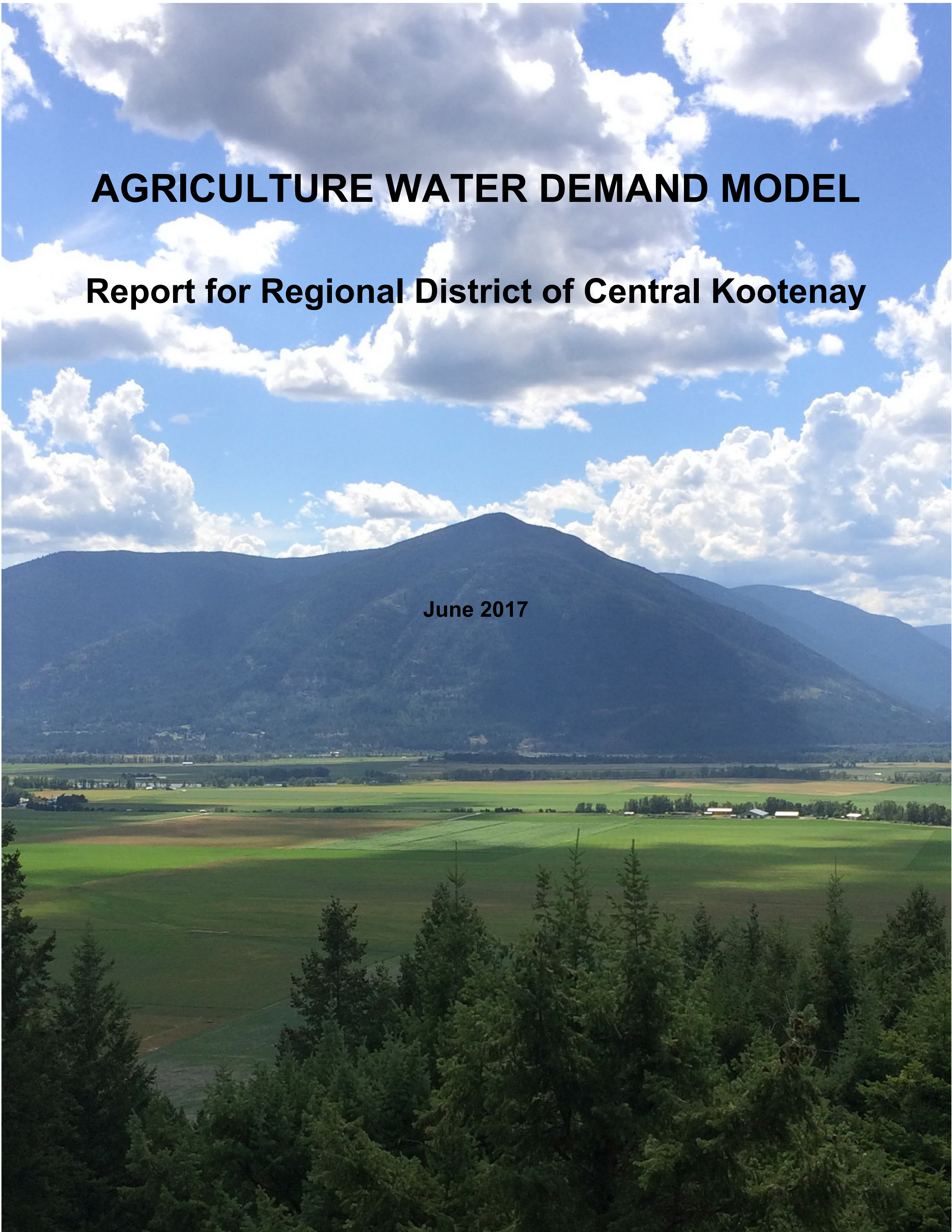

AGRICULTURE WATER DEMAND MODEL

Report for Regional District of Central Kootenay

June 2017

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Funding for this project has been provided in part by the Governments of Canada and British Columbia through the Canada-BC Agri-Innovation Program under *Growing Forward 2*, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

Table of Contents

List of Figures

List of Tables

Acknowledgements

The Ministry of Agriculture acknowledges the work done by:

- **Ron Fretwell**
  Program Developer
  RHF Systems Ltd.

- **Denise Neilsen**
  Research Scientist
  Summerland Research and Development Centre
  Agriculture and Agri-Food Canada

in the original development of the model algorithms, climate change scenarios and model development. Without their effort, the development of the model would not have been possible.

There are over twenty people that have been involved with the preparation and collection of data for the development of the Agriculture Water Demand Model in the project area. The authors wish to express appreciation to the following individuals for their contribution for the tasks noted.

Alex Cannon	Environment and Climate Change Canada	Climate data downscaling
Bill Taylor	Environment and Climate Change Canada	Climate data layer
Corrine Roesler	Ministry of Agriculture	GIS data coordination
Sam Lee	Ministry of Agriculture	GIS data preparation
Joel Comer	Contractor	Land Use Inventory
Steve Thompson	Contractor	Land Use Inventory
Alison Thorpe	Contractor	Land Use Inventory
Tara Haynes	Contractor	Land Use Inventory

Background

The Agriculture Water Demand Model (AWDM) was developed in the Okanagan Watershed. It was developed in response to rapid population growth, drought conditions from climate change, and the overall increased demand for water. Many of the watersheds in British Columbia (BC) are fully allocated already or may be in the next 15 to 20 years. The AWDM helps to understand current agricultural water use and helps to fulfil the Province's commitment under the "*Living Water Smart – BC Water Plan*" to reserve water for agricultural lands. The Model can be used to establish agricultural water reserves throughout the various watersheds in BC by providing current and future agricultural water use data.

Climate change scenarios developed by the University of British Columbia (UBC) and the Summerland Research and Development Centre predict an increase in agricultural water demand due to warmer and longer summers and lower precipitation during summer months in the future.

The Model was developed to provide current and future agricultural water demands. The Model calculates water use on a property-by-property basis, and sums each property to obtain a total water demand for the entire basin or each sub-basin. Crop, irrigation system type, soil texture and climate data are used to calculate the water demand. Climate data from 2003 was used to present information on one of the hottest and driest years on record, and 1997 data was used to represent a wet year. Lands within the Agriculture Land Reserve (ALR), depicted in green in Figure 1, were included in the project.

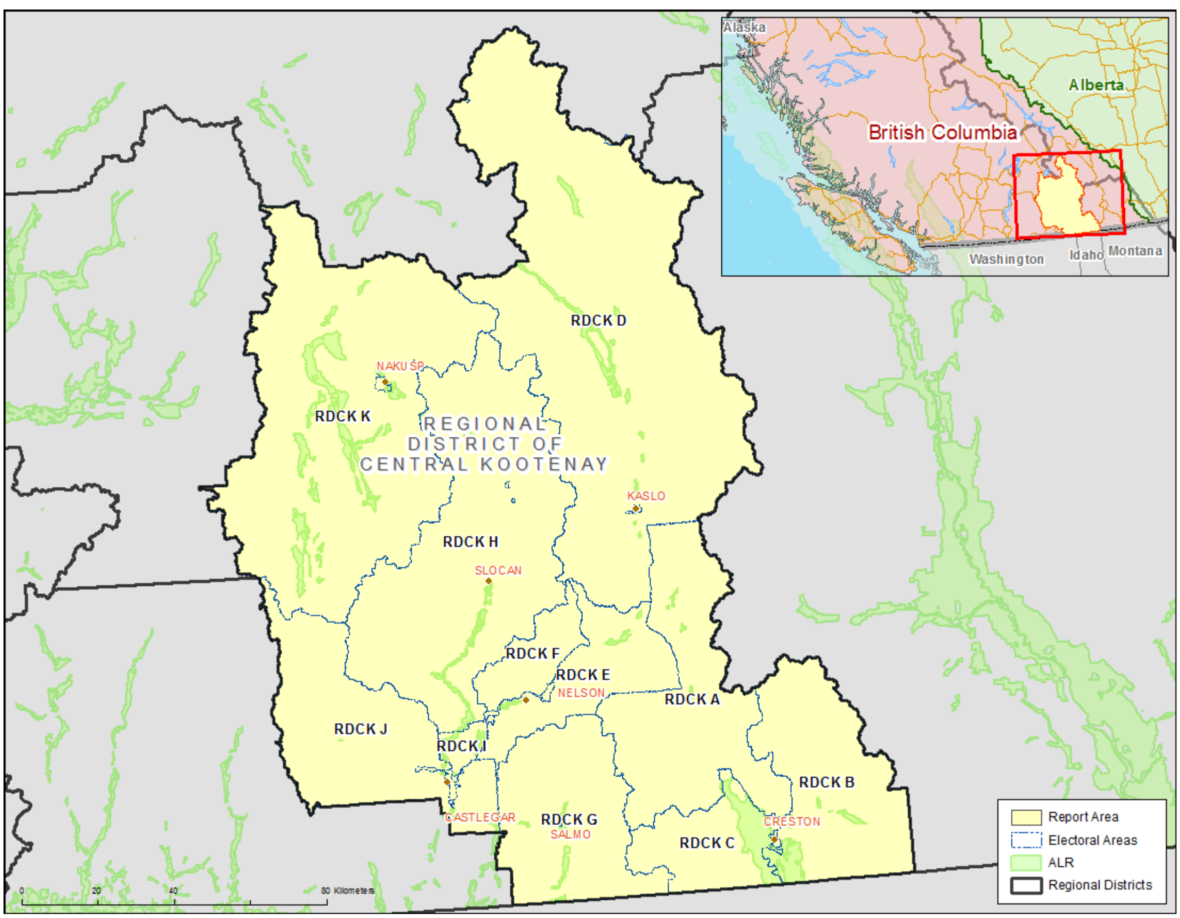

Figure 1 Map of Regional District of Central Kootenay (RDCK)

Methodology

The Model is based on a Geographic Information System (GIS) database that contains information on cropping, irrigation system type, soil texture and climate. An explanation of how the information was compiled for each is given below. The survey area included all properties within the ALR and areas that were zoned for agriculture by the local governments. The inventory was undertaken by Ministry of Agriculture (AGRI) staff, hired professional contractors and summer students.

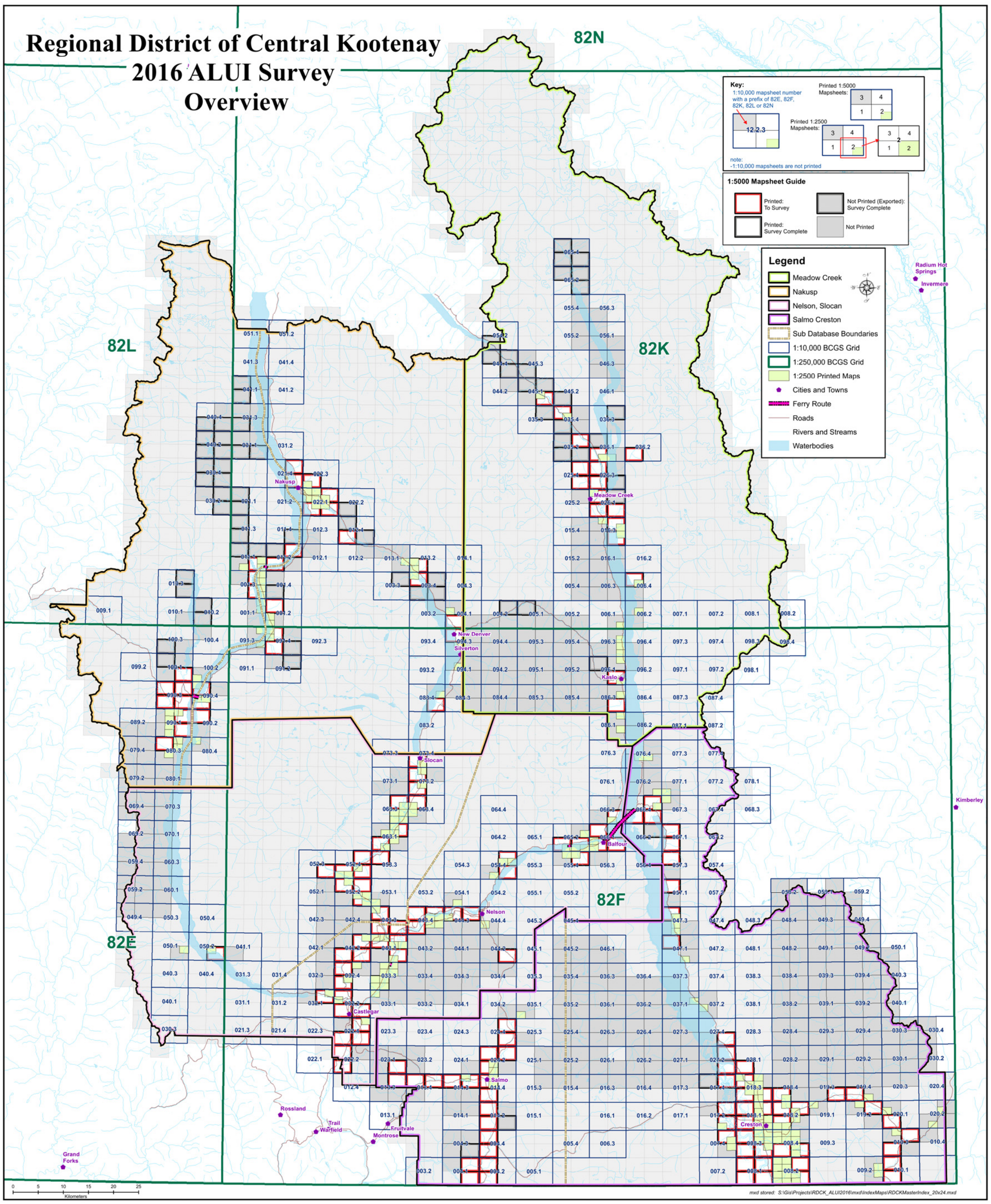

Figure 2 Map of the Project Area Overlaid with Map Sheets

Cadastre

Cadastre information was provided by the Integrated Cadastral Information Society (ICIS). A consultant was hired to unify all of the cadastral information into one seamless cover for the entire watershed. This process allows the Model to calculate water demand for each parcel and 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 separate farmstead and driveways from cropping areas. Different crops were also separated into different polygons if the difference could be identified on the aerial photographs. 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 AGRI for the survey crew to enter data about each property. Surveys were done through the summer of 2016. The survey crew drove by each property where the team checked the database for accuracy using visual observation and the aerial photographs on the survey maps. A Professional Agrologist verified what was on the site, and a GIS technician altered the codes in the database as necessary (Figure 3). Corrections were handwritten on the maps during survey. The maps were then brought back to the office to have the hand-drawn lines digitized into the GIS system and have the additional polygons entered into the database.

