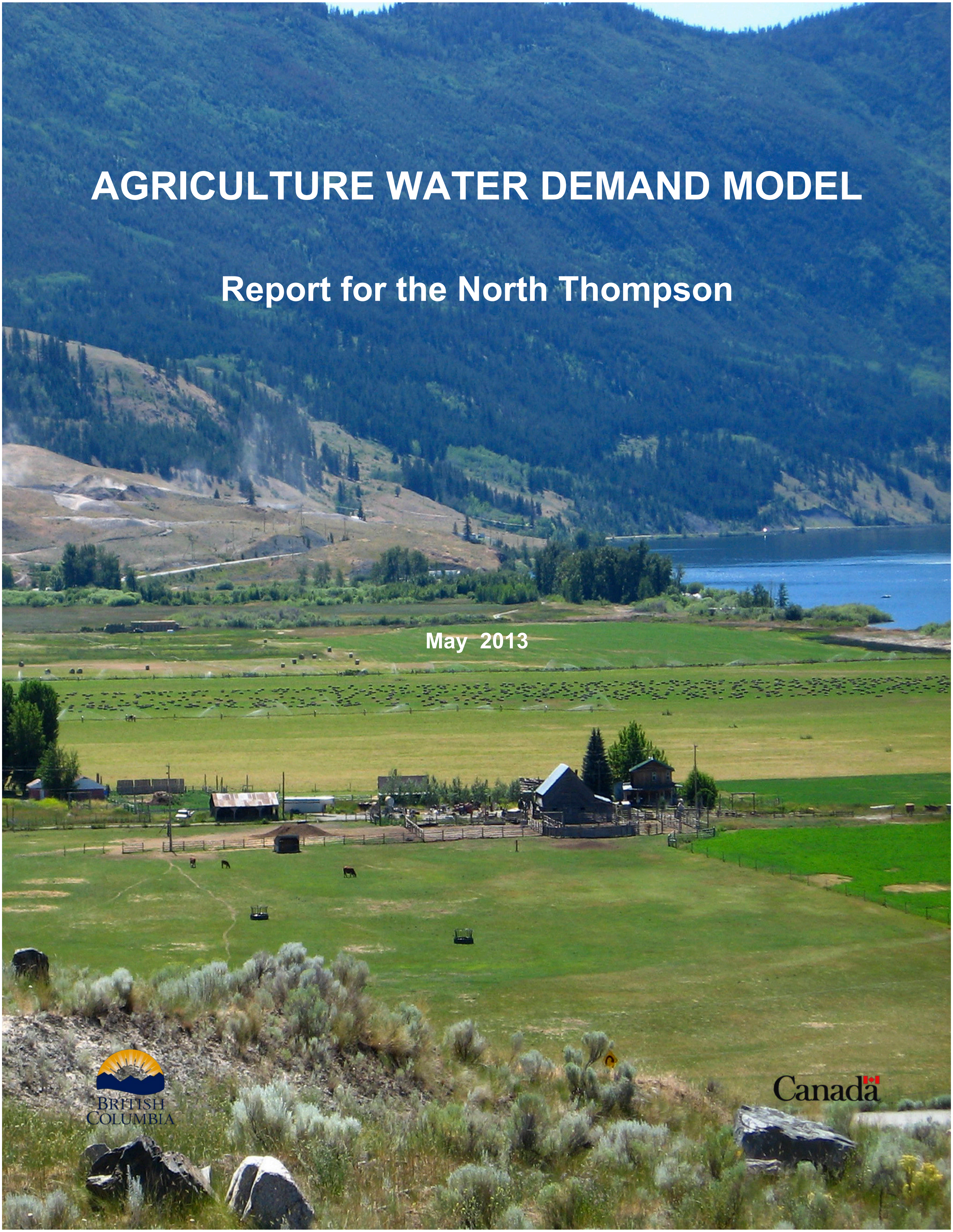
AGRICULTURE WATER DEMAND MODEL

Report for the North Thompson

May 2013



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Report for the North Thompson

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DISCLAIMER

The data that is presented in this report provides the best estimates for agriculture water demand that can be generated at this time. While every effort has been made to ensure the accuracy and completeness of the information, the information should not be considered as final. The Government of Canada, the BC Ministry of Agriculture, and the BC Agriculture Council or its directors, agents, employees, or contractors will not be liable for any claims, damages, or losses of any kind whatsoever arising out of the use of, or reliance upon, this information.

