	**631**	**-**	**-**	**-**	**110**	**1,060,759**	**962**	**912**	**6,122,396**	**671**
Private	2,685	19,115,203	712	-	-	-	3,185	23,198,605	728	5,870	**42,313,808**	721
Basin Total	**19,893**	**158,476,840**	**797**	**1,054**	**9,451,217**	**897**	**5,046**	**39,046,480**	**774**	**25,993**	**206,974,536**	**796**

Table A5 - Total Basin Water Demand by Local Government - Indoor and Outdoor

Year: 2003	Okanagan Basin - Outdoor Water Use - Average Irrigation Management											
Water Source	Water Licence			Reclaimed Water			Groundwater			Total		
Outdoor Irrigation / Local Government	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)
CORD	1,744	13,999,284	803	0	1,216	1,003	270	2,384,348	883	2,014	**16,384,847**	813
CSRD	42	244,325	589	-	-	-	135	990,741	736	176	**1,235,066**	701
KBRD	36	79,920	225	-	-	-	104	579,439	556	140	**659,359**	472
KELOWNA	4,423	36,099,027	816	-	-	-	930	8,447,340	909	5,353	**44,546,367**	832
LAKE COUNTRY	2,041	16,913,594	829	-	-	-	75	754,627	1,000	2,117	**17,668,222**	835
NORD	3,272	26,983,795	825	360	2,709,802	752	2,202	15,578,632	708	5,834	**45,272,229**	776
PEACHLAND	225	1,979,157	880	-	-	-	21	198,977	941	246	**2,178,134**	885
PENTICTON	884	6,644,507	751	27	300,088	1,096	-	-	-	912	**6,944,594**	762
RDOS	4,399	33,029,494	751	127	1,376,336	1,083	1,295	9,976,372	770	5,821	**44,382,202**	762
INDIAN RESERVE	741	4,546,001	613	-	-	-	-	-	-	741	**4,546,001**	613
SUMMERLAND	1,372	11,051,672	806	-	-	-	-	322	1,081	1,372	**11,051,994**	806
VERNON	714	6,906,066	968	539	5,063,774	940	14	135,684	972	1,267	**12,105,524**	956
Total Outdoor	**19,893**	**158,476,842**	**8,856**	**1,054**	**9,451,216**	**4,874**	**5,046**	**39,046,482**	**8,556**	**25,993**	**206,974,539**	**796**

Table A6 - Irrigation Water Demand - Management Factors

Okanagan Basin - Irrigation Management Comparison												
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Management	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Average Management												
1997	19,893	115,959,507	583	1,054	6,763,952	642	5,046	29,075,137	576	25,993	**151,798,596**	584
2003	19,893	158,476,840	797	1,054	9,451,216	897	5,046	39,046,483	774	25,993	**206,974,539**	796
2006	19,893	149,173,230	750	1,054	8,881,785	843	5,046	36,848,484	730	25,993	**194,903,499**	750
Poor Management												
2003	19,893	162,294,233	816	1,054	9,687,104	919	5,046	39,856,852	790	25,993	**211,838,188**	815
Good Management												
2003	19,893	154,659,448	777	1,054	9,215,329	874	5,046	38,236,113	758	25,993	**202,110,890**	778