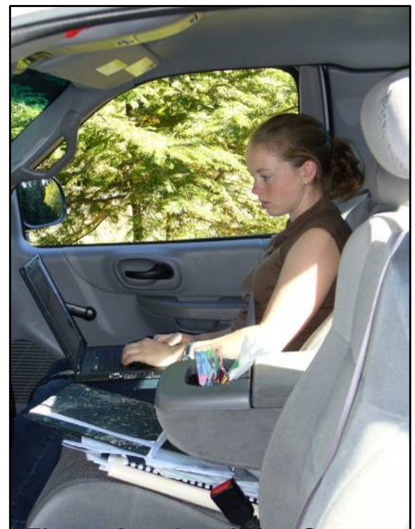

Figure 3 Land Use Survey

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

Figure 4 provides an example of a map sheet. The project area was divided into 1,114 map sheets. Each map sheet also had a key map to indicate where it was located.

The smallest unit for which water use is calculated are 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 shown in Figures 4 and 5. The project area encompasses 8,367 parcels that are in or partially in the ALR. There are a total of 27,521 polygons (land covers) generated for the project area. Figure 5 provides an enhanced view of a cadastre containing three 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.

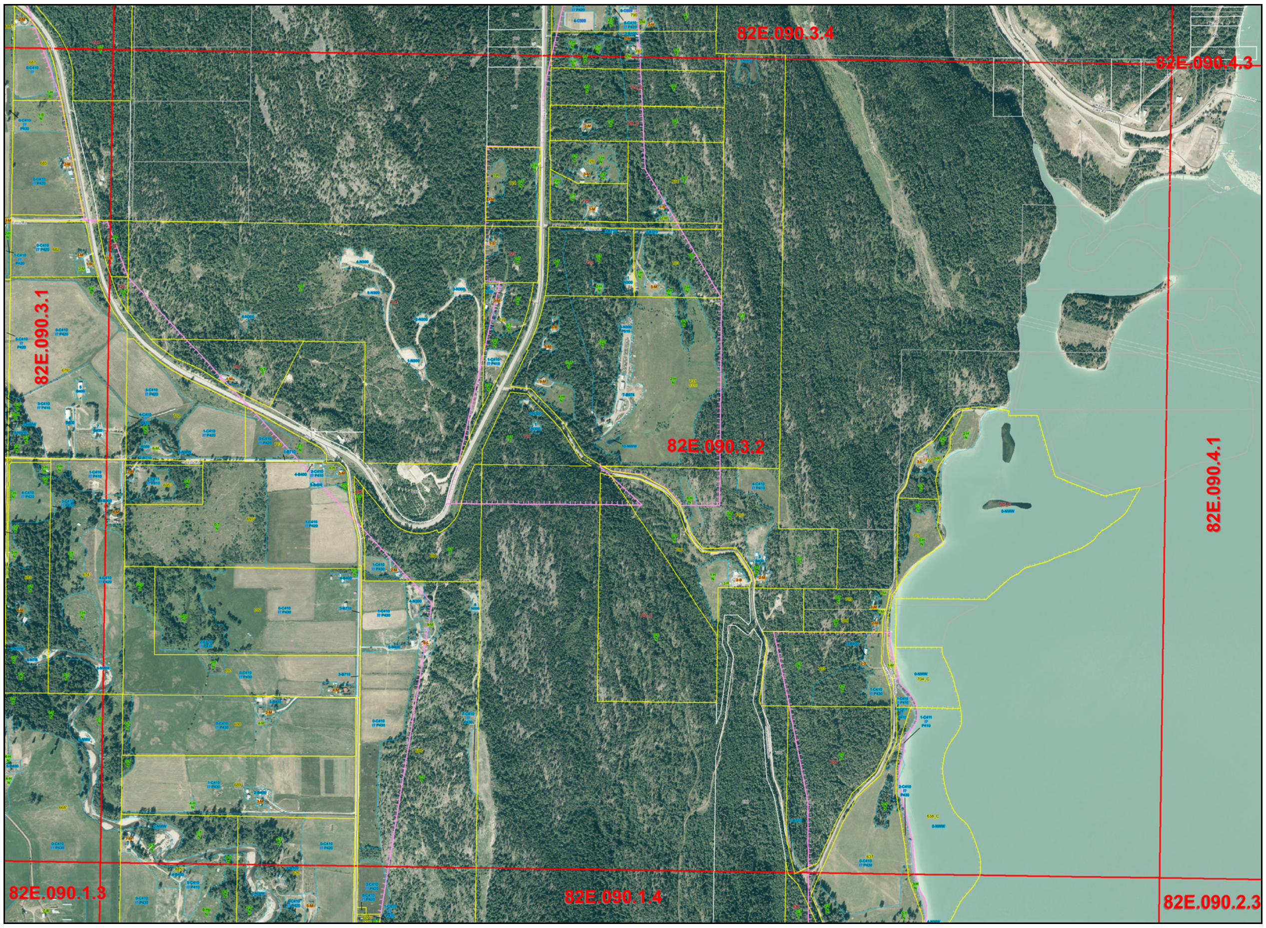

Figure 4 GIS Map Sheet

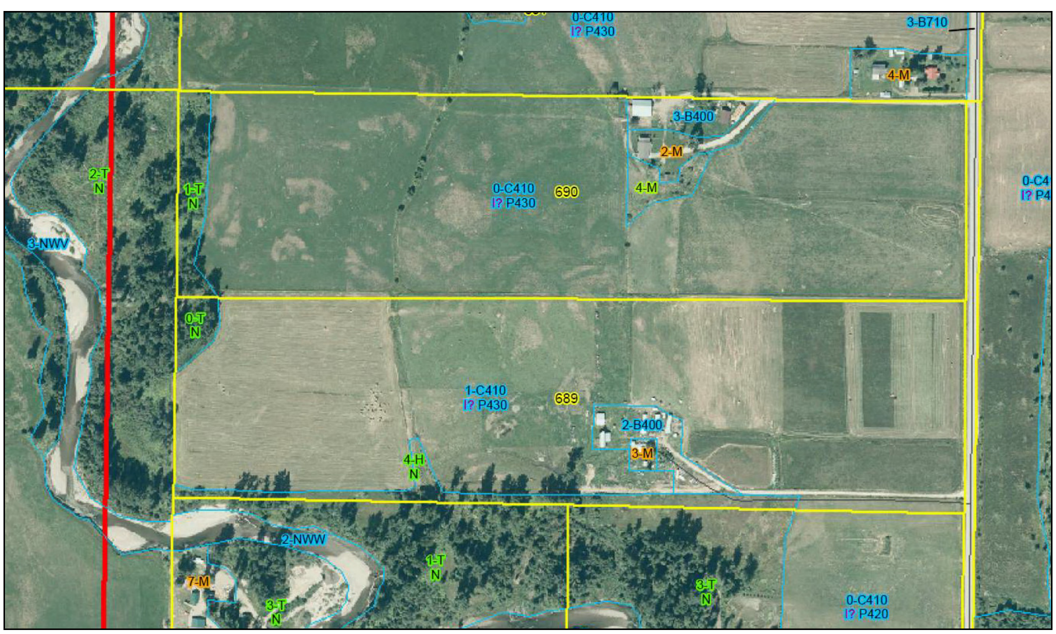

Figure 5 Cadastre with Polygons

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) soil 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. Soil information required for this project was the soil texture (loam, etc.), the available water storage capacity and the 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 6 shows how the land use information is divided into additional polygons using the soil boundaries. The Model calculates water demand using every different combination of crop, soil and irrigation system as identified by each polygon.

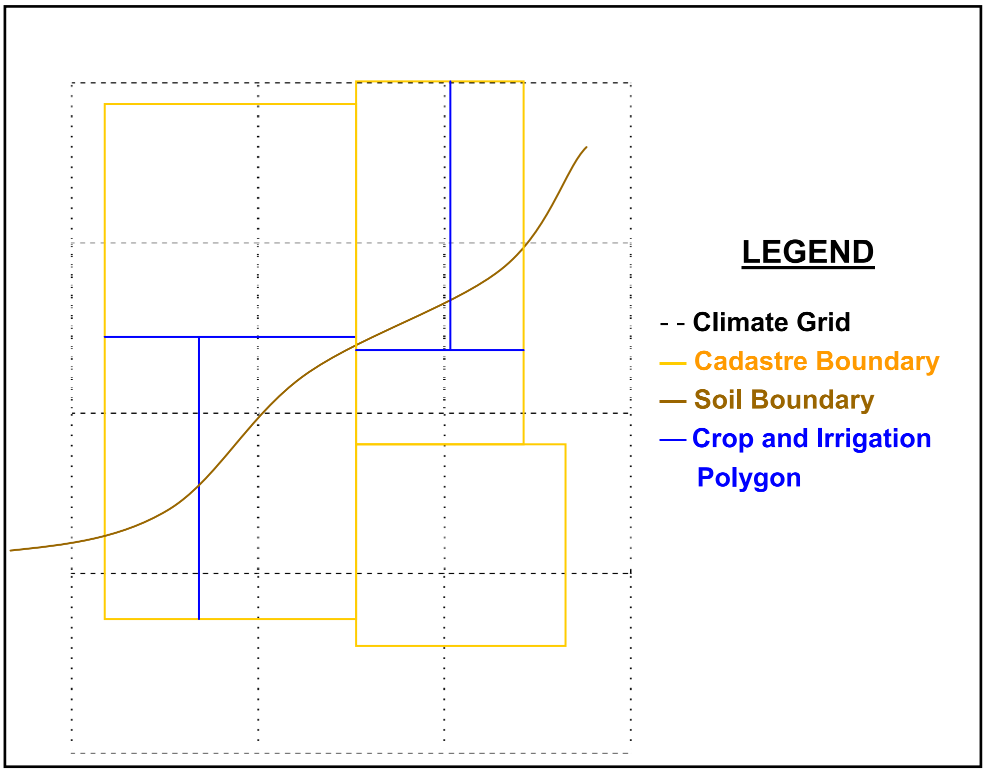

Figure 6 GIS Model Graphics

Climate Information

The agricultural water demand is calculated using climate, crop, irrigation system and soil information data. The climate in the interior region 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 region on a 500 m x 500 m grid. Each grid cell contains daily climate data, minimum and maximum temperature (T_{min} and T_{max}), and precipitation which allows the Model to calculate a daily reference evapotranspiration rate (ET_o) value. A range of agro-climatic indices such as growing degree days (GDD), corn heat units (CHU), frost free days and temperature sum (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 Model.

The climate dataset has been developed by using existing data from climate stations in and around the project area from 1961 to 2010. This climate dataset was then interpolated to provide a climate data layer for the entire watershed on the 500 m x 500 m grid. A detailed description of the Model can be obtained by contacting the authors. The climate grid cell that is prominent for a cadastre boundary is assigned to that cadastre. Additional polygons are not generated with the climate grid.

Some of the existing climate stations that were used to determine the climate coverage are shown in Figure 7. The attributes attached to each climate grid cell include:

- Latitude
- Longitude
- Elevation
- Aspect
- Slope
- Daily Precipitation
- Daily T_{min} and T_{max}

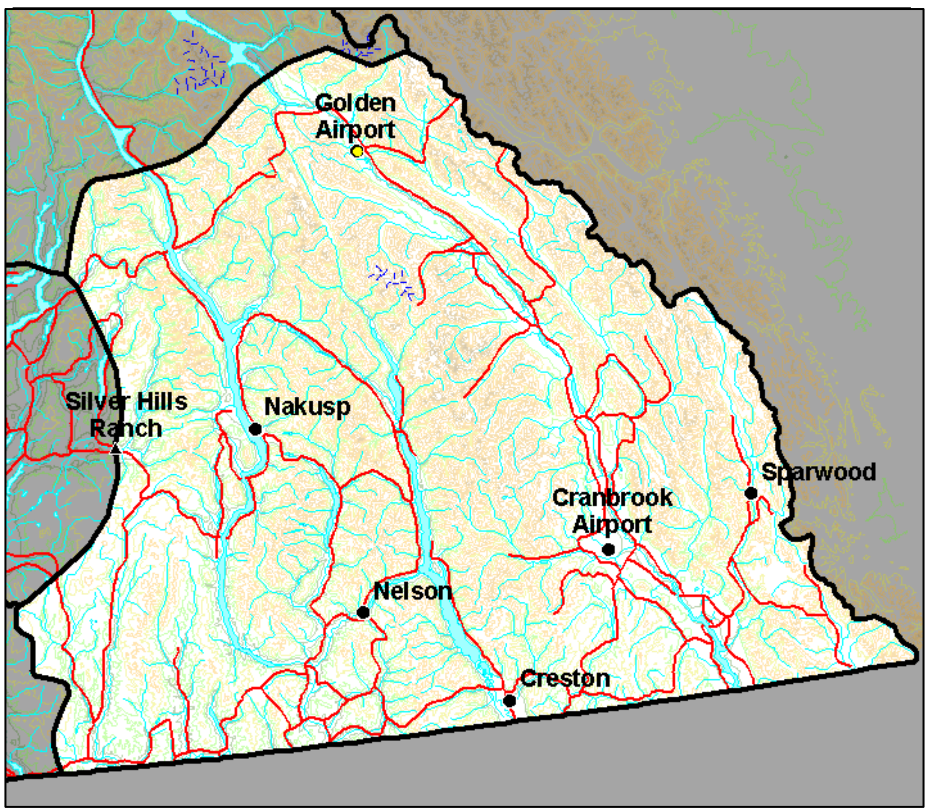

Figure 7 Climate Stations in the Project Area

A climate database contains T_{min}, T_{max}, T_{mean} and Precipitation for each day of the year from 1961 until 2006. The parameters that need to be selected, calculated and stored within the Model are evapotranspiration (ET_o), Tsum of 600 (for Kamloops), effective precipitation (EP), frost free days, GDD with base temperatures of 5 ^oC and 10 ^oC, CHU, and first frost date. These climate and crop parameters are used to determine the growing season length as well as the beginning and end of the growing season in Julian day.