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Acknowledgements

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

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Jim Forbes	Ministry of Agriculture	Land Use Inventory
Katie Bennett	Agriculture and Agri-Food Canada	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 Pacific Agri-Food Research Centre (PARC) in Summerland 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.

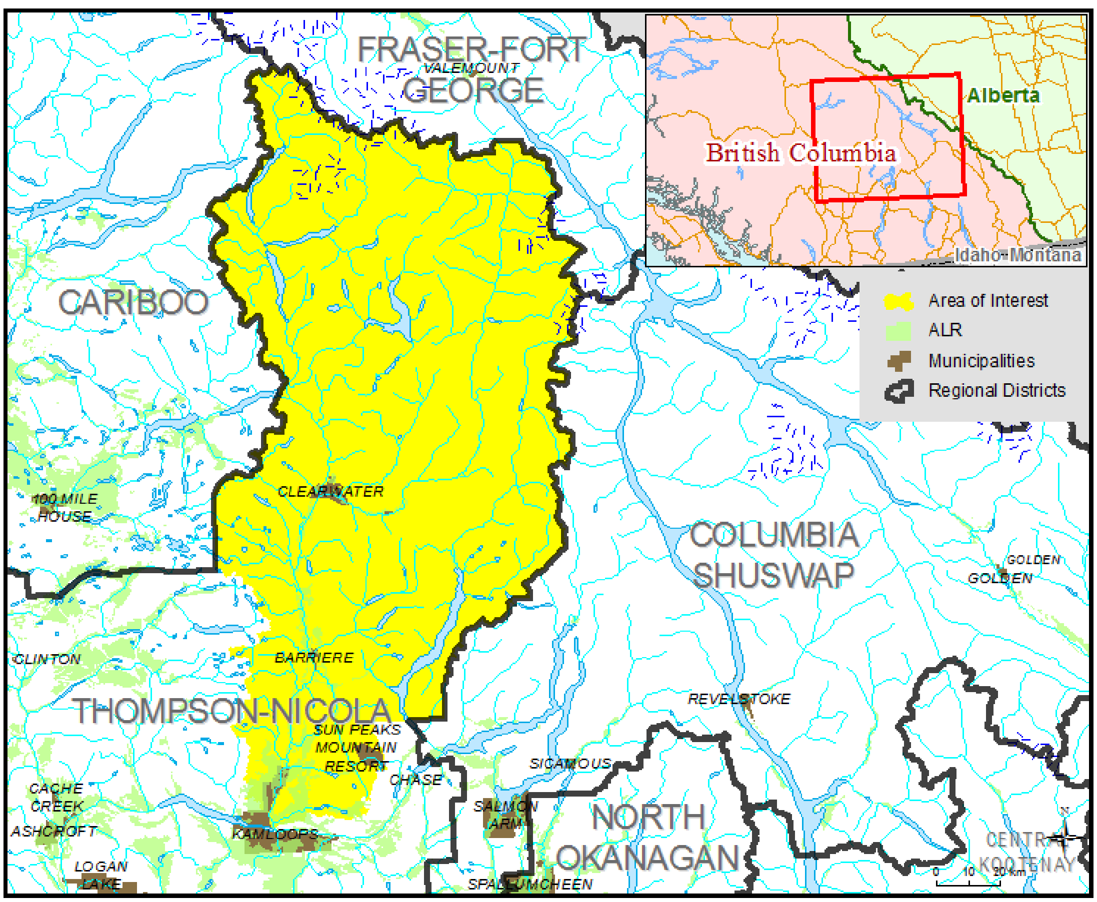

Figure 1 Map of North Thompson

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.