Table A7 - Percolation Rates

Okanagan Basin - Deep Percolation														
Year: 2003	**Water Source**	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**			
Agriculture	**Irrigation**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Percolation (m3 / hectare)**
Irrigation Type	**Management**													
Drip	Poor	1,541	6,792,890	717,782	76	367,134	32,126	173	693,732	69,800	1,791	7,853,755	**819,707**	458
	Average	1,541	6,675,004	599,895	76	359,269	24,262	173	680,240	56,310	1,791	7,714,513	**680,465**	380
	Good	1,541	6,557,119	482,009	76	351,404	16,397	173	666,749	42,818	1,791	7,575,272	**541,223**	302
Gun	Poor	221	2,470,985	481,686	16	219,398	49,539	54	702,078	155,131	291	3,392,461	**686,356**	2,360
	Average	221	2,394,895	405,594	16	215,014	45,155	54	681,592	134,645	291	3,291,501	**585,395**	2,013
	Good	221	2,318,804	329,504	16	210,629	40,771	54	661,107	114,160	291	3,190,540	**484,435**	1,666
Handline	Poor	1,020	8,514,874	1,220,058	30	303,820	59,566	328	2,849,443	396,158	1,377	11,668,137	**1,675,781**	1,217
	Average	1,020	8,313,920	1,019,103	30	285,950	41,696	328	2,784,921	331,636	1,377	11,384,792	**1,392,436**	1,011
	Good	1,020	8,112,966	818,149	30	268,080	23,826	328	2,720,400	267,115	1,377	11,101,446	**1,109,091**	805
Microspray	Poor	453	3,159,340	383,941	-	-	-	29	200,666	24,030	482	3,360,005	**407,972**	847
	Average	453	3,081,987	306,588	-	-	-	29	196,382	19,747	482	3,278,369	**326,335**	677
	Good	453	3,004,634	229,235	-	-	-	29	192,098	15,463	482	3,196,732	**244,698**	508
Microsprinkler	Poor	1,467	10,574,950	1,273,431	-	-	-	90	610,039	72,869	1,557	11,184,989	**1,346,299**	865
	Average	1,467	10,246,902	945,382	-	-	-	90	590,922	53,752	1,557	10,837,824	**999,134**	642
	Good	1,467	9,918,854	617,334	-	-	-	90	571,805	34,635	1,557	10,490,659	**651,969**	419
Pivot	Poor	332	1,858,422	139,750	-	-	-	109	655,811	57,066	441	2,514,232	**196,815**	446
	Average	332	1,854,673	136,001	-	-	-	109	655,532	56,788	441	2,510,206	**192,789**	437
	Good	332	1,850,925	132,253	-	-	-	109	655,254	56,509	441	2,506,179	**188,762**	428
Sprinkler	Poor	2,469	20,210,718	3,312,165	125	986,208	163,202	1,361	9,777,248	1,366,509	3,955	30,974,174	**4,841,876**	1,224
	Average	2,469	19,717,409	2,818,855	125	944,397	121,391	1,361	9,553,260	1,142,521	3,955	30,215,066	**4,082,768**	1,032
	Good	2,469	19,224,100	2,325,546	125	902,586	79,580	1,361	9,329,272	918,534	3,955	29,455,958	**3,323,660**	840

Table A7 continued - Percolation Rates

Okanagan Basin - Deep Percolation														
Year: 2003	**Water Source**	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**			
Agriculture	**Irrigation**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Deep Percolation (m3)**	**Percolation (m3 / hectare)**
Irrigation Type	**Management**													
Ssovertree	Poor	2,833	18,957,110	2,549,961	6	47,959	4,214	378	2,312,211	290,464	3,217	21,317,280	**2,844,639**	884
	Average	2,833	18,227,519	1,820,371	6	46,902	3,157	378	2,226,790	205,043	3,217	20,501,211	**2,028,570**	631
	Good	2,833	17,497,929	1,090,780	6	45,845	2,100	378	2,141,369	119,622	3,217	19,685,143	**1,212,502**	377
Ssundertree	Poor	1,711	14,751,798	1,960,086	47	362,387	45,262	76	618,294	80,356	1,834	15,732,479	**2,085,704**	1,137
	Average	1,711	14,159,404	1,367,692	47	347,444	30,319	76	593,545	55,607	1,834	15,100,393	**1,453,618**	793
	Good	1,711	13,567,009	775,297	47	332,501	15,376	76	568,796	30,858	1,834	14,468,306	**821,531**	448
Subirrig	Poor	67	476,375	66,588	-	-	-	131	752,008	89,328	198	1,228,382	**155,916**	788
	Average	67	464,008	54,222	-	-	-	131	734,616	71,937	198	1,198,625	**126,158**	637
	Good	67	451,642	41,856	-	-	-	131	717,225	54,545	198	1,168,867	**96,401**	487
Travgun	Poor	844	6,830,479	967,798	302	2,994,538	448,672	690	5,066,227	601,858	1,835	14,891,244	**2,018,327**	1,100
	Average	844	6,640,803	778,122	302	2,920,141	374,275	690	4,951,837	487,467	1,835	14,512,782	**1,639,865**	894
	Good	844	6,451,128	588,447	302	2,845,744	299,878	690	4,837,447	373,077	1,835	14,134,319	**1,261,402**	687
Wheelline	Poor	972	7,989,552	1,083,654	137	1,084,773	138,996	505	4,187,357	567,551	1,614	13,261,682	**1,790,202**	1,109
	Average	972	7,790,052	884,153	137	1,062,191	116,414	505	4,091,520	471,714	1,614	12,943,762	**1,472,282**	912
	Good	972	7,590,551	684,653	137	1,039,609	93,832	505	3,995,682	375,877	1,614	12,625,842	**1,154,362**	715
Turf														
GolfSprinkler	Poor	446	4,527,234	840,152	298	3,145,547	649,551	315	3,117,839	586,353	1,058	10,790,620	**2,076,055**	1,962
	Average	446	4,471,113	784,031	298	3,095,884	599,888	315	3,075,845	544,359	1,058	10,642,842	**1,928,278**	1,822
	Good	446	4,414,993	727,911	298	3,046,221	550,225	315	3,033,851	502,364	1,058	10,495,065	**1,780,500**	1,682
Landscapesprinkler	Poor	5,519	55,179,505	11,288,450	17	175,342	30,058	807	8,313,901	1,617,725	6,343	63,668,747	**12,936,233**	2,039
	Average	5,519	54,439,150	10,548,095	17	174,026	28,742	807	8,229,479	1,533,304	6,343	62,842,655	**12,110,140**	1,909
	Good	5,519	53,698,795	9,807,740	17	172,710	27,426	807	8,145,058	1,448,882	6,343	62,016,563	**11,284,048**	1,779
Total	Poor	19,893	162,294,233	26,285,499	1,054	9,687,104	1,621,186	5,046	39,856,852	5,975,198	25,993	211,838,188	**33,881,882**	1,303
	Average	19,893	158,476,840	22,468,106	1,054	9,451,216	1,385,298	5,046	39,046,483	5,164,829	25,993	206,974,539	**29,018,233**	1,116
	Good	**19,893**	**154,659,448**	**18,650,714**	**1,054**	**9,215,329**	**1,149,411**	**5,046**	**38,236,113**	**4,354,460**	**25,993**	202,110,890	**24,154,584**	929