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 the land use survey) 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 ET_o 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 ET_o 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 the land use survey) 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. Two irrigation ID's occur when an overhead irrigation system has been retained to provide crop cooling or frost protection. In this case, the efficiencies used in the Model are the drip and microsprinkler efficiencies.

Soil

The soil layer came from CAPAMP at the Ministry of Environment. In addition, soil data provided by Agriculture and Agri-Food Canada (AAFC) was also used to generate multiple soil layers within each polygon. Each parcel was assigned the most predominant soil polygon, and then for each crop field within that soil polygon, the most predominant texture within the crop's rooting depth was determined and assigned to the crop field.

Note that textures could repeat at different depths – the combined total of the thicknesses determined the most predominant texture. For example, a layer of 20 cm sand, followed by 40 cm clay and then 30 cm of sand would have sand be designated at the predominant soil texture.

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 decide the parameters for the algorithm that is used to determine the Irrigation Requirement (IR). The 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 (ET_o) 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 (^oC)
- Maximum Temperature, degree Celsius (^oC)
- 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

Agricultural Water Demand Equation

The Model calculates the Agriculture Water Demand (AWD) for each polygon, as a unique crop, irrigation system, soil and climate data is recorded on a polygon basis. The polygons are then summed to determine the AWD for each cadastre. The cadastre water demand values are then summed to determine AWD for the basin, sub-basin, water purveyor or local government. The following steps provide the process used by the Model to calculate Agricultural Water Demand. Detailed information is available on request.

1. Pre-Season Soil Moisture Content

Prior to the start of each crop's growing season, the soil's stored moisture content is modelled using the soil and crop evaporation and transpiration characteristics and the daily precipitation values. Precipitation increases the soil moisture content and evaporation (modelled using the reference potential evapotranspiration) depletes it. In general, during the pre-season, the soil moisture depth cannot be reduced beyond the maximum evaporation depth; grass crops in wet climates, however, can also remove moisture through crop transpiration.

The process used to model the pre-season soil moisture content is:

1. Determine whether the modelling area is considered to be in a *wet* or *dry* climate (see *Wet/Dry Climate Assessment*), and retrieve the early season evaporation factor in the modelling area
2. For each crop type, determine the start of the growing season (see *Growing Season Boundaries*)
3. For each crop and soil combination, determine the *maximum soil water deficit* (MSWD) and *maximum evaporation factor* (maxEvaporation)
4. Start the initial storedMoisture depth on January 1 at the MSWD level
5. For each day between the beginning of the calendar year and the crop's growing season start, calculate a new storedMoisture from:

    a. the potential evapotranspiration (ET_o)
    b. the early season evaporation factor (earlyEvaporationFactor)
    c. the effective precipitation (EP) = actual precipitation x earlyEvaporationFactor
    d. daily Climate Moisture Deficit (CMD) = ET_o – EP
    e. storedMoisture = previous day's storedMoisture – CMD

A negative daily CMD (precipitation in excess of the day's potential evapotranspiration) adds to the stored moisture level while a positive climate moisture deficit reduces the amount in the stored moisture reservoir. The stored moisture cannot exceed the maximum soil moisture deficit; any precipitation that would take the stored moisture level above the MSWD gets ignored.

For all crops and conditions except for grass in wet climates, the stored moisture content cannot drop below the maximum soil water deficit minus the maximum evaporation depth; without any crop transpiration in play, only a certain amount of water can be removed from the soil through evaporative processes alone. Grass in wet climates does grow and remove moisture from the soil prior to the start of the irrigation season however. In those cases, the stored moisture level can drop beyond the maximum evaporation depth, theoretically to 0.

Greenhouses and mushroom barns have no stored soil moisture content.

2. In-Season Precipitation

During the growing season, the amount of precipitation considered effective (EP) depends on the overall wetness of the modelling area's climate (see *Wet/Dry Climate Assessment*). In dry climates, the first 5 mm of precipitation is ignored, and the EP is calculated as 75% of the remainder:

$$EP = (Precip - 5) \times 0.75$$

In wet climates, the first 5 mm is included in the EP. The EP is 75% of the actual precipitation:

$$EP = Precip \times 0.75$$

Greenhouses and mushroom barns automatically have an EP value of 0.

3. *Crop Cover Coefficient (K_c)*

As the crops grow, the amount of water they lose due to transpiration changes. Each crop has a pair of polynomial equations that provide the crop coefficient for any day during the crop's growing season. It was found that two curves, one for modelling time periods up to the present and one for extending the modelling into the future, provided a better sequence of crop coefficients than using a single curve for all years (currently 1961 to 2100). The application automatically selects the current or future curve as modelling moves across the c*rop Curve Changeover Year*.

For alfalfa crops, there are different sets of equations corresponding to different cuttings throughout the growing season.

4. *Crop Evapotranspiration (ET_c)*

The evapotranspiration for each crop is calculated as the general ET_o multiplied by the crop coefficient (K_c):

$$ET_c = ET_o \times K_c$$

5. *Climate Moisture Deficit (CMD)*

During the growing season, the daily Climate Moisture Deficit (CMD) is calculated as the crop evapotranspiration (ET_c) less the Effective Precipitation (EP):

$$CMD = ET_c - EP$$

During each crop's growing season, a stored moisture reservoir methodology is used that is similar to the soil moisture content calculation in the pre-season. On a daily basis, the stored moisture level is used towards satisfying the climate moisture deficit to produce an *adjusted Climate Moisture Deficit* (CMD_a):

$$CMD_a = CMD - storedMoisture$$

If the storedMoisture level exceeds the day's CMD, then the CMD_a is 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 soil water deficit (MSWD) setting.

6. *Crop Water Requirement (CWR)*

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

$$CWR = CMD_a \times swFactor \times stressFactor$$

7. *Irrigation Requirement (IR)*

The Irrigation Requirement is the Crop Water Requirement (CWR) after taking into account the irrigation efficiency (I_e) and, for drip systems, the drip factor (D_f):

$$IR = CWR \times \frac{D_f}{I_e}$$

For irrigation systems other than drip, the drip factor is 1.

8. *The Irrigation Water Demand (IWD_{perc} and IWD)*

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

$$IWD_{perc} = IR \times soilPercFactor$$

The final Irrigation Water Demand (IWD) is then the Irrigation Requirement (IR) plus the loss to percolation (IWD_{perc}):

$$IWD = IR + IWD_{perc}$$

9. *Frost Protection*

For some crops (e.g. cranberries), an application of water is often used under certain climatic conditions to provide protection against frost damage. For cranberries, the rule is: when the temperature drops to 0 ^{o}C or below between March 16 and May 20 or between October 1 and November 15, a frost event will be calculated. The calculated value is an application of 2.5 mm per hour for 10 hours. In addition, 60% of the water is recirculated and reused, accounting for evaporation and seepage losses.

This amounts to a modelled water demand of 10 mm over the cranberry crop's area for each day that a frost event occurs between the specified dates.

10. *Annual Soil Moisture Deficit*

Prior to each crop's growing season, the Model calculates the soil's moisture content by starting it at full (maximum soil water deficit level) on January 1, and adjusting it daily according to precipitation and evaporation. During the growing season, simple evaporation is replaced by the crop's evapotranspiration as it progresses through its growth stages. At the completion of each crop's growing season, an annual soil moisture deficit (SMD) is calculated as the difference between the soil moisture content at that point and the maximum soil water deficit (MSWD):

$$SMD = MSWD - storedMoisture$$

In dry/cold climates, this amount represents water that the farmer would add to the soil in order to prevent it from freezing. Wet climates are assumed to have sufficient precipitation and warm enough temperatures to avoid the risk of freezing without this extra application of water; the SMD demand is therefore recorded only for dry areas.

There is no fixed date associated with irrigation to compensate for the annual soil moisture deficit. The farmer may choose to do it any time after the end of the growing season and before the freeze up. In the Model's summary reports, the water demand associated with the annual soil moisture deficit shows as occurring at time 0 (week 0, month 0, etc.) simply to differentiate it from other demands that do have a date of occurrence during the crop's growing season.

Greenhouses and mushroom barns do not have an annual soil moisture deficit.

Livestock Water Use

The Model calculates an estimated livestock water demand using agricultural census data and an estimate of the water use per animal. Water use for each animal type is calculated a bit differently depending on requirements. For example, for a dairy milking cow, the water demand for each animal includes, drinking, preparation for milking, pen and barn cleaning, milking system washout, bulk tank washout and milking parlor washing. However, for a dry dairy cow, the demand only includes drinking and pen and barn cleaning.

The water use is estimated on a daily basis per animal even though the facility is not cleaned daily. For example, for a broiler operation, the water use for cleaning a barn is calculated as 4 hours of pressure washing per cycle at a 10 gpm flow rate, multiplied by 6 cycles per barn with each barn holding 50,000 birds. On a daily basis, this is quite small with a value of 0.01 litres per day per bird applied.

For all cases, the daily livestock demand is applied to the farm location. However, in the case of beef, the livestock spend quite a bit of the year on the range. Since the actual location of the animals cannot be ascertained, the water demand is applied to the home farm location, even though most of the demand will not be from this location. Therefore, the animal water demand on a watershed scale will work fine but not when the demand is segregated into sub-watersheds or groundwater areas.

The estimates used for each livestock are shown in Table 1.

Table 1 Livestock Water Demand (Litres/day)

Animal Type	Drinking	Milking Preparation	Barn Component	Total
Milking Dairy Cow	65	5	15	85
Dry Cow	45		5	50
Swine	12		0.5	12.5
Poultry – Broiler	0.16		0.01	0.17
Poultry – Layer	0.08		0.01	0.09
Turkeys	0.35		0.01	0.36
Goats	8			8
Sheep	8			8
Beef – range, steer, bull, heifer	50			50
Horses	50			50

Definition and 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 growing season derivations, generally using Temperature Sum (Tsum) or Growing Degree Day (GDD) accumulations
- the growing season overrides table
- the irrigation season overrides table

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 growing 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 minimum start day in the irrigation season overrides table would prevent any irrigation water demands until day 105.

This section describes the rules used to establish growing season boundaries based on the internal calculations of the Model. 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 end date of Growing Degree Day with base temperature of 5 ^{o}C (GDD_5) or the first frost.

1. Corn (silage corn)

- uses the corn_start date for the season start
- season end: earlier of the killing frost or the day that the CHU2700 (2700 Corn Heat Units) threshold is reached

2. Sweetcorn, Potato, Tomato, Pepper, Strawberry, Vegetable, Pea

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

3. Cereal

- GDD_5 start for the season start
- GDD_5 start plus 130 days for the season end

4. AppleHD, AppleMD, AppleLD, Asparagus, Berry, Blueberry, Ginseng, Nuts, Raspberry, Sourcherry, Treefruit, Vineberry

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

5. Pumpkin

- corn_start date
- standard end of season

6. ***Apricot***
   - season start: (0.9153 x tsum400_day) + 5.5809
   - standard end of season

7. ***CherryHD, CherryMD, CherryLD***
   - season start: (0.7992 x tsum450_day) + 24.878
   - standard end of season

8. ***Grape, Kiwi***
   - season start: (0.7992 x tsum450_day) + 24.878
   - standard end of season

9. ***Peach, Nectarine***
   - season start: (0.8438 x tsum450_day) + 19.68
   - standard end of season

10. ***Plum***
    - season start: (0.7982 x tsum500_day) + 25.417
    - standard end of season

11. ***Pear***
    - season start: (0.8249 x tsum600_day) + 17.14
    - standard end of season

12. ***Golf, TurfFarm***
    - season start: later of the GDD_5 start and the tsum300_day
    - standard end of season

13. ***Domestic, Yard, TurfPark***
    - season start: later of the GDD_5 start and the tsum400_day
    - standard end of season

14. ***Greenhouse (interior greenhouses)***
    - fixed season of April 1 – October 30

15. ***GH Tomato, GH Pepper, GH Cucumber***
    - fixed season of January 15 – November 30

16. ***GH Flower***
    - fixed season of March 1 – October 30

17. ***GH Nursery***
    - fixed season of April 1 – October 30

18. ***Mushroom***
    - all year: January 1 – December 31

19. Shrubs/Trees, Fstock, NurseryPOT
- season start: tsum500_day
- end: Julian day 275

20. Floriculture
- season start: tsum500_day
- end: Julian day 225

21. Cranberry
- season start: tsum500_day
- end: Julian day 275

22. Grass, Forage, Alfalfa, Pasture
- season start: later of the GDD_5 and the tsum600_day
- standard end of season

23. Nursery
- season start: tsum400_day
- standard end of season

Evapotranspiration (ET_o)

The ET_o calculation follows the FAO Penman-Montieth equation. Two modifications were made to the equation:

- Step 6 – Inverse Relative Distance Earth-Sun (d_r)
  Instead of a fixed 365 days as a divisor, the actual number of days for each year (365 or 366) was used.

- Step 19 – Evapotranspiration (ET_o)
  For consistency, a temperature conversion factor of 273.16 was used instead of the rounded 273 listed.

Availability Coefficient (AC)

The availability coefficient is a factor representing the percentage of the soil's total water storage that the crop can readily extract. The factor is taken directly from the crop factors table (crop_factors) based on the cropId value.

Rooting Depth (RD)

The rooting depth represents the crop's maximum rooting depth and thus the depth of soil over which the plant interacts with the soil in terms of moisture extraction. The value is read directly from the crop factors table.

Stress Factor (stressFactor)

Some crops, such as *grasses*, are often irrigated to a less degree than their full theoretical requirement for optimal growth. The *stress factor* (*crop_groups_and_factors*) reduces the calculated demand for these crops.

Available Water Storage Capacity (AWSC)

The available water storage capacity is a factor representing the amount of water that a particular soil texture can hold without the water dropping through and being lost to deep percolation. The factor 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:

$$MSWD = RD \times AWSC \times AC$$

Deep Percolation Factor (Soilpercfactor)

The soil percolation factor is used to calculate the amount of water lost to deep percolation under different management practices.