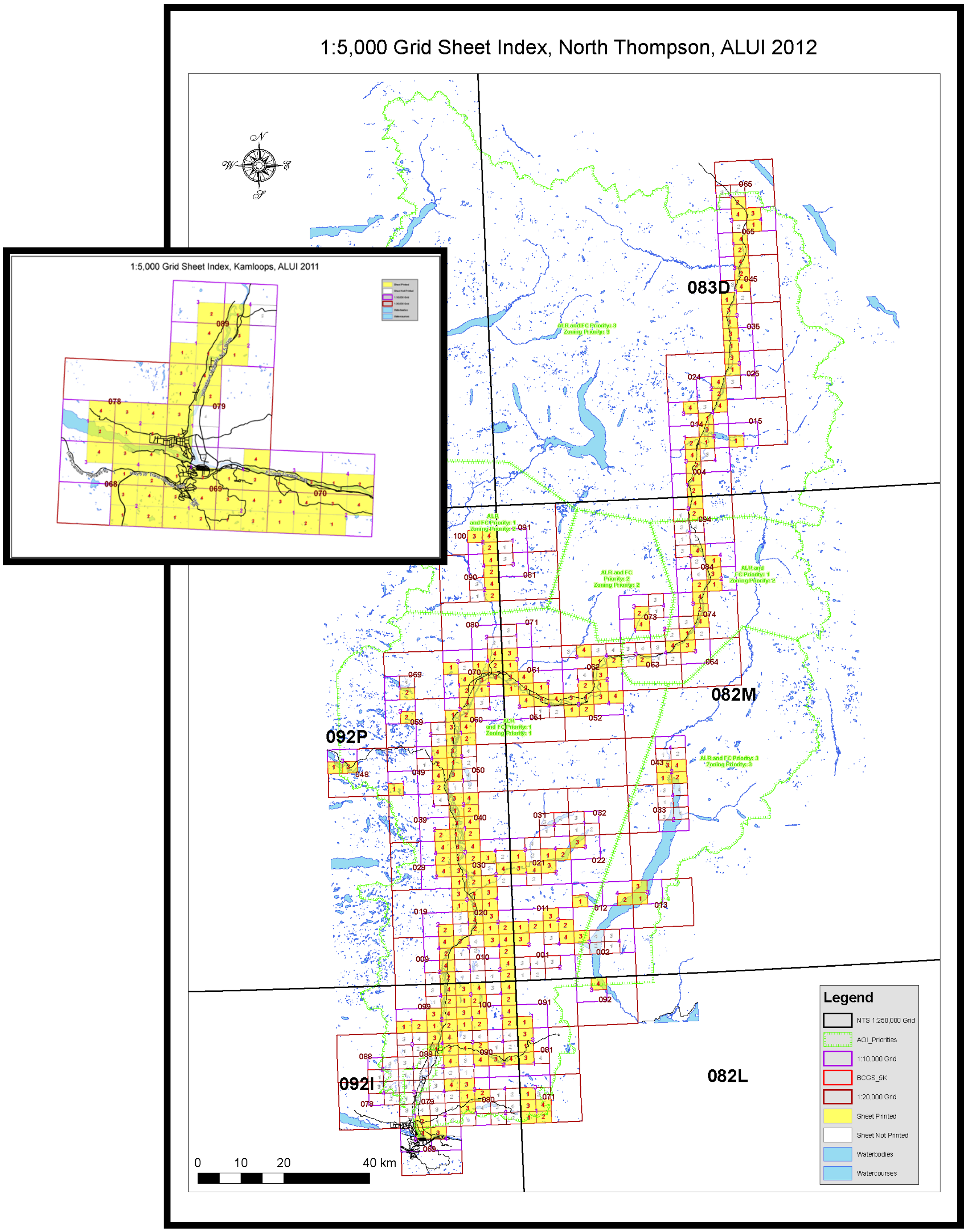

Figure 2 Map of the Kamloops and North Thompson Overlaid with Map Sheets

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 summers of 2011 and 2012. 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. 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.

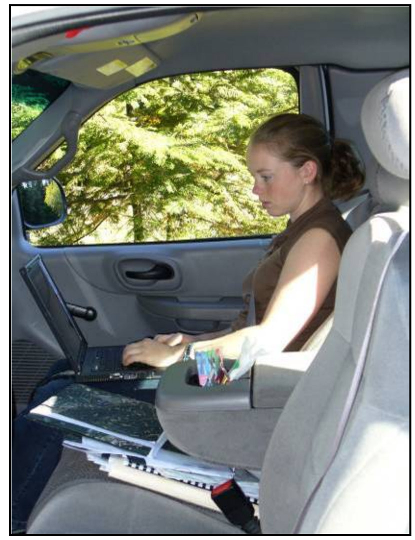

Figure 3 Land Use Survey

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 North Thompson (including the City of Kamloops) was divided into 307 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 North Thompson encompasses 5,503 parcels that are in or partially in the ALR. There are a total of 13,723 polygons (land covers) generated for the North Thompson for this project. 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.