Table A8 Crop Water Demand - All Properties with Irrigation Systems Irrigated

Year: 2003	Okanagan Basin - Average Irrigation Management											
Crop Type	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Crop Group**	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)
Alfalfa	1,317	9,308,304	707	96	647,964	677	950	6,382,746	672	2,363	**16,339,013**	691
Apple	4,083	29,255,799	717	-	-	-	211	1,511,750	717	4,293	**30,767,550**	717
Berry	44	291,916	672	-	-	-	18	110,656	603	62	**402,572**	651
Cherry	1,076	8,133,972	756	-	-	-	45	367,359	819	1,121	**8,501,331**	758
Corn	413	1,979,627	480	23	120,830	525	189	821,606	436	624	**2,922,064**	468
Forage	3,614	34,028,041	942	432	4,158,652	964	2,150	18,078,450	841	6,196	**56,265,143**	908
Fruit	796	6,600,011	829	-	-	-	102	771,618	759	898	**7,371,630**	821
Grape	2,292	9,786,191	427	6	15,923	250	436	1,863,362	427	2,734	**11,665,477**	427
Nursery	253	2,546,821	1,006	185	1,263,641	684	127	1,047,376	823	565	**4,857,838**	859
Turf Farm	60	606,512	1,008	-	-	-	46	414,190	911	106	**1,020,702**	966
Vegetable	374	2,764,242	739	-	-	-	137	845,546	618	511	**3,609,788**	707
	14,321	105,301,436		742	6,207,010		4,410	32,214,659		19,473	**143,723,108**	
Turf												
Golf	447	4,472,158	1,002	299	3,107,412	1,041	319	3,117,737	977	1,064	**10,697,308**	1,005
Landscape Turf	509	4,995,583	982	17	172,714	1,004	102	978,027	960	628	**6,146,324**	979
Domestic Outdoor	5,169	50,987,109	986	0	1,312	1,006	741	7,578,839	1,023	5,910	**58,567,260**	991
	6,125	60,454,850		316	3,281,438		1,161	11,674,603		7,602	**75,410,892**	
Total	**20,446**	**165,756,286**	**811**	**1,057**	**9,488,448**	**897**	**5,572**	**43,889,262**	**788**	**27,075**	**219,134,000**	809