For greenhouse crops, the *greenhouse leaching factor* is used as the basic soil percolation factor. This is then multiplied by a greenhouse recirculation factor, if present, to reflect the percentage of water re-captured and re-used in greenhouse operations.

$$soilPercFactor = soilPercFactor \times (1 - recirculationFactor)$$

For Nursery Pot (Nursery POT) and Forestry Stock (Fstock) crops, the soil percolation factor is fixed at 35%. For other crops, the factor depends on the soil texture, the MSWD, 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 MSWD value that matches or exceeds the value calculated for the current land use 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 mm, a soil texture of sandy loam (SL) and an irrigation system of solid set overtree (Ssovertree) would retrieve the percolation factor associated with the MSWD index value of 75 mm in the current table (presently, there are rows for MSWD 50 mm and 75 mm for SL and Ssovertree).

Maximum Evaporation Factor (maxEvaporation)

Just as different soil textures can hold different amounts of water, they also have different depths that can be affected by evaporation. The factor is taken directly from the soil factors table.

Irrigation Efficiency (I_e)

Each irrigation system type has an associated efficiency factor (inefficient systems require the application of more water in order to satisfy the same crop water demand). The factor is read directly from the irrigation factors table (*irrigation_factors*).

Soil Water Factor (swFactor)

For the greenhouse "crop", the soil water factor is set to 1. For other crops, it is interpolated from a table (*soil_water_factors*) based on the MSWD. For Nurseries, the highest soil water factor (lowest MSWD index) in the table is used; otherwise, the two rows whose MSWD 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 mm and 100 mm respectively, a calculated MSWD value of 82.5 mm would return a soil water factor of:

$$0.95 + \left[\frac{82.5 - 75}{100 - 75} \times (0.9 - 0.95) \right]$$
$$= 0.935$$

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)

The effective precipitation (precipitation that adds to the stored soil moisture content) can be different in the cooler pre-season than in the growing season. The early season evaporation factor is used to determine what percentage of the precipitation is considered effective prior to the growing season.

Crop Coefficient (K_c)

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 equalling 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:

$$K_c = [0.0000000031 \times (35)^4] + [-0.0000013775 \times (35)^3] + (0.0001634536 \times (35)^2] + (-0.0011179845 \times 35) + 0.2399004137$$
$$= 0.346593241$$

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.

There are two sets of polynomial coefficients used to calculate the crop coefficient; the first set is used for modelling time periods up to the year specified as the *crop curve changeover year*; and the second for modelling into the future. The changeover year will be modified as time goes on and new historical climate observations become available.

Growing Degree Days (GDD)

The Growing Degree Day calculations generate the start and end of GDD accumulation.

1. ***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 T_{mean} matching or exceeding the base temperature (BaseT). The search for the start day gets reset if a killing frost ($< -2\ ^oC$) occurs, even after the accumulation has started. The search also restarts if there are 2 or more consecutive days of $T_{min} \leq 0\ ^oC$. The GDD start is limited to Julian days 1 to 210; if the accumulation has not started by that point, then it is unlikely to produce a reasonable starting point for any crop.

2. ***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 T_{mean} fails to reach BaseT (strictly *less than*) or the first killing frost ($-2\ ^oC$).

During the GDD accumulation period, the daily contribution is the difference between T_{mean} and BaseT, as long as T_{mean} is not less than BaseT:

$$GDD = T_{mean} - BaseT;\ 0 \text{ if negative}$$

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 $T_{min} \leq 0\ ^oC$
- the first fall frost is the first day between days 240 and the end of the year where $T_{min} \leq 0\ ^oC$
- the killing frost is the first day on or after the first fall frost where $T_{min} \leq -2\ ^oC$

Corn Heat Units (CHU)

The Corn Heat Unit is the average of two terms using T_{min} and T_{max}. Prior to averaging, each term is set to 0 individually if it is negative.

$$\text{term1} = [3.33 \times (T_{max} - 10)] - [0.084 \times (T_{max} - 10) \times (T_{max} - 10)]; \text{ 0 if negative}$$

$$\text{term2} = 1.8 \times (T_{min} - 4.44); \text{ 0 if negative}$$

$$\text{CHU} = \frac{(\text{term1} + \text{term2})}{2}$$

Corn Season Start and End

The corn season boundary derivations are similar to the GDD determinations. The start day is established by 3 consecutive days where $T_{mean} \geq 11.2\ ^{o}C$. As in the case of the GDD calculations, the search for the corn season start day gets reset if $T_{min} \leq -2\ ^{o}C$, or if there are 2 or more consecutive days of $-2\ ^{o}C \leq T_{min} \leq 0\ ^{o}C$.

The search for the silage corn season end begins 50 days after the start. The season ends on the earlier of a mean temperature dropping below 10.1 or a killing frost.

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 daily T_{mean} reaches that number. For example, the Tsum400 day is the day where the sum of the positive T_{mean} starting on January 1 sum to 400 units or greater.

Days where T_{mean} falls below 0 ^{o}C are simply not counted; therefore, the Model does not restart the accumulation sequence.

Wet/Dry Climate Assessment

Starting with the Lower Mainland, some of the modelling calculations depend on an assessment of the general climatic environment as *wet* or *dry*. For example, when modelling the soil moisture content prior to the start of the crop's growing season, the reservoir can only be drawn down by evaporation except for *grass* crops in *wet* climates which can pull additional moisture out of the soil.

The assessment of wet or dry uses the total precipitation between May 1 and September 30. If the total is more than 125 mm during that period, the climate is considered to be *wet* and otherwise *dry*.

Groundwater Use

The Model generates water sources for irrigation systems. This is done by first determining which farms are supplied by a water purveyor, and then coding those farms as such. Most water purveyors use surface water but where groundwater is used, the farms are coded as groundwater use. The second step is to check all water licences and assign the water licences to properties in the database. The remaining farms that are irrigating will therefore not have a water licence or be supplied by a water purveyor. The assumption is made that these farms are irrigated by groundwater sources.

Land Use Results

A summary of the land area and the inventoried project area are shown in Table 2. The inventoried area includes parcels that are in and partially in the Agricultural Land Reserve (ALR). The primary agricultural use of the ARL area is shown in Table 3. Refer to the Agricultural Land Use Inventory (ALUI) reports for details.

Table 2 Overview of the Land and Inventoried Area

Area Type	Area (ha)
Regional District of Central Kootenay (RDCK)	
Total Area	2,316,142
Area of Water Feature	106,667
Area of Land (excluding water features)	2,209,475
ALR Area	63,084
Inventoried Area	
Total Inventoried Area	283,983

Table 3 Summary of Primary Agricultural Activities within the ALR where Primary Land Use is agriculture in the Project Area

Primary Agriculture Activity	Total Land Cover (ha)
Forage	11,466
Cereal	2,557
Natural pasture and natural rangeland	2,045
Turf farm, turf park and yard	738
Tree Fruits	396
Nursery & Tree Plantations	174
Vegetables	137
Others	483
Total	**22,964**

Figures 8, 9 and 10 show the areas of water, ALR land and land parcels in the basin graphically. Figure 11 provides a schematic of the higher yielding aquifer areas in the project area based on the information from B.C. Ministry of Environment.