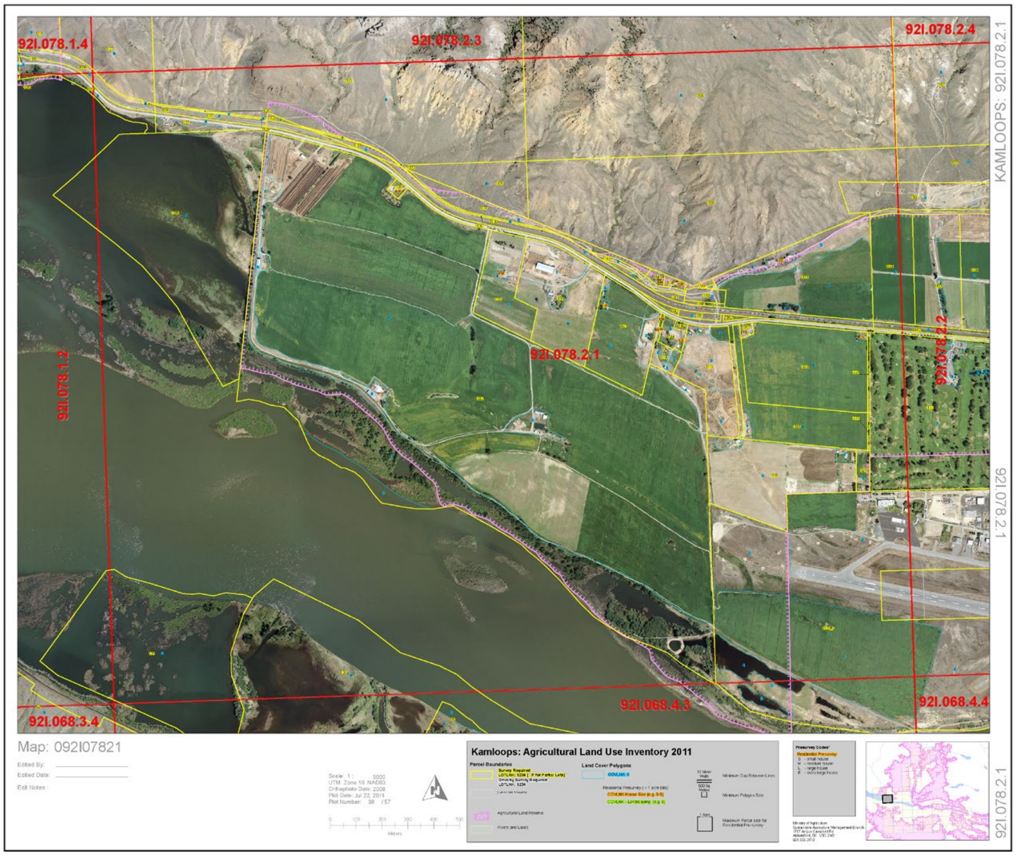

Figure 4 GIS Map Sheet

Figure 5 Cadastre with Polygons

Soil Information

Digital soil information is currently not available for the North Thompson region. The soils have therefore been defaulted to sandy loam for use in the model. Digitized soil data will be added in the future and the report will be updated when this data is available.

For other regions, 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.