Table A9 Irrigation System Demand 2003 - All Properties with Irrigation Systems Irrigated

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Irrigation Type**	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)
Drip	1,311	5,568,431	425	71	324,317	460	146	579,729	397	1,528	**6,472,477**	424
Gun	239	2,595,748	1,087	16	215,014	1,349	54	681,592	1,265	309	**3,492,354**	1,131
Handline	1,051	8,633,615	822	30	285,950	955	412	3,432,402	833	1,493	**12,351,967**	827
Microspray	439	2,978,031	678	-	-	-	29	196,382	685	468	**3,174,413**	679
Microsprinkler	1,477	10,324,993	699	-	-	-	90	592,735	661	1,566	**10,917,728**	697
Overtreedrip	193	900,760	468	6	34,952	588	27	100,511	369	226	**1,036,223**	459
Overtreemicro	17	125,182	757	-	-	-	-	-	-	17	**125,182**	757
Pivot	328	1,825,295	557	-	-	-	107	642,587	600	435	**2,467,882**	567
PivotLP	4	29,378	736	-	-	-	2	12,945	628	6	**42,324**	699
SDI	43	236,715	554	-	-	-	-	-	-	43	**236,715**	554
Sprinkler	2,652	22,742,567	858	128	967,981	759	1,566	11,473,194	733	4,345	**35,183,743**	810
Ssgun	18	165,098	913	-	-	-	-	-	-	18	**165,098**	913
Ssovertree	2,761	18,009,532	652	6	46,902	777	359	2,195,769	611	3,126	**20,252,203**	648
Sssprinkler	114	935,482	825	-	-	-	25	253,902	1,021	138	**1,189,383**	860
Ssundertree	1,724	14,472,693	840	47	347,444	739	77	604,892	790	1,847	**15,425,030**	835
Subirrig	67	464,008	697	-	-	-	131	734,616	559	198	**1,198,625**	606
Travgun	935	7,557,098	808	302	2,920,141	968	874	6,575,840	753	2,110	**17,053,080**	808
Wheelline	1,090	9,071,395	832	137	1,064,310	777	549	4,479,875	816	1,776	**14,615,581**	823
	14,461	106,636,021		741	6,207,011		4,447	32,556,971		19,649	**145,400,008**	
Turf												
GolfSprinkler	447	4,472,158	1,002	298	3,095,884	1,041	315	3,081,474	978	1,059	**10,649,516**	1,006
Landscapesprinkler	5,539	54,648,107	987	18	185,554	1,014	810	8,250,816	1,019	6,367	**63,084,478**	991
	5,985	59,120,265		316	3,281,438		1,125	11,332,290		7,426	**73,733,994**	
Total	**20,446**	**165,756,286**	**811**	**1,057**	**9,488,449**	**897**	**5,572**	**43,889,261**	**788**	**27,075**	**219,134,002**	809

Table A10 Crop Irrigation System Comparison - All Properties with Irrigation Systems Being Irrigated

Water Source	Water Licence		Reclaimed Water		Groundwater		Total	
Agriculture	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)	Irrigated Area (ha)
Crop Group	2006	2040	2006	2040	2006	2040	2006	2040
Alfalfa	1,317	4,469	96	94	950	1,159	2,363	5,722
Apple	4,083	7,088	-	42	211	974	4,293	8,104
Berry	44	43	-	-	18	18	62	61
Cherry	1,076	1,024	-	-	45	54	1,121	1,078
Corn	413	411	23	20	189	182	624	613
Forage	3,614	3,446	432	407	2,150	2,086	6,196	5,939
Fruit	796	763	-	-	102	101	898	864
Grape	2,292	2,158	6	6	436	415	2,734	2,579
Nursery	253	241	185	185	127	127	565	553
Turf Farm	60	52	-	-	46	36	106	88
Vegetable	374	368	-	-	137	136	511	504
	14,321	20,062	742	753	4,410	5,288	19,473	26,103
Turf								
Golf	447	443	299	293	319	284	1,064	1,019
Landscape Turf	509	471	17	17	102	102	628	590
Domestic Outdoor	5,169	4,826	0	156	741	1,266	5,910	6,249
	6,125	5,740	316	466	1,161	1,652	7,602	7,857
Total	**20,446**	**25,802**	**1,057**	**1,219**	**5,572**	**6,939**	**27,075**	**33,961**