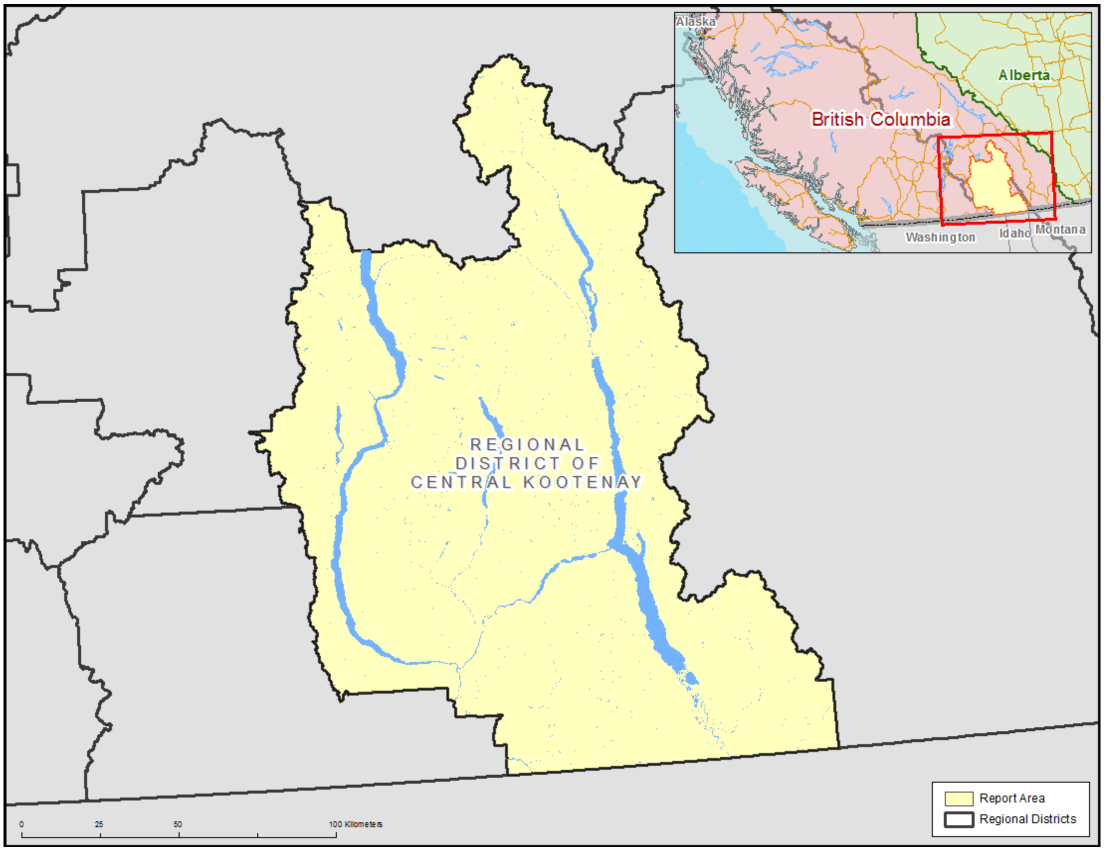

Figure 8 Water Areas in the Project Area

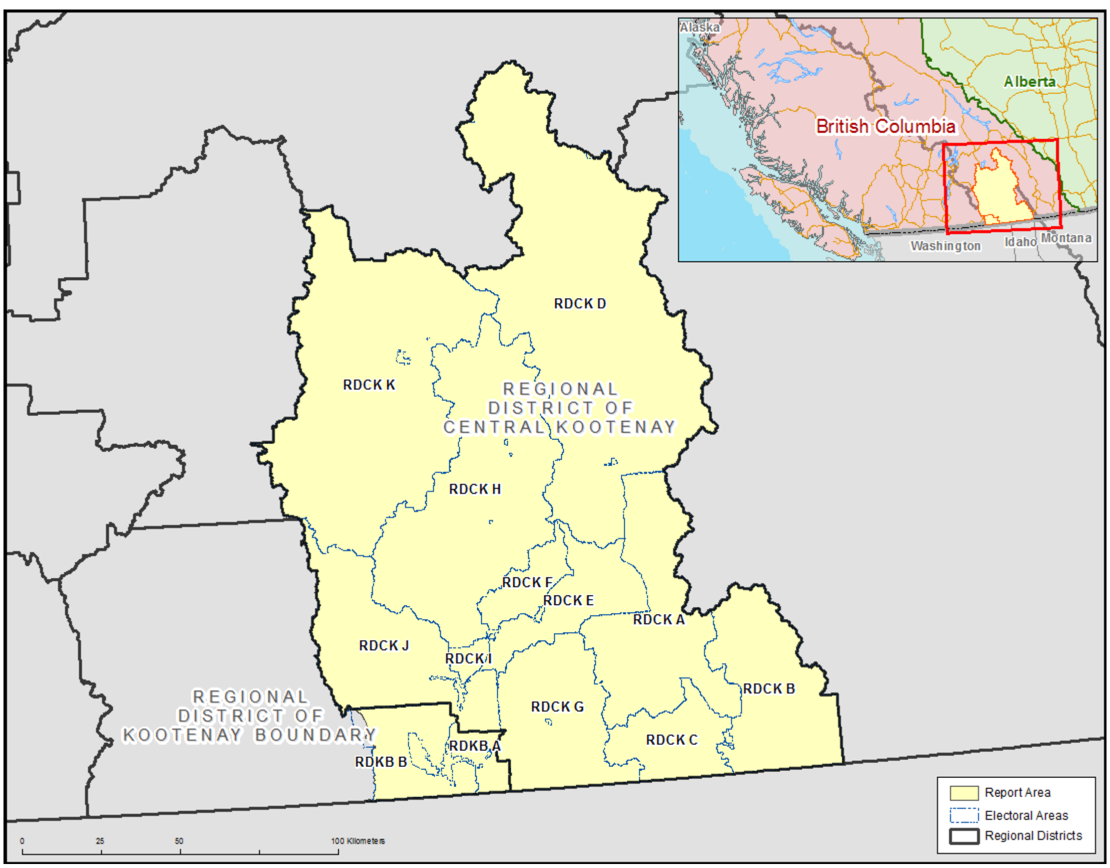

Figure 9 Electoral Areas in the Project Area

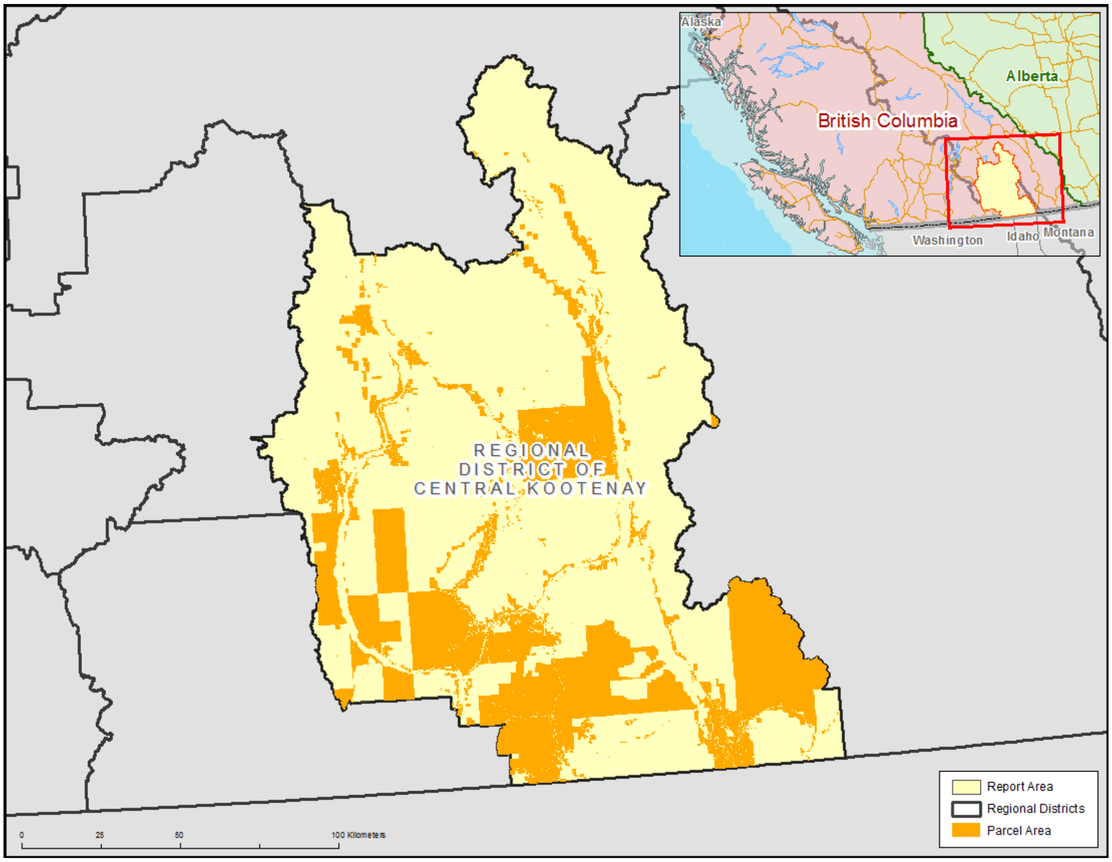

Figure 10 Land Parcels in the Project Area

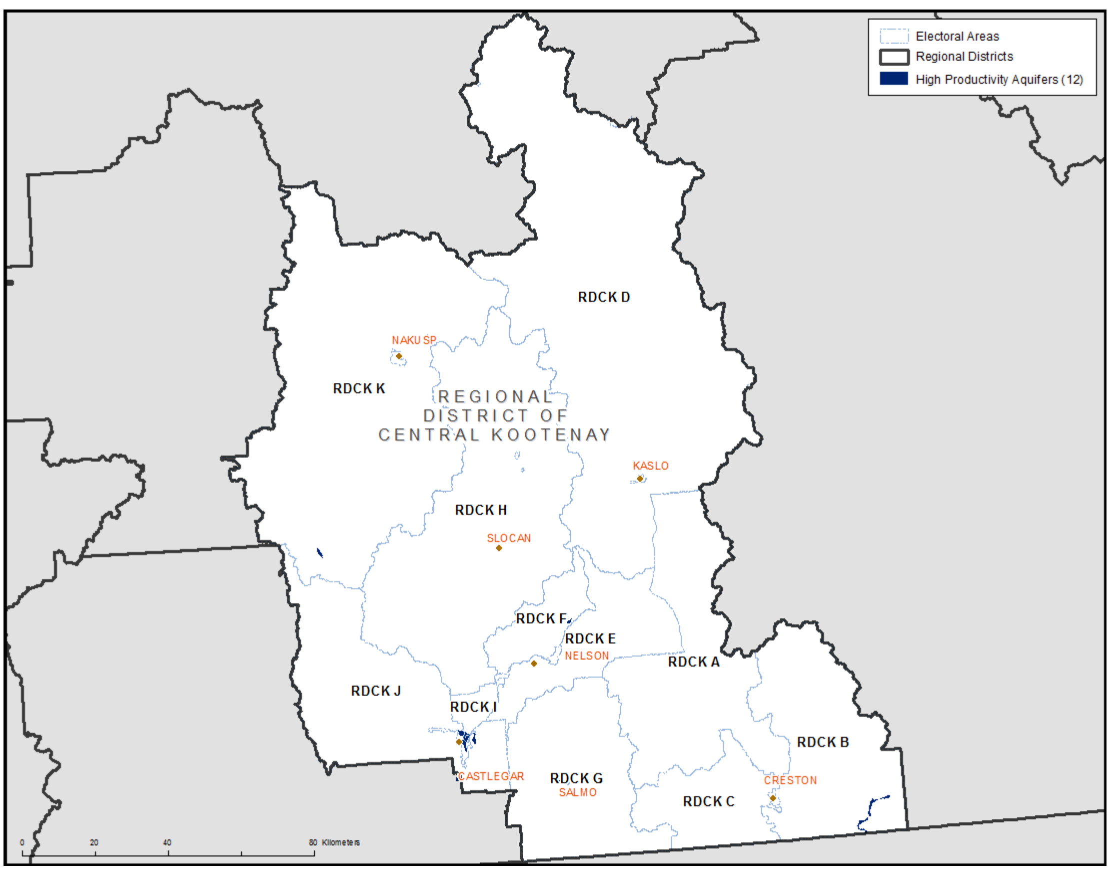

Figure 11 Higher Productive Groundwater Aquifers in the Project Area

Agricultural Water Demand Results

The Model has a reporting feature that can save and generate reports for many different scenarios that have been pre-developed. This report will provide a summary of the reported data in the Appendices. Climate data from 1997 and 2003 were chosen as they represent a relatively wet year and dry year respectively. Most reports are based on the 2003 data since the maximum current demand can then be presented. Scenarios using climate change information in the 2050's is also presented.

Annual Crop Water Demand – Tables A and B

The Model can use three different irrigation management factors, good, average and poor. Unless otherwise noted, average management were used in the tables. Appendix Table A provides the annual irrigation water demand for current crop and irrigation systems used for the year 2003 using average irrigation management, and Table B provides the same data for 1997.

Where a crop was not established, the acreage was assigned a forage crop so that the Model could determine a water demand. The total irrigated acreage in RDCK is 3,645 hectares (ha), including 2,805 ha (77%) for forage crops (alfalfa, forage corn, grass, legume and pasture). In RDCK, 978 ha (27%) is supplied by licensed surface water sources, and 2,667 ha (73%) is irrigated with groundwater.

The total annual irrigation demand was 30,893,044 m^3 in 2003, and dropped to 15,631,804 m^3 in 1997. During a wet year like 1997, the demand was only 51% of a hot dry year like 2003.

In addition, the Model also calculates demand based on relatively good practices. As such, actual use may actually be higher or lower than what is calculated by the Model.

Annual Water Demand by Irrigation System – Table C

The crop irrigation demand can also be reported by irrigation system type as shown in Table C. The more efficient irrigation system for forage is low-pressure pivots which irrigated 248 ha (7%) in the project area. Travelling guns, wheelline and handline irrigate 1,740 ha (48%) of the agricultural crops.

Annual Water Demand by Soil Texture – Table D

Table D provides annual water demand by soil texture. Where soil texture data is missing, the soil texture has been defaulted to sandy loam. The defaults are shown in Table D.

Annual Water Demand by Water Purveyor – Table E

The model calculates water demand on a property by property basis and can summarize the data for each water purveyor in the project area. Table E provides an estimated water demand for each purveyor. The bottom of the table shows the first nations and private irrigated area – this is included as a check to allow the total numbers to be compared against the other tables.

Annual Water Demand by Local Government – Table F

Table F provides a breakdown of the agriculture irrigated areas within the boundaries of each local government within the project area.

Annual Water Demand by Electoral Area – Table G

Table G shows the water demands by electoral areas. Figure 9 shows the electoral areas boundaries in the project area.

Irrigation Management Factors – Table H

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 based on subjective decision and percolation rates. The Maximum Soil Water Deficit (MSWD) is the maximum amount of water that can be stored in the soil within the crop rooting zone. An irrigation system applying more water than what can be stored will result in percolation beyond the crop's rooting depth. Irrigation systems with high application rates will have a probability of higher percolation rates, a stationary gun for instance.

For each soil class, a range of four MSWD are provided, which reflect a range of crop rooting depths. An irrigation management factor, which determines the amount of leaching, is established for each of the MSWD values for the soil types (Table 4). The management factor is based on irrigation expertise as to how the various irrigation systems are able to operate. For example, Table 5 indicates that for a loam soil and a MSWD of 38 mm, a solid set overtree system has a management factor of 0.10 for good management while the drip system has a management factor of 0.05. This indicates that it is easier to prevent percolation with a drip system than it is with a solid set sprinkler system. For poor management, the factors are higher.

There are a total of 1,344 irrigation management factors established for the 16 different soil textures, MSWD and 21 different irrigation system combinations used in the Model.

Table 4 Irrigation Management Factors

Soil Texture	MSWD	Solid Set Overtree			Drip		
		Good	Average	Poor	Good	Average	Poor
Loam	38	0.10	0.15	0.20	0.05	0.10	0.15
	50	0.05	0.10	0.15	0.05	0.075	0.10
	75	0.05	0.10	0.15	0.05	0.075	0.10
	100	0.05	0.075	0.10	0.05	0.075	0.10
Sandy loam	25	0.20	0.225	0.25	0.10	0.15	0.20
	38	0.10	0.15	0.20	0.10	0.125	0.15
	50	0.05	0.10	0.15	0.05	0.10	0.10
	75	0.05	0.10	0.15	0.05	0.075	0.10

The management factors increase as the MSWD decreases because 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 0.50.

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 H provides an overview of the impacts on the management factors and irrigation systems used. Since a large portion of the crops in the region are forage crops which are currently irrigated with sprinkler system which need to be run almost non-stop especially in peak season, the impacts of improved management are not significant at all. An improvement of 3% in total water use reduction could be achieved by improved management. A further reduction could be achieved by improving irrigation efficiencies as shown in Table J.

Table H also provides percolation rates based on good, average and poor management using 2003 climate data. In summary, good management is 2,487,584 m^3, average is 3,273,956 $m^3$and poor management is 4,060,328 m^3. Percolation rates for poor management are 39% higher than for good management.

Deep Percolation – Table I

The percolation rates vary by crop, irrigation system type, soil and the management factor used. Table I shows the deep percolation amounts by irrigation system type for average management. The last column provides a good indication of the average percolation per hectare for the various irrigation system types. For example, low pressure pivot irrigation systems have only 13 to 22% 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.

Improved Irrigation Efficiency and Good Management – Table J

There is an opportunity to reduce water use by converting irrigation systems to a higher efficiency for some crops. For example, drip systems could be used for all fruit crops, vegetable crops and some of the other horticultural crops, but not forage crops. In addition, using better management such as irrigation scheduling techniques will also reduce water use, especially for forage where drip conversion is not possible. Table J provides a scenario of water demand if all sprinkler systems are converted to drip systems for horticultural crops in the project area, as well as converting irrigation systems to low-pressure pivot systems for forage fields over 10 ha, using good irrigation management. In this case, the water demand for 2003 would reduce from 30,893,044 m^3 to 27,405,072 m^3 (11% reduction).

Livestock Water Use – Table K

The Model provides an estimate of water use for livestock. The estimate is based on the number of animals in the project area as determined by the latest census, the drinking water required for each animal per day and the barn or milking parlour wash water. Values used are shown in Table 1. For the project area, the amount of livestock water is estimated at 138,593 m^3.

Climate Change Water Demand for 2050 – Table L

The Model also has access to climate change information until the year 2100. While data can be run for each year, three driest years in the 2050's were selected to give a representation of climate change. Figure 12 shows the climate data results which indicate that 2053, 2056, and 2059 generate the highest annual ET_o and lowest annual precipitation. These three years were used in this report.

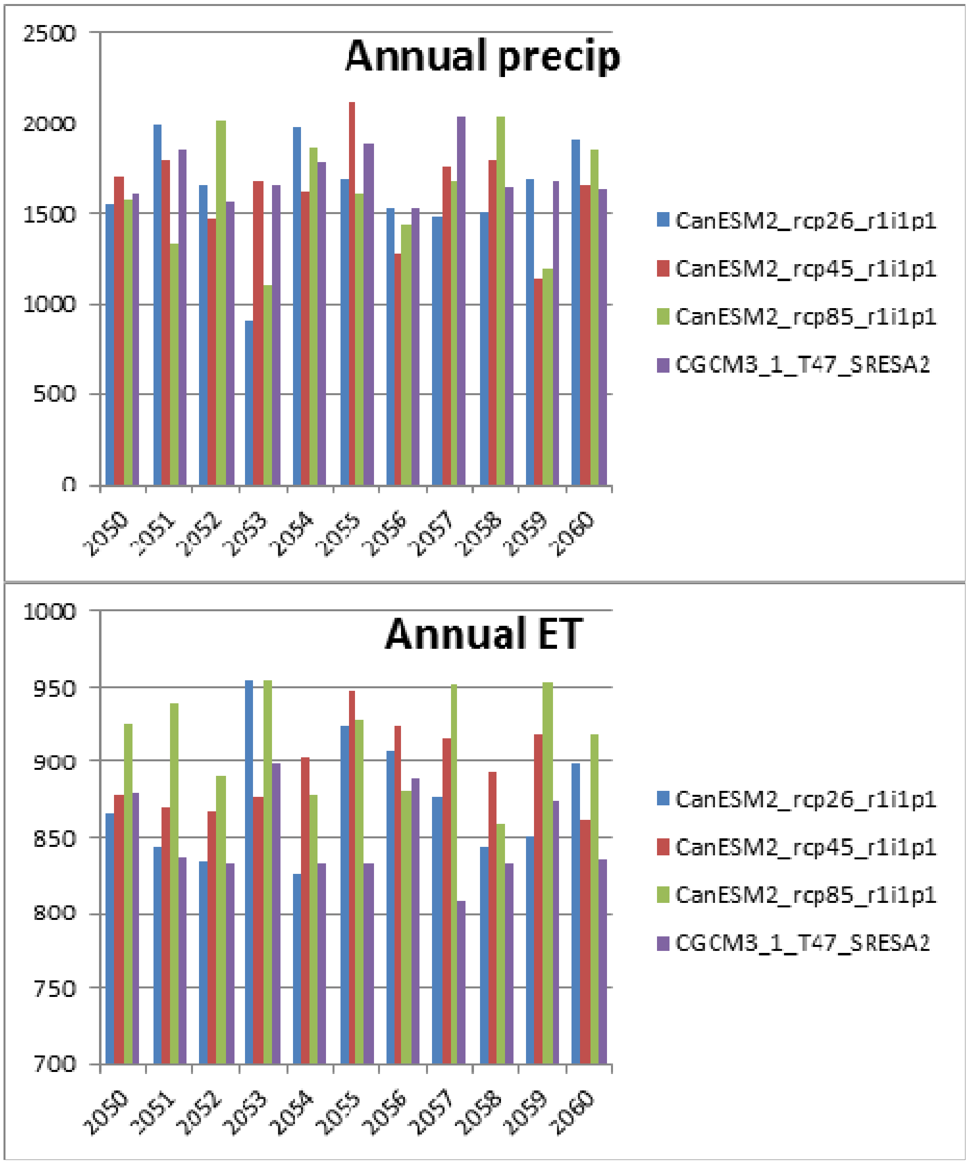

Figure 12 Annual ET and Effective Precipitation in 2050's

Table L provides the results of climate change on irrigation demand for the three years selected using current crops and irrigation systems. Current crops and irrigation systems are used to show the increase due to climate change only, with no other changes taking place.