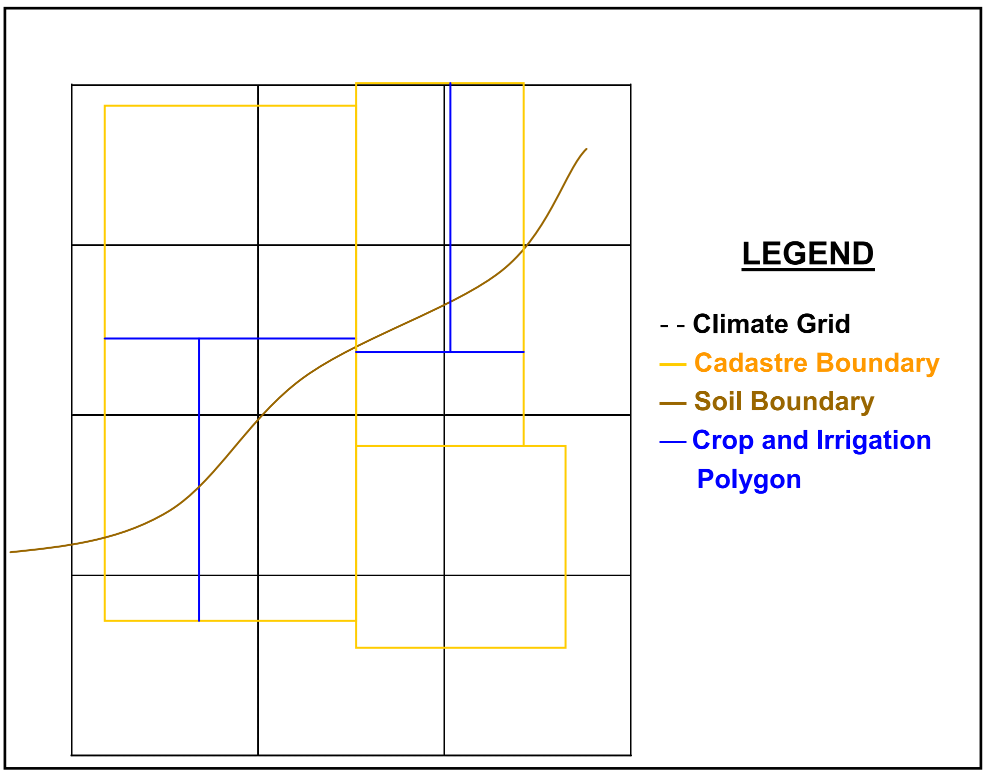

Figure 6 GIS Model Graphics

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 North Thompson Basin from 1961 to 2006. 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}

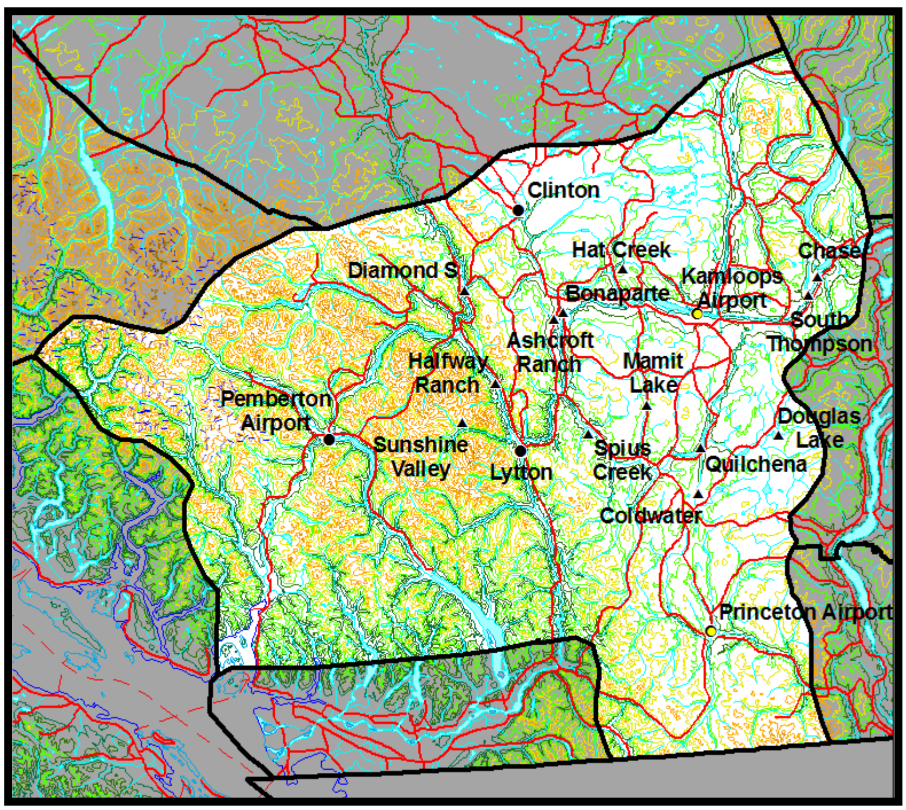

Figure 7 North Thompson Area Climate Stations

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 the North Thompson region), 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 texture layer is not available for the North Thompson region. Therefore, all parcels have been assigned to sandy loam by default. The soil layer will be added to the Model and results generated again when it becomes available in the future.

For other regions that the Model has been developed for, 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:

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

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:

$$
\begin{aligned}
K_c &= [0.0000000031 \times (35)^4] + [-0.0000013775 \times (35)^3] + (0.0001634536 \times (35)^2] + (-0.0011179845 \times 35) + 0.2399004137 \\
&= 0.346593241
\end{aligned}
$$

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.