Irrigation Type	Total	
Agriculture	Irrigated Area (ha)	Irrigated Area (ha)
	2006	2040
Drip	1,528	1,440
Gun	309	308
Handline	1,493	1,434
Microspray	468	453
Microsprinkler	1,566	5,462
Overtreedrip	226	224
Overtreemicro	17	16
Pivot	435	430
PivotLP	6	6
SDI	43	43
Sprinkler	4,345	7,578
Ssgun	18	18
Ssovertree	3,126	3,019
Sssprinkler	138	133
Ssundertree	1,847	1,777
Subirrig	198	186
Travgun	2,110	2,050
Wheelline	1,776	1,692
	19,649	26,266
Turf		
GolfSprinkler	1,059	1,014
Landscapesprinkler	6,367	6,680
	7,426	7,694
Total	**27,075**	**33,961**

Table A11 Crop Water Demand - Increased Agricultural Acreage and Domestic Buildout to 2040

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**
Crop Group	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**
	(ha)	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**
Alfalfa	4,469	27,733,769	621	94	635,746	679	1,159	7,841,402	676	5,722	**36,210,918**	633
Apple	7,088	46,353,895	654	42	263,067	625	974	5,907,341	607	8,104	**52,524,303**	648
Berry	43	291,674	672	-	-	-	18	107,125	604	61	**398,799**	652
Cherry	1,024	7,730,498	755	-	-	-	54	430,617	802	1,078	**8,161,115**	757
Corn	411	1,967,680	479	20	105,718	530	182	792,486	435	613	**2,865,883**	468
Forage	3,446	32,443,771	941	407	3,965,771	974	2,086	17,503,189	839	5,939	**53,912,731**	908
Fruit	763	6,337,478	831	-	-	-	101	763,842	758	864	**7,101,320**	822
Grape	2,158	9,257,317	429	6	14,317	252	415	1,777,314	428	2,579	**11,048,948**	428
Nursery	241	2,442,916	1,015	185	1,263,704	684	127	1,047,811	823	553	**4,754,431**	860
Turf Farm	52	529,111	1,019	-	-	-	36	330,022	918	88	**859,133**	978
Vegetable	368	2,723,014	740	-	-	-	136	842,391	619	504	**3,565,405**	707
	20,062	137,811,123		753	6,248,323		5,288	37,343,540		26,103	**181,402,986**	
Turf												
Golf	443	4,435,377	1,002	293	3,045,970	1,041	284	2,792,974	985	1,019	**10,274,321**	1,008
Landscape Turf	471	4,616,938	981	17	172,756	1,004	102	978,823	962	590	**5,768,517**	978
Domestic Outdoor	4,826	47,618,401	987	156	1,497,405	959	1,266	12,719,155	1,004	6,249	**61,834,962**	990
	5,740	56,670,716		466	4,716,131		1,652	16,490,952		7,857	**77,877,800**	
Total	**25,802**	**194,481,839**	**780**	**1,219**	**10,964,454**	**885**	**6,939**	**53,834,492**	**786**	**33,961**	**259,280,786**	**786**

Table A12 - Water Demand - Management Comparison - Increased Agricultural Acreage and Domestic Buildout to 2040

	Okanagan Basin - Irrigation Management Comparison											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Year: 2003	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**	**Irrigated**	**Irrigation**	**Average**
	Area	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**	**Area**	**Demand**	**Req.**
Management	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**	**(ha)**	**(m3)**	**(mm)**
Average	25,802	194,481,840	780	1,219	10,964,454	885	6,939	53,834,492	786	33,961	**259,280,786**	786
Good	25,802	189,597,168	735	1,219	10,699,677	877	6,939	52,652,579	759	33,961	**252,949,425**	745

Table A13 Irrigation System Demand 2003 - Increased Agricultural Acreage and Domestic Buildout to 2040