Figure 13 shows all of the climate change scenario runs for the Okanagan using 12 climate models from 1960 to 2100. This work was compiled by Denise Neilsen at the Agriculture and Agri-Food Canada – Summerland Research and Development Centre. There is a lot of scatter in this figure, but it is obvious that there is a trend of increasing water demand.

The three climate change models used in this report are access1 rcp85, canESM2 rcp85 and cnrm-cm5 rcp85. Running only three climate change models on three selected future years in the project area is not sufficient to provide a trend like in Figure 13. What the results do show is that in an extreme climate scenario, it is possible to have an annual water demand that is 22% higher than what was experienced in 2003 based on canESM2 rcp85 climate model in 2053. More runs of the climate change models will be required to better estimate a climate change trend for the region.

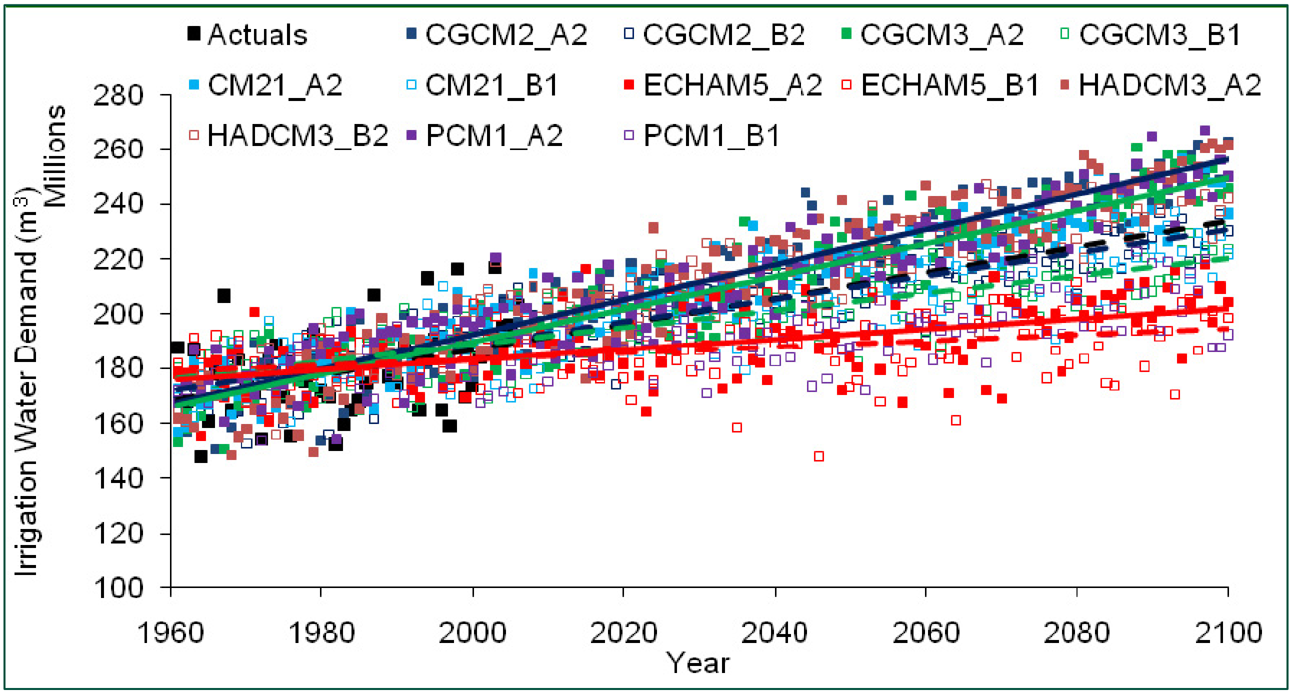

Figure 13 Future Irrigation Demand for All Outdoor Uses in the Okanagan in Response to Observed Climate Data (Actuals) and Future Climate Data Projected from a Range of Global Climate Models

Agricultural Buildout Crop Water Demand Using 2003 Climate Data – Table M

An agricultural irrigated buildout scenario was developed that looked at potential agricultural lands that could be irrigated in the future. The rules used to establish where potential additional agricultural lands were located are as follows:

- within 1,000 m of water supply (lake)
- within 1,000 m of water supply (water course)
- within 1,000 m of water supply (wetland)
- within 1,000 m of high productivity aquifer
- within 1,000 m of water purveyor
- with Ag Capability class 1-4 only where available
- must be within the ALR
- below 750 m average elevation
- must be private ownership

Physical structure (e.g., farmstead, houses) are not considered to be available for the buildout scenario. For the areas that are determined to be eligible for future buildout, a crop and irrigation system need to be applied. Where a crop already existed in the land use inventory, that crop would remain and an irrigation system assigned. If no crop existed, then a crop and an irrigation system are assigned as per the criteria below:

- **pivots to be applied to parcels larger than 10 ha:**
  - 30% travelling gun on forage
  - 25% sprinkler on forage
  - 15% pivot on forage
  - 15% travelling gun on pasture
  - 10% drip on tree fruits
  - 5% pivot on cereal
- **otherwise:**
  - 35% travelling gun on forage
  - 30% sprinkler on forage
  - 20% travelling gun on pasture
  - 15% drip on tree fruits

Figure 14 indicates the location of agricultural land that is currently irrigated (red) and the land that can be potentially irrigated (blue). Based on the scenario provided for the project area, the additional agricultural land that could be irrigated is 9,353 ha, which is an increase in irrigated acreage of 257%. The water demand for a year like 2003 would then be almost 106 million m^3 assuming efficient irrigation systems and good management. Figure 14 can be provided in a larger scale by contacting the Ministry of Agriculture

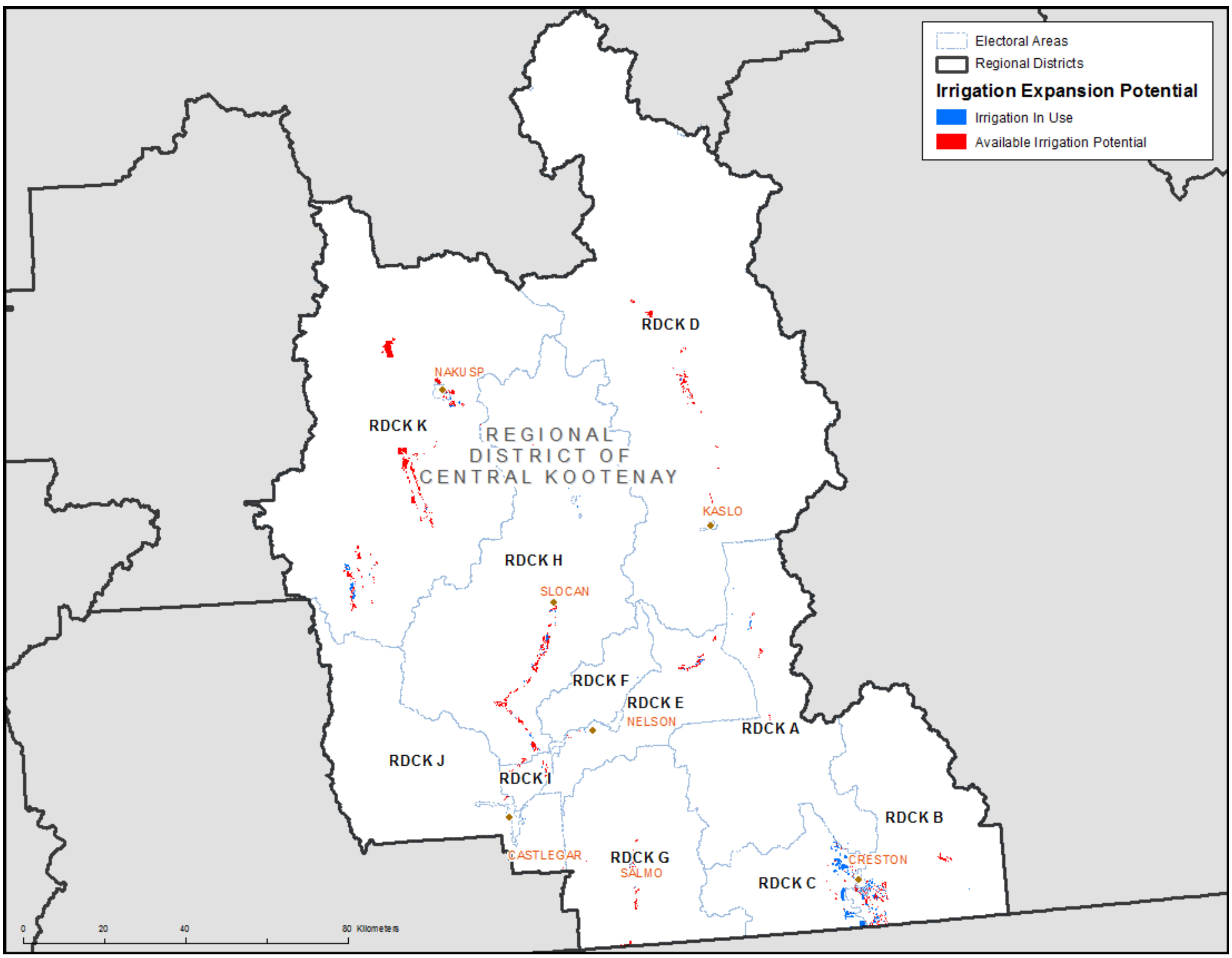

Figure 14 Irrigation Expansion Potential for the Project Area

Agricultural Buildout Crop Water Demand for 2050 – Table N

The same irrigation expansion and cropping scenario used to generate the values in Table M were used to generate the climate change water demand shown in Table N. See discussion under Table L section. When climate change is added to the buildout scenario, the water demand increases from 106 million m^3 to 130 million m^3 (a further 23% increase) based on climate change model canESM2 rcp85 in 2053 using the highest potential scenario.

Irrigation Systems Used for the Buildout Scenario for 2003 – Table O

Table O provides an account of the irrigation systems used by area for the buildout scenario in the previous two examples. Note that pivot irrigation is the predominant system type. Note that low pressure pivots should have been used which have the higher efficiency.

Water Demand for the Buildout Area by Water Purveyor 2003 Climate Data – Table P

Table P provides the water demand by water purveyors for the buildout scenario used in this report. Comparing these values with the result in Table E will provide information on the possible increased water demand by groundwater for the purveyed areas. The Model does not determine that there is sufficient groundwater available, only that this would be the potential demand.

Water Demand for the Buildout Area by Local Government 2003 Climate Data – Table Q

Table Q provides the water demand by local governments for the buildout scenario used in this report. Comparing these values with the result in Table F will provide information on the possible increased water demand.

Water Demand for the Buildout Area by Electoral Area 2003 Climate Data – Table R

Table R provides the future water demand within electoral area boundaries using previous scenarios. Comparing these values with the result in Table G will provide information on the possible increased water demand within electoral areas if the buildout scenarios actually occurred in the future.

Literature

Cannon, A.J., and Whitfield, P.H. (2002), Synoptic map classification using recursive partitioning and principle component analysis. *Monthly Weather Rev.* 130:1187-1206.

Cannon, A.J. (2008), Probabilistic multi-site precipitation downscaling by an expanded Bernoulli-gamma density network. *Journal of Hydrometeorology*. http://dx.doi.org/10.1175%2F2008JHM960.1
Intergovernmental Panel on Climate Change (IPCC) (2008), Fourth Assessment Report –AR4. http://www.ipcc.ch/ipccreports/ar4-syr.htm

Merritt, W, Alila, Y., Barton, M., Taylor, B., Neilsen, D., and Cohen, S. 2006. Hydrologic response to scenarios of climate change in the Okanagan Basin, British Columbia. J. Hydrology. 326: 79-108.

Neilsen, D., Smith, S., Frank, G., Koch, W., Alila, Y., Merritt, W., Taylor, B., Barton, M, Hall, J. and Cohen, S. 2006. Potential impacts of climate change on water availability for crops in the Okanagan Basin, British Columbia. Can. J. Soil Sci. 86: 909-924.