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

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

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

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 area of the North Thompson are shown in Table 2. The inventoried area includes parcels that are in and partially in the Agricultural Land Reserve (ALR) which explains why there are more parcels inventoried (5,503) than in the actual ALR land (3,523). The primary agricultural use of the ARL area is shown in Table 3 where only 1,107 parcels currently have active agriculture. Refer to the Agricultural Land Use Inventory reports for details.

Table 2 Overview of the Land and Inventoried Area of North Thompson

Area Type	Area (ha)	Number of Parcels
North Thompson		
Total Area	1,942,334	-
Area of Water Feature	75,813	-
Area of Land (excluding water features)	1,866,520	-
ALR Area	59,719	3,523
Area of First Nations Reserve	15,299	60
Inventoried Area		
Total Inventoried Area	116,855	5,503
Area of First Nations Reserve in ALR	13,730	36

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

Primary Agriculture Activity	Total Land Cover (ha)	Number of Parcels
Alfalfa	69	11
Forage corn	9	3
Grass	11,423	1,034
Grains, Cereals, Oilseed	42	5
Nursery & Tree Plantations	49	4
Crop Transition	14	2
Poly Greenhouse	1	7
Tree Fruits	3	12
Vegetables	169	29
Total	**11,778**	**1,107**

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 North Thompson based on the information from B.C. Ministry of Environment.