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Irrigation Type**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Drip	1,232	5,280,991	429	70	322,736	462	138	554,381	401	1,440	**6,158,109**	428
Gun	239	2,595,593	1,087	16	214,795	1,349	54	679,214	1,267	308	**3,489,602**	1,132
Handline	1,009	8,301,316	823	19	177,266	953	406	3,370,928	830	1,434	**11,849,510**	827
Microspray	425	2,880,557	679	-	-	-	29	195,864	685	453	**3,076,421**	679
Microsprinkler	4,563	28,029,117	614	42	263,067	625	857	5,031,346	587	5,462	**33,323,529**	610
Overtreedrip	191	893,920	469	6	34,956	588	27	100,516	369	224	**1,029,392**	460
Overtreemicro	16	120,878	757	-	-	-	-	-	-	16	**120,878**	757
Pivot	323	1,784,563	552	-	-	-	107	641,488	600	430	**2,426,052**	564
PivotLP	3	25,448	739	-	-	-	2	12,953	628	6	**38,400**	698
SDI	43	236,741	554	-	-	-	-	-	-	43	**236,741**	554
Sprinkler	5,708	40,185,513	704	119	934,942	786	1,751	12,735,905	727	7,578	**53,856,360**	711
Ssgun	18	165,137	913	-	-	-	-	-	-	18	**165,137**	913
Ssovertree	2,663	17,406,733	654	6	46,903	777	350	2,145,876	613	3,019	**19,599,512**	649
Sssprinkler	109	889,151	816	-	-	-	24	241,995	1,012	133	**1,131,146**	851
Ssundertree	1,653	13,891,054	840	47	347,389	739	77	605,505	790	1,777	**14,843,948**	835
Subirrig	60	418,957	704	-	-	-	126	707,146	562	186	**1,126,103**	607
Travgun	916	7,375,657	805	294	2,857,326	971	840	6,280,071	748	2,050	**16,513,054**	806
Wheelline	1,021	8,549,190	838	135	1,048,942	779	536	4,367,590	814	1,692	**13,965,722**	826
	20,190	139,030,516		753	6,248,322		5,323	37,670,778		26,266	**182,949,616**	
Turf												
GolfSprinkler	443	4,435,377	1,002	292	3,034,442	1,040	280	2,756,711	986	1,014	**10,226,530**	1,009
Landscapesprinkler	5,169	51,015,947	987	174	1,681,690	965	1,337	13,407,003	1,003	6,680	**66,104,640**	990
	5,612	55,451,324		466	4,716,132		1,616	16,163,714		7,694	**76,331,170**	
Total	**25,802**	**194,481,840**	**780**	**1,219**	**10,964,454**	**885**	**6,939**	**53,834,492**	**786**	**33,961**	**259,280,786**	786

Table A14 Irrigation System Demand 2003 - Horticulture Converted to Drip

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	Water Licence			Reclaimed Water			Groundwater			Total		
Agriculture / Irrigation Type	Irrigated Area (ha)	Irrigation Demand (m3)	Deep Percolation (m3)	Irrigated Area (ha)	Irrigation Demand (m3)	Deep Percolation (m3)	Irrigated Area (ha)	Irrigation Demand (m3)	Deep Percolation (m3)	Irrigated Area (ha)	Irrigation Demand (m3)	Deep Percolation (m3)
Drip	8,918	40,845,547	3,587,494	191	895,802	60,000	1,076	4,269,830	356,338	10,185	**46,011,180**	4,003,832
Gun	179	1,968,049	339,036	16	215,014	45,155	54	681,592	134,645	249	**2,864,655**	518,836
Handline	699	5,984,568	763,375	30	285,950	41,696	337	2,832,456	323,933	1,065	**9,102,973**	1,129,004
Microspray	2	17,545	1,196	-	-	-	-	-	-	2	**17,545**	1,196
Microsprinkler	4	42,329	3,690	-	-	-	0	1,813	124	5	**44,142**	3,814
Pivot	325	1,807,147	131,059	-	-	-	107	642,587	55,395	432	**2,449,734**	186,454
PivotLP	4	26,218	2,829	-	-	-	2	12,945	1,393	6	**39,164**	4,221
Sprinkler	1,938	17,380,163	2,385,912	127	960,957	124,359	1,276	9,626,155	1,100,806	3,340	**27,967,276**	3,611,077
Ssgun	18	165,098	21,104	-	-	-	-	-	-	18	**165,098**	21,104
Ssovertree	188	1,836,213	208,792	-	-	-	25	260,355	28,087	214	**2,096,568**	236,879
Sssprinkler	59	531,727	62,554	-	-	-	18	194,658	20,477	77	**726,385**	83,032
Ssundertree	55	548,635	66,431	-	-	-	1	11,347	1,013	56	**559,983**	67,444
Subirrig	64	449,841	52,709	-	-	-	130	726,109	71,365	194	**1,175,950**	124,074
Travgun	918	7,426,270	865,945	241	2,401,215	319,893	873	6,571,940	649,976	2,031	**16,399,425**	1,835,815
Wheelline	1,090	9,065,960	1,138,742	137	1,064,310	116,625	549	4,477,348	524,172	1,775	**14,607,618**	1,779,540
Total	**14,460**	**88,095,310**	**9,630,868**	**742**	**5,823,248**	**707,728**	**4,447**	**30,309,135**	**3,267,724**	**19,649**	**124,227,696**	**13,606,322**