Neilsen, D., Duke, G., Taylor, W., Byrne, J.M., and Van der Gulik T.W. (2010). Development and Verification of Daily Gridded Climate Surfaces in the Okanagan Basin of British Columbia. *Canadian Water Resources Journal* 35(2), pp. 131-154. http://www4.agr.gc.ca/abstract-resume/abstract-resume.htm?lang=eng&id=21183000000448

Allen, R. G., Pereira, L. S., Raes, D. and Smith, M. 1998. Crop evapotranspiration Guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56. United Nations Food and Agriculture Organization. Rome. 100pp

Appendix Tables

Appendix Table A 2003 Water Demand by Crop with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Crop Group	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Apple	34.4	230,556	670	-	-	-	15.2	106,656	704	49.6	**337,211**	680
Berry	7.1	35,047	497	-	-	-	11.8	67,173	569	18.9	**102,221**	542
Cherry	152.4	1,125,846	739	-	-	-	110.4	879,296	796	262.8	**2,005,142**	763
Forage	677.3	6,170,101	911	-	-	-	2,128.1	18,479,228	868	2,805.5	**24,649,328**	879
Fruit	10.1	60,063	595	-	-	-	3.6	24,173	673	13.7	**84,236**	615
Golf	14.9	125,565	841	-	-	-	112.0	1,005,054	897	127.0	**1,130,619**	891
Grape	23.8	82,822	348	-	-	-	14.1	62,727	444	37.9	**145,549**	384
Nursery	2.7	19,008	693	-	-	-	149.8	1,164,762	778	152.5	**1,183,770**	776
Nursery Floriculture	1.0	5,115	503	-	-	-	-	-	-	1.0	**5,115**	503
Recreational Turf	-	-	-	-	-	-	3.2	24,879	776	3.2	**24,879**	776
Turf Farm	-	-	-	-	-	-	24.0	235,121	979	24.0	**235,121**	979
Vegetable	52.7	318,535	604	-	-	-	79.5	555,783	699	132.2	**874,318**	661
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table B 1997 Water Demand by Crop with Average Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Agriculture Crop Group	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Apple	34.4	107,762	313	-	-	-	15.2	47,314	312	49.6	**155,076**	313
Berry	7.1	15,890	225	-	-	-	11.8	29,147	247	18.9	**45,037**	239
Cherry	152.4	583,783	383	-	-	-	110.4	465,690	422	262.8	**1,049,473**	399
Forage	677.3	3,188,462	471	-	-	-	2,128.1	9,210,722	433	2,805.5	**12,399,183**	442
Fruit	10.1	28,256	280	-	-	-	3.6	9,446	263	13.7	**37,703**	275
Golf	14.9	80,101	537	-	-	-	112.0	663,760	593	127.0	**743,862**	586
Grape	23.8	26,793	113	-	-	-	14.1	19,034	135	37.9	**45,827**	121
Nursery	2.7	7,407	270	-	-	-	149.8	456,505	305	152.5	**463,913**	304
Nursery Floriculture	1.0	2,553	251	-	-	-	-	-	-	1.0	**2,553**	251
Recreational Turf	-	-	-	-	-	-	3.2	17,790	555	3.2	**17,790**	555
Turf Farm	-	-	-	-	-	-	24.0	143,062	595	24.0	**143,062**	595
Vegetable	52.7	186,184	353	-	-	-	79.5	342,142	430	132.2	**528,326**	400
TOTALS	976.5	**4,227,191**	433	-	-	-	2,651.7	**11,404,613**	430	3,628.3	**15,631,804**	431

Appendix Table C 2003 Water Demand by Irrigation System with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
Drip	150.3	901,135	600	-	-	-	159.4	1,030,585	647	309.6	**1,931,721**	624
Flood	-	-	-	-	-	-	18.3	402,943	2,197	18.3	**402,943**	2,197
Gun	18.5	280,333	1,515	-	-	-	34.6	502,010	1,452	53.1	**782,343**	1,474
Handline	66.2	563,356	851	-	-	-	71.7	675,599	943	137.9	**1,238,955**	898
Landscapesprinkler	14.9	125,565	841	-	-	-	115.2	1,029,933	894	130.2	**1,155,498**	888
Microspray	35.8	274,305	766	-	-	-	1.1	8,915	796	36.9	**283,219**	767
Microsprinkler	26.1	207,958	797	-	-	-	10.0	56,826	566	36.1	**264,784**	733
Overtreedrip	7.1	37,419	525	-	-	-	14.9	71,744	482	22.0	**109,163**	496
PivotLP	17.3	170,979	986	-	-	-	231.2	1,551,364	671	248.5	**1,722,343**	693
SDI	0.8	5,714	716	-	-	-	-	-	-	0.8	**5,714**	716
Sprinkler	201.0	1,661,650	827	-	-	-	620.5	5,336,811	860	821.5	**6,998,462**	852
Ssovertree	61.8	519,349	840	-	-	-	31.1	253,440	815	93.0	**772,789**	831
Sssprinkler	54.3	489,086	901	-	-	-	71.9	675,301	940	126.2	**1,164,387**	923
Ssundertree	5.3	42,532	803	-	-	-	4.2	36,107	862	9.5	**78,639**	829
Travgun	186.0	1,730,672	930	-	-	-	997.6	8,374,421	839	1,183.6	**10,105,093**	854
Wheelline	133.3	1,178,273	884	-	-	-	285.3	2,698,718	946	418.6	**3,876,991**	926
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table D 2003 Water Demand by Soil Texture with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Irrigation System	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Clay Loam	7.5	58,694	788	-	-	-	41.6	356,006	855	49.1	**414,700**	845
Loam	0.4	2,231	546	-	-	-	1.0	5,318	523	1.4	**7,548**	530
Sand	343.1	3,215,327	937	-	-	-	481.9	4,852,107	1,007	825.0	**8,067,434**	978
Sandy Clay Loam	8.8	63,537	721	-	-	-	14.5	109,920	757	23.3	**173,457**	743
Sandy Loam	59.3	497,935	840	-	-	-	76.2	848,834	1,113	135.5	**1,346,769**	994
Sandy Loam (defaulted)	13.1	134,080	1,020	-	-	-	4.5	48,898	1,091	17.6	**182,979**	1,038
Silt Loam	374.8	2,435,324	650	-	-	-	1,318.3	10,263,531	779	1,693.1	**12,698,855**	750
Silty Clay Loam	171.8	1,781,198	1,037	-	-	-	729.0	6,220,104	853	900.7	**8,001,303**	888
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table E 2003 Water Demand by Water Purveyor with Average Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Water Purveyor	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Balfour	0.3	2,116	636	-	-	-	-	-	-	0.3	**2,116**	636
Beaver Falls	-	-	-	-	-	-	7.0	71,267	1,020	7.0	**71,267**	1,020
Beaver Valley	-	-	-	-	-	-	5.9	58,123	987	5.9	**58,123**	987
Burton	-	-	-	-	-	-	9.1	59,968	662	9.1	**59,968**	662
Creston	-	-	-	-	-	-	414.0	3,316,854	801	414.0	**3,316,854**	801
Denver Siding	0.5	3,142	667	-	-	-	-	-	-	0.5	**3,142**	667
Duck Lake	-	-	-	-	-	-	113.0	902,494	799	113.0	**902,494**	799
Erickson	235.6	1,597,699	678	-	-	-	-	-	-	235.6	**1,597,699**	678
Fauquier	-	-	-	-	-	-	0.1	503	589	0.1	**503**	589
Glade	-	-	-	-	-	-	2.4	17,441	736	2.4	**17,441**	736
Lister	27.3	274,463	1,005	-	-	-	43.8	432,984	988	71.1	**707,447**	995
Nicks Island	-	-	-	-	-	-	71.9	647,609	900	71.9	**647,609**	900
North Canyon	3.3	24,383	741	-	-	-	69.1	514,633	745	72.4	**539,017**	745
Oasis/Rivervale Sewerage (SA)	-	-	-	-	-	-	-	11	916	-	**11**	916
Ootischenia	-	-	-	-	-	-	4.0	32,589	806	4.0	**32,589**	806
Orde Creek	35.8	450,503	1,260	-	-	-	45.9	492,819	1,074	81.6	**943,323**	1,156
Reclamation	0.9	7,230	834	-	-	-	726.2	5,854,828	806	727.1	**5,862,057**	806
Riondel	1.3	10,130	802	-	-	-	-	-	-	1.3	**10,130**	802
Robson Raspberry	-	-	-	-	-	-	4.9	45,303	916	4.9	**45,303**	916
Rykert	37.5	379,272	1,012	-	-	-	37.0	400,119	1,081	74.5	**779,390**	1,046
Slocan Park	-	-	-	-	-	-	5.9	77,993	1,314	5.9	**77,993**	1,314
South Canyon	-	-	-	-	-	-	13.6	126,155	925	13.6	**126,155**	925
West Robson	-	-	-	-	-	-	0.4	4,274	950	0.4	**4,274**	950
Wynndel	-	-	-	-	-	-	17.2	128,446	745	17.2	**128,446**	745
TOTALS	342.4	**2,748,938**	803	-	-	-	1,591.6	**13,184,413**	828	1,934.0	**15,933,351**	824
Multiple Band First Nation	4.7	**39,195**	842	-	-	-	189.9	**1,514,396**	797	194.6	**1,553,591**	798
Private	631.7	**5,400,193**	855	-	-	-	885.5	**8,005,909**	904	1,517.2	**13,406,102**	884
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table F   2003 Water Demand by Local Government with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Local Government	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
Creston	10.0	87,308	872	-	-	-	1.3	5,775	460	11.3	**93,082**	826
Fruitvale	-	-	-	-	-	-	1.5	13,742	937	1.5	**13,742**	937
Multiple Band First Nation	4.7	39,195	842	-	-	-	189.9	1,514,396	797	194.6	**1,553,591**	798
Nakusp	-	-	-	-	-	-	6.9	43,237	622	6.9	**43,237**	622
Nelson	5.7	46,491	823	-	-	-	-	-	-	5.7	**46,491**	823
Regional District Of Central Kootenay	874.3	7,052,234	807	-	-	-	2,351.2	19,879,949	846	3,225.5	**26,932,183**	835
Regional District Of Kootenay	84.2	963,099	1,144	-	-	-	116.3	1,247,618	1,073	200.4	**2,210,717**	1,103
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table G   2003 Water Demand by Electoral Area with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Electoral Area	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
RDCK Electoral Area A	27.5	201,317	731	-	-	-	67.5	550,691	816	95.0	**752,009**	791
RDCK Electoral Area B	385.1	3,266,792	848	-	-	-	341.6	3,213,530	941	726.7	**6,480,321**	892
RDCK Electoral Area C	38.5	280,495	729	-	-	-	1,548.9	12,723,461	821	1,587.3	**13,003,955**	819
RDCK Electoral Area D	10.0	56,806	569	-	-	-	22.9	151,832	663	32.9	**208,638**	634
RDCK Electoral Area E	77.9	624,975	802	-	-	-	44.3	322,851	728	122.3	**947,826**	775
RDCK Electoral Area F	12.5	97,569	780	-	-	-	2.7	19,990	754	15.2	**117,560**	775
RDCK Electoral Area G	0.4	3,465	791	-	-	-	33.7	299,874	889	34.2	**303,338**	888
RDCK Electoral Area H	138.0	1,167,615	846	-	-	-	165.3	1,697,237	1,027	303.3	**2,864,852**	945
RDCK Electoral Area I	16.3	145,913	896	-	-	-	12.9	115,487	897	29.2	**261,400**	896
RDCK Electoral Area J	2.2	20,054	929	-	-	-	10.6	93,632	883	12.8	**113,686**	891
RDCK Electoral Area K	180.0	1,301,165	723	-	-	-	295.8	2,237,134	756	475.8	**3,538,299**	744
RDKB Electoral Area A	11.2	100,714	898	-	-	-	93.5	1,036,024	1,108	104.7	**1,136,738**	1,086
RDKB Electoral Area B	73.0	862,385	1,182	-	-	-	22.8	211,594	929	95.7	**1,073,979**	1,122
TOTALS	978.8	**8,188,326**	837	-	-	-	2,667.1	**22,704,718**	851	3,645.8	**30,893,044**	847

Appendix Table H 2003 Management Comparison on Irrigation Demand and Percolation Volumes

Water Source	Surface Water				Reclaimed Water				Groundwater				Total				
Agriculture Management	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Deep Percolation (m^3)	Percolation (m^3/ha)
Poor	978.8	8,421,027	860	1,256,250	-	-	-	-	2,667.1	23,258,753	872	2,804,078	3,645.8	31,679,781	869	4,060,328	1,114
Avg	978.8	8,188,326	837	1,023,549	-	-	-	-	2,667.1	22,705,083	851	2,250,407	3,645.8	30,893,409	847	3,273,956	898
Good	978.8	7,955,625	813	790,848	-	-	-	-	2,667.1	22,151,412	831	1,696,737	3,645.8	30,107,037	826	2,487,584	682

Appendix Table I 2003 Percolation Volumes by Irrigation System with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total			
Agriculture Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Irrigated Area (ha)	Irrigation Demand (m^3)	Deep Percolation (m^3)	Percolation (m^3/ha)
Drip	150.3	901,135	61,546	-	-	-	159.4	1,030,585	69,219	309.6	1,931,721	**130,765**	422
Flood	-	-	-	-	-	-	18.3	402,943	99,231	18.3	402,943	**99,231**	5,422
Gun	18.5	280,333	45,848	-	-	-	34.6	502,010	135,653	53.1	782,343	**181,500**	3,418
Handline	66.2	563,356	88,808	-	-	-	71.7	675,599	75,090	137.9	1,238,955	**163,897**	1,189
Landscapesprinkler	14.9	125,565	15,335	-	-	-	115.2	1,029,933	171,014	130.2	1,155,498	**186,350**	1,431
Microspray	35.8	274,305	23,544	-	-	-	1.1	8,915	1,038	36.9	283,219	**24,581**	666
Microsprinkler	26.1	207,958	17,689	-	-	-	10.0	56,826	5,196	36.1	264,784	**22,885**	634
Overtreedrip	7.1	37,419	1,678	-	-	-	14.9	71,744	1,990	22.0	109,163	**3,669**	167
PivotLP	17.3	170,979	18,451	-	-	-	231.2	1,551,364	91,009	248.5	1,722,343	**109,460**	440
SDI	0.8	5,714	374	-	-	-	-	-	-	0.8	5,714	**374**	468
Sprinkler	201.0	1,661,650	221,832	-	-	-	620.5	5,336,811	571,268	821.5	6,998,462	**793,100**	965
Ssovertree	61.8	519,349	86,909	-	-	-	31.1	253,440	33,463	93.0	772,789	**120,373**	1,294
Sssprinkler	54.3	489,086	74,181	-	-	-	71.9	675,301	80,371	126.2	1,164,387	**154,552**	1,225
Ssundertree	5.3	42,532	3,926	-	-	-	4.2	36,107	4,536	9.5	78,639	**8,462**	891
Travgun	186.0	1,730,672	228,606	-	-	-	997.6	8,374,421	652,269	1,183.6	10,105,093	**880,874**	744
Wheelline	133.3	1,178,273	134,822	-	-	-	285.3	2,698,718	259,060	418.6	3,876,991	**393,882**	941
TOTALS	978.8	8,188,326	**1,023,549**	-	-	-	2,667.1	22,704,718	**2,250,407**	3,645.8	30,893,044	**3,273,956**	898