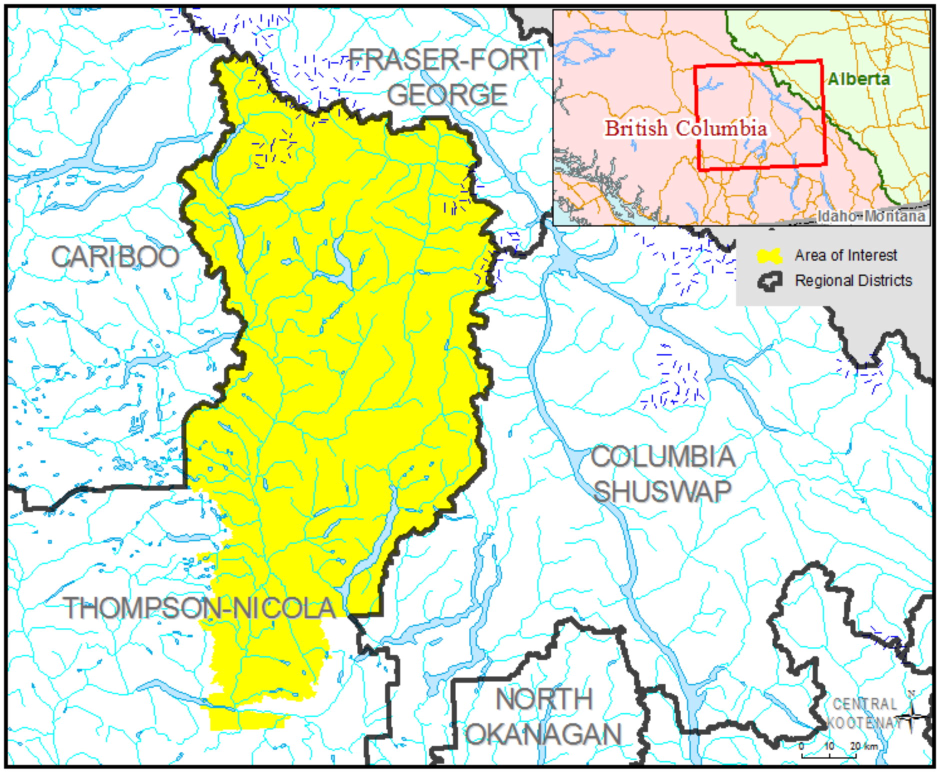

Figure 8 Water Areas in the North Thompson

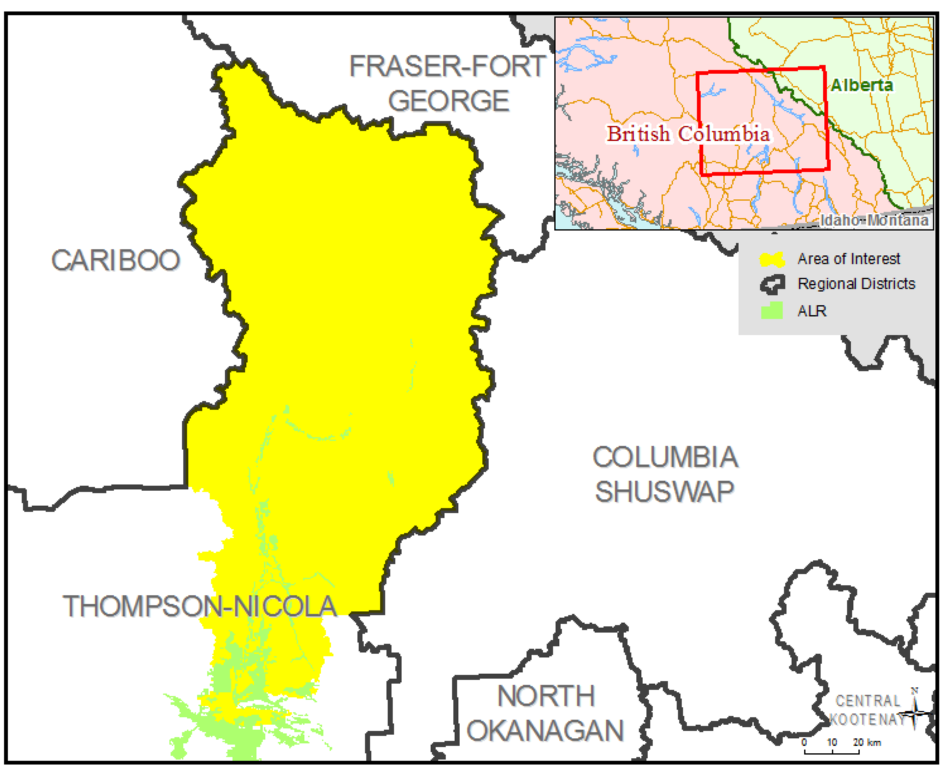

Figure 9 ALR Areas in the North Thompson

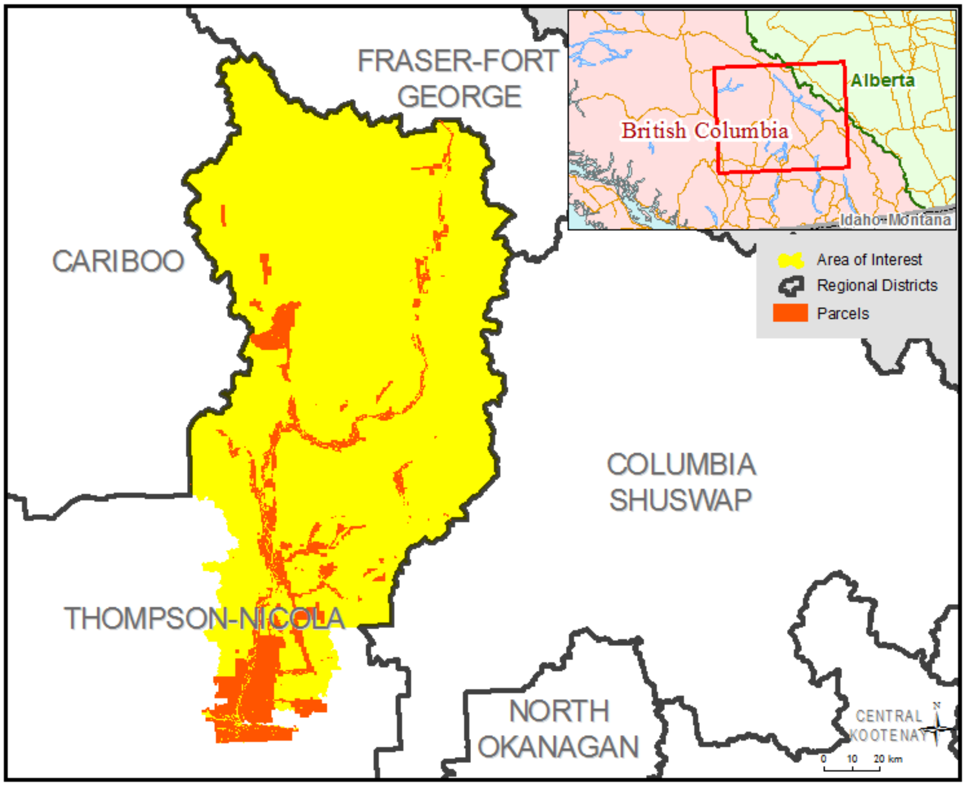

Figure 10 Land Parcels in the North Thompson