Year: 2003	Okanagan Basin - Good Irrigation Management											
Total	**14,460**	**86,228,545**	**7,764,104**	**742**	**5,652,579**	**537,059**	**4,447**	**29,615,227**	**2,573,814**	**19,649**	**121,496,351**	**10,874,976**

Table A15 Crop Water Demand - Half Tree Fruits Converted to Grape

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture Crop Group	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Alfalfa	1,294	9,109,024	704	96	647,964	677	950	6,382,746	672	2,340	**16,139,734**	690
Apple	1,996	10,398,132	521	-	-	-	102	542,041	531	2,099	**10,940,174**	521
Berry	43	290,721	672	-	-	-	18	110,656	603	62	**401,377**	652
Cherry	585	3,219,165	551	-	-	-	19	115,434	606	604	**3,334,599**	552
Corn	413	1,979,627	480	23	120,830	525	189	821,606	436	624	**2,922,064**	468
Forage	3,614	34,021,289	942	432	4,158,652	964	2,150	18,078,450	841	6,195	**56,258,392**	908
Fruit	383	2,143,959	559	-	-	-	55	271,446	494	438	**2,415,405**	551
Grape	5,308	17,183,724	324	6	15,923	250	621	2,318,733	374	5,935	**19,518,381**	329
Nursery	252	2,535,049	1,007	185	1,263,641	684	127	1,047,376	823	564	**4,846,066**	859
Turf Farm	60	606,512	1,008	-	-	-	46	414,190	911	106	**1,020,702**	966
Vegetable	374	2,764,242	739	-	-	-	134	818,048	612	508	**3,582,290**	706
Total	14,321	84,251,444		742	6,207,010		4,410	30,920,726		19,473	**121,379,184**	

Table A16 Irrigation System Demand - Half Tree Fruits Converted to Grapes - Drip Irrigated

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / Irrigation Type	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Drip	6,497	24,383,607	375	71	324,317	460	443	1,610,356	363	7,010	**26,318,280**	375
Gun	218	2,410,344	1,107	16	215,014	1,349	54	681,592	1,265	288	**3,306,950**	1,150
Handline	731	6,240,860	854	30	285,950	955	352	2,949,243	838	1,113	**9,476,053**	851
Microspray	14	80,397	556	-	-	-	8	42,653	507	23	**123,049**	538
Microsprinkler	83	471,672	570	-	-	-	29	143,886	491	112	**615,557**	549
Overtreedrip	134	537,188	401	6	34,952	588	23	76,373	332	163	**648,513**	398
Pivot	328	1,824,525	557	-	-	-	107	642,587	600	435	**2,467,112**	567
PivotLP	4	26,218	733	-	-	-	2	12,945	628	6	**39,164**	695
SDI	6	33,225	545	-	-	-	-	-	-	6	**33,225**	545
Sprinkler	2,429	20,991,166	864	128	967,981	759	1,532	11,223,027	732	4,088	**33,182,174**	812
Ssgun	18	165,098	913	-	-	-	-	-	-	18	**165,098**	913
Ssovertree	1,723	9,775,073	567	6	46,902	777	310	1,795,941	580	2,039	**11,617,915**	570
Sssprinkler	95	807,635	848	-	-	-	19	203,807	1,063	114	**1,011,442**	884
Ssundertree	92	760,689	829	47	347,444	739	14	90,299	663	152	**1,198,432**	786
Subirrig	64	449,841	699	-	-	-	131	734,616	559	196	**1,184,457**	605
Travgun	935	7,557,098	808	302	2,920,141	968	874	6,575,840	753	2,110	**17,053,080**	808
Wheelline	1,090	9,071,395	832	137	1,064,310	777	549	4,479,875	816	1,776	**14,615,581**	823
Total	14,461	85,586,031		741	6,207,011		4,447	31,263,040		19,649	**123,056,082**	