Appendix Table J   2003 Crop Water Demand for Improved Irrigation System Efficiency and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
Apple	34.4	183,742	534	-	-	-	15.2	79,744	526	49.6	**263,486**	531
Berry	7.1	34,056	483	-	-	-	11.8	65,709	557	18.9	**99,765**	529
Cherry	152.4	1,091,653	716	-	-	-	110.4	852,771	772	262.8	**1,944,424**	740
Forage	677.3	5,590,454	825	-	-	-	2,128.1	16,226,102	762	2,805.5	**21,816,556**	778
Fruit	10.1	57,466	569	-	-	-	3.6	23,910	666	13.7	**81,376**	594
Golf	14.9	123,121	825	-	-	-	112.0	989,829	884	127.0	**1,112,950**	877
Grape	23.8	81,594	343	-	-	-	14.1	62,278	441	37.9	**143,872**	379
Nursery	2.7	18,385	670	-	-	-	149.8	1,140,174	761	152.5	**1,158,559**	760
Nursery Floriculture	1.0	5,013	493	-	-	-	-	-	-	1.0	**5,013**	493
Recreational Turf	-	-	-	-	-	-	3.2	24,341	760	3.2	**24,341**	760
Turf Farm	-	-	-	-	-	-	24.0	229,999	957	24.0	**229,999**	957
Vegetable	52.7	206,430	392	-	-	-	79.5	318,301	400	132.2	**524,731**	397
TOTALS	976.5	**7,391,915**	757	-	-	-	2,651.7	**20,013,157**	755	3,628.3	**27,405,072**	755

Appendix Table K   2003 Water Demand by Animal Type

Animal Type	Demand (m^3)
Beef	40,114
Dairy - dry	26,271
Dairy - milking	68,304
Goats	44
Horses	1,715
Poultry - broiler	120
Poultry - laying	63
Sheep	1,022
Swine	940
TOTALS	**138,593**

Appendix Table L Climate Change Water Demand Circa 2050 for High Demand Year with Good Management Using Current Crops and Irrigation Systems

Climate Change	Access1 rcp85			CanESM2 rcp85			cnrm-cm5 rcp45			Average		
Year	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
2053	3,645.8	30,017,043	823	3,645.8	37,688,135	1,034	3,645.8	25,825,505	708	3,645.8	31,176,894	855
2056	3,645.8	28,808,720	790	3,645.8	24,054,328	660	3,645.8	17,443,327	478	3,645.8	23,435,458	643
2059	3,645.8	19,821,891	544	3,645.8	31,728,411	870	3,645.8	24,427,869	670	3,645.8	25,326,057	695
Average	3,645.8	26,215,885	719	3,645.8	31,156,958	855	3,645.8	22,565,567	619	3,645.8	26,646,137	731

Appendix Table M Buildout Crop Water Demand for 2003 Climate Data with Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Crop Group	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
Fruit	10.1	58,623	580	-	-	-	3.6	23,910	666	13.7	**82,534**	603
Golf	14.9	123,121	825	-	-	-	112.0	989,829	884	127.0	**1,112,950**	877
Grape	24.6	85,699	348	-	-	-	14.1	62,278	441	38.8	**147,976**	382
Nursery	2.7	18,385	670	-	-	-	149.8	1,140,174	761	152.5	**1,158,559**	760
Nursery Floriculture	1.0	5,013	493	-	-	-	-	-	-	1.0	**5,013**	493
Recreational Turf	-	-	-	-	-	-	3.2	24,341	760	3.2	**24,341**	760
Turf Farm	-	-	-	-	-	-	24.0	229,999	957	24.0	**229,999**	957
Vegetable	52.7	311,088	590	-	-	-	79.5	536,365	675	132.2	**847,453**	641
TOTALS	10,225.9	**82,716,518**	809	-	-	-	2,773.3	**23,214,520**	837	12,999.2	**105,931,038**	815

Appendix Table N Buildout Crop Water Demand for Climate Change Data Circa 2050 and Good Management

Climate Change	Access1 rcp85			CanESM2 rcp85			cnrm-cm5 rcp45			Average		
Year	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
2053	13,016.8	109,266,188	839	13,016.8	130,381,609	1,002	13,016.8	93,040,590	715	13,016.8	**110,896,129**	852
2056	13,016.8	102,913,819	791	13,016.8	85,549,447	657	13,016.8	59,489,390	457	13,016.8	**82,650,885**	635
2059	13,016.8	72,309,666	556	13,016.8	115,714,926	889	13,016.8	81,897,016	629	13,016.8	**89,973,869**	691
Average	13,016.8	**94,829,891**	729	13,016.8	**110,548,661**	849	13,016.8	**78,142,332**	600	13,016.8	**94,506,961**	726

Appendix Table O Buildout Irrigation System Demand for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Agriculture Irrigation System	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)	Irrigated Area (ha)	Irrigation Demand (m^3)	Avg. Req. (mm)
Drip	1,449.3	5,991,943	413	-	-	-	167.6	1,040,583	621	1,616.9	**7,032,526**	435
Flood	-	-	-	-	-	-	18.3	402,943	2,197	18.3	**402,943**	2,197
Gun	18.5	268,871	1,453	-	-	-	34.6	474,755	1,373	53.1	**743,626**	1,401
Handline	66.2	544,186	822	-	-	-	71.7	656,660	916	137.9	**1,200,846**	871
Landscapesprinkler	14.9	123,121	825	-	-	-	115.2	1,014,170	880	130.2	**1,137,291**	874
Microspray	35.8	262,553	733	-	-	-	1.1	8,569	765	36.9	**271,122**	734
Microsprinkler	26.1	199,981	765	-	-	-	10.0	54,280	541	36.2	**254,261**	703
Overtreedrip	8.0	41,008	515	-	-	-	15.1	72,938	482	23.1	**113,946**	493
PivotLP	802.5	5,309,831	662	-	-	-	231.2	1,521,028	658	1,033.7	**6,830,859**	661
SDI	0.8	5,589	700	-	-	-	-	-	-	0.8	**5,589**	700
Sprinkler	2,277.0	19,740,058	867	-	-	-	635.0	5,332,656	840	2,912.0	**25,072,714**	861
Ssovertree	64.0	516,878	807	-	-	-	32.4	261,158	806	96.4	**778,036**	807
Sssprinkler	54.3	473,719	872	-	-	-	71.9	649,772	904	126.2	**1,123,491**	890
Ssundertree	5.3	40,786	770	-	-	-	4.2	34,680	828	9.5	**75,466**	795
Travgun	5,272.2	48,061,781	912	-	-	-	1,031.0	8,478,434	822	6,303.1	**56,540,215**	897
Wheelline	133.3	1,151,604	864	-	-	-	349.3	3,309,341	947	482.5	**4,460,945**	924
TOTALS	10,228.2	**82,731,908**	809	-	-	-	2,788.6	**23,311,968**	836	13,016.8	**106,043,875**	815

Appendix Table P Buildout Demand by Water Purveyor for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Water Purveyor	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Balfour	12.3	90,835	741	-	-	-	-	-	-	12.3	**90,835**	741
Beaver Falls	20.2	206,797	1,026	-	-	-	7.0	68,567	982	27.1	**275,364**	1,015
Beaver Valley	1.0	8,512	859	-	-	-	5.9	56,724	963	6.9	**65,236**	948
Burton	22.3	191,555	858	-	-	-	9.1	58,510	646	31.4	**250,065**	797
Columbia Gardens Industrial Park	-	4	1,148	-	-	-	-	-	-	-	**4**	1,148
Creston	52.9	304,093	575	-	-	-	434.7	3,402,576	783	487.6	**3,706,670**	760
Denver Siding	0.5	3,081	654	-	-	-	-	-	-	0.5	**3,081**	654
Duck Lake	24.8	147,463	594	-	-	-	113.0	883,934	782	137.8	**1,031,397**	748
Edgewood	1.0	8,408	855	-	-	-	-	-	-	1.0	**8,408**	855
Erickson	353.3	2,556,564	724	-	-	-	-	-	-	353.3	**2,556,564**	724
Fauquier	23.2	140,324	604	-	-	-	0.1	481	565	23.3	**140,805**	604
Glade	57.8	552,095	956	-	-	-	2.4	17,026	718	60.1	**569,120**	947
Lister	115.2	1,103,054	957	-	-	-	43.8	420,611	960	159.0	**1,523,665**	958
Nicks Island	10.3	65,353	636	-	-	-	71.9	635,302	883	82.2	**700,655**	852
North Canyon	97.4	947,266	973	-	-	-	69.1	502,441	727	166.4	**1,449,707**	871
Oasis/Rivervale Sewerage (SA)	-	-	-	-	-	-	-	11	897	-	**11**	897
Ootischenia	-	358	826	-	-	-	4.0	31,448	778	4.1	**31,807**	779
Orde Creek	100.7	1,122,527	1,115	-	-	-	45.9	480,245	1,047	146.6	**1,602,773**	1,094
Reclamation	13.0	106,149	819	-	-	-	726.2	5,733,969	790	739.2	**5,840,118**	790
Riondel	1.3	9,825	778	-	-	-	-	-	-	1.3	**9,825**	778
Robson Raspberry	11.4	132,530	1,164	-	-	-	4.9	44,175	893	16.3	**176,705**	1,082
Rykert	95.4	942,864	989	-	-	-	37.0	391,459	1,058	132.4	**1,334,323**	1,008
Slocan Park	69.5	907,990	1,307	-	-	-	6.5	80,668	1,249	75.9	**988,658**	1,302
South Canyon	6.9	69,823	1,017	-	-	-	13.6	122,723	900	20.5	**192,546**	939
West Robson	-	-	-	-	-	-	0.4	4,186	931	0.4	**4,186**	931
Wynndel	5.3	48,045	898	-	-	-	17.2	124,932	725	22.6	**172,977**	766
TOTALS	1,095.4	**9,665,516**	882	-	-	-	1,612.8	**13,059,988**	810	2,708.2	**22,725,504**	839

Multiple Band First Nation	18.0	**147,095**	818	-	-	-	189.9	**1,473,250**	776	207.9	**1,620,345**	779
Private	9,114.9	**72,919,297**	800	-	-	-	985.9	**8,778,730**	890	10,100.7	**81,698,026**	809
TOTALS	10,228.2	**82,731,908**	809	-	-	-	2,788.6	**23,311,968**	836	13,016.8	**106,043,875**	815

Appendix Table Q Buildout Demand by Local Government for 2003 Climate Data and Good Management

Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Local Government	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
Creston	20.1	167,401	835	-	-	-	1.3	5,653	450	21.3	**173,054**	812
Fruitvale	-	-	-	-	-	-	1.5	13,467	918	1.5	**13,467**	918
Multiple Band First Nation	18.0	147,095	818	-	-	-	189.9	1,473,250	776	207.9	**1,620,345**	779
Nakusp	203.3	1,596,726	785	-	-	-	6.9	42,279	609	210.3	**1,639,006**	779
Nelson	5.7	45,517	806	-	-	-	-	-	-	5.7	**45,517**	806
Regional District Of Central Kootenay	9,590.4	76,648,582	799	-	-	-	2,472.8	20,572,609	832	12,063.2	**97,221,191**	806
Regional District Of Kootenay	384.1	4,060,446	1,057	-	-	-	116.3	1,204,710	1,036	500.3	**5,265,156**	1,052
Salmo	2.9	26,953	944	-	-	-	-	-	-	2.9	**26,953**	944
Trail	3.8	39,186	1,032	-	-	-	-	-	-	3.8	**39,186**	1,032
TOTALS	10,228.2	**82,731,908**	809	-	-	-	2,788.6	**23,311,968**	836	13,016.8	**106,043,875**	815

Appendix Table R Buildout Demand by Electoral Area for 2003 Climate Data and Good Management												
Water Source	**Surface Water**			**Reclaimed Water**			**Groundwater**			**Total**		
Electoral Area	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**	**Irrigated Area (ha)**	**Irrigation Demand (m^3)**	**Avg. Req. (mm)**
RDCK Electoral Area A	189.0	1,658,924	878	-	-	-	67.5	539,701	799	256.5	**2,198,625**	857
RDCK Electoral Area B	1,435.8	13,528,434	942	-	-	-	341.6	3,136,952	918	1,777.4	**16,665,385**	938
RDCK Electoral Area C	345.3	2,707,380	784	-	-	-	1,569.5	12,612,245	804	1,914.9	**15,319,625**	800
RDCK Electoral Area D	852.8	5,493,010	644	-	-	-	22.9	148,596	648	875.7	**5,641,607**	644
RDCK Electoral Area E	456.5	3,549,894	778	-	-	-	44.3	310,985	701	500.8	**3,860,879**	771
RDCK Electoral Area F	12.5	96,764	773	-	-	-	2.7	19,589	739	15.2	**116,354**	767
RDCK Electoral Area G	528.6	5,307,203	1,004	-	-	-	77.0	815,377	1,059	605.6	**6,122,581**	1,011
RDCK Electoral Area H	1,884.3	16,861,320	895	-	-	-	166.9	1,659,407	994	2,051.2	**18,520,727**	903
RDCK Electoral Area I	236.4	2,239,115	947	-	-	-	12.9	112,656	875	249.3	**2,351,771**	943
RDCK Electoral Area J	144.6	1,573,114	1,088	-	-	-	10.6	91,055	859	155.2	**1,664,170**	1,072
RDCK Electoral Area K	3,710.6	25,333,004	683	-	-	-	351.8	2,629,996	747	4,062.4	**27,963,001**	688
RDKB Electoral Area A	265.8	2,725,575	1,025	-	-	-	93.5	999,543	1,069	359.3	**3,725,118**	1,037
RDKB Electoral Area B	118.3	1,334,871	1,129	-	-	-	22.8	205,166	901	141.0	**1,540,037**	1,092
TOTALS	10,228.2	**82,731,908**	809	-	-	-	2,788.6	**23,311,968**	836	13,016.8	**106,043,875**	815