Table A17 Crop Water Demand - Half of Forage Converted to Tree Fruits, Grapes or Vegetables in a 33% split

Year: 2003 — Okanagan Basin - Average Irrigation Management

Crop Type	Water Licence			Reclaimed Water			Groundwater			Total		
Agriculture Crop Group	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m3)	Average Req. (mm)
Alfalfa	1,317	9,308,304	707	96	647,964	677	950	6,382,746	672	2,363	**16,339,013**	691
Apple	4,686	31,905,495	681	80	357,011	446	575	2,961,280	515	5,341	**35,223,787**	659
Berry	44	291,916	672	-	-	-	18	110,656	603	62	**402,572**	651
Cherry	1,076	8,133,972	756	-	-	-	45	367,359	819	1,121	**8,501,331**	758
Corn	413	1,979,627	480	23	120,830	525	189	821,606	436	624	**2,922,064**	468
Forage	1,763	16,598,914	942	198	1,895,376	957	1,040	8,803,637	847	3,001	**27,297,927**	910
Fruit	796	6,600,011	829	-	-	-	102	771,618	759	898	**7,371,630**	821
Grape	2,906	11,088,579	382	82	184,682	225	792	2,613,325	330	3,779	**13,886,587**	367
Nursery	253	2,546,821	1,006	185	1,263,641	684	127	1,047,376	823	565	**4,857,838**	859
Turf Farm	60	606,512	1,008	-	-	-	46	414,190	911	106	**1,020,702**	966
Vegetable	1,008	5,427,260	538	78	327,057	421	527	2,485,336	471	1,613	**8,239,653**	511
Total	14,321	94,487,411		741	4,796,561		4,410	26,779,129		19,473	**126,063,104**	

Table A18 Irrigation System Demand - Half of Forage Converted to Tree Fruits, Grapes, Vegetables - 33% split

Year: 2003	Okanagan Basin - Average Irrigation Management											
Water Source	**Water Licence**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture / **Irrigation Type**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m3)**	**Average Req. (mm)**
Drip	3,162	12,176,227	385	304	1,177,144	387	1,256	4,419,012	352	4,722	**17,772,383**	376
Gun	186	1,922,209	1,033	3	38,025	1,351	30	387,750	1,303	219	**2,347,984**	1,074
Handline	804	6,348,098	789	7	62,292	957	344	2,777,150	807	1,155	**9,187,540**	795
Microspray	439	2,975,167	678	-	-	-	29	196,382	685	468	**3,171,549**	678
Microsprinkler	1,476	10,320,534	699	-	-	-	90	590,922	660	1,566	**10,911,456**	697
Overtreedrip	193	900,760	468	6	34,952	588	27	100,511	369	226	**1,036,223**	459
Overtreemicro	17	125,182	757	-	-	-	-	-	-	17	**125,182**	757
Pivot	252	1,343,655	533	-	-	-	42	267,359	631	294	**1,611,015**	547
PivotLP	0	3,160	758	-	-	-	-	281	628	1	**3,442**	745
SDI	43	236,715	554	-	-	-	-	-	-	43	**236,715**	554
Sprinkler	1,857	15,388,301	829	69	546,513	789	1,016	7,256,473	714	2,942	**23,191,287**	788
Ssgun	13	105,515	820	-	-	-	-	-	-	13	**105,515**	820
Ssovertree	2,701	17,393,756	644	6	46,902	777	349	2,089,665	598	3,057	**19,530,323**	639
Sssprinkler	91	726,627	799	-	-	-	15	136,954	943	106	**863,582**	818
Ssundertree	1,692	14,139,992	836	47	347,444	739	76	601,271	788	1,815	**15,088,708**	831
Subirrig	42	276,426	663	-	-	-	104	582,426	559	146	**858,852**	589
Travgun	616	4,453,407	723	189	1,730,885	916	682	4,729,767	694	1,487	**10,914,060**	734
Wheelline	878	6,986,264	796	111	812,404	733	387	2,985,519	771	1,376	**10,784,186**	784
Total	14,460	95,821,995		741	4,796,561		4,447	27,121,442		19,649	**127,740,002**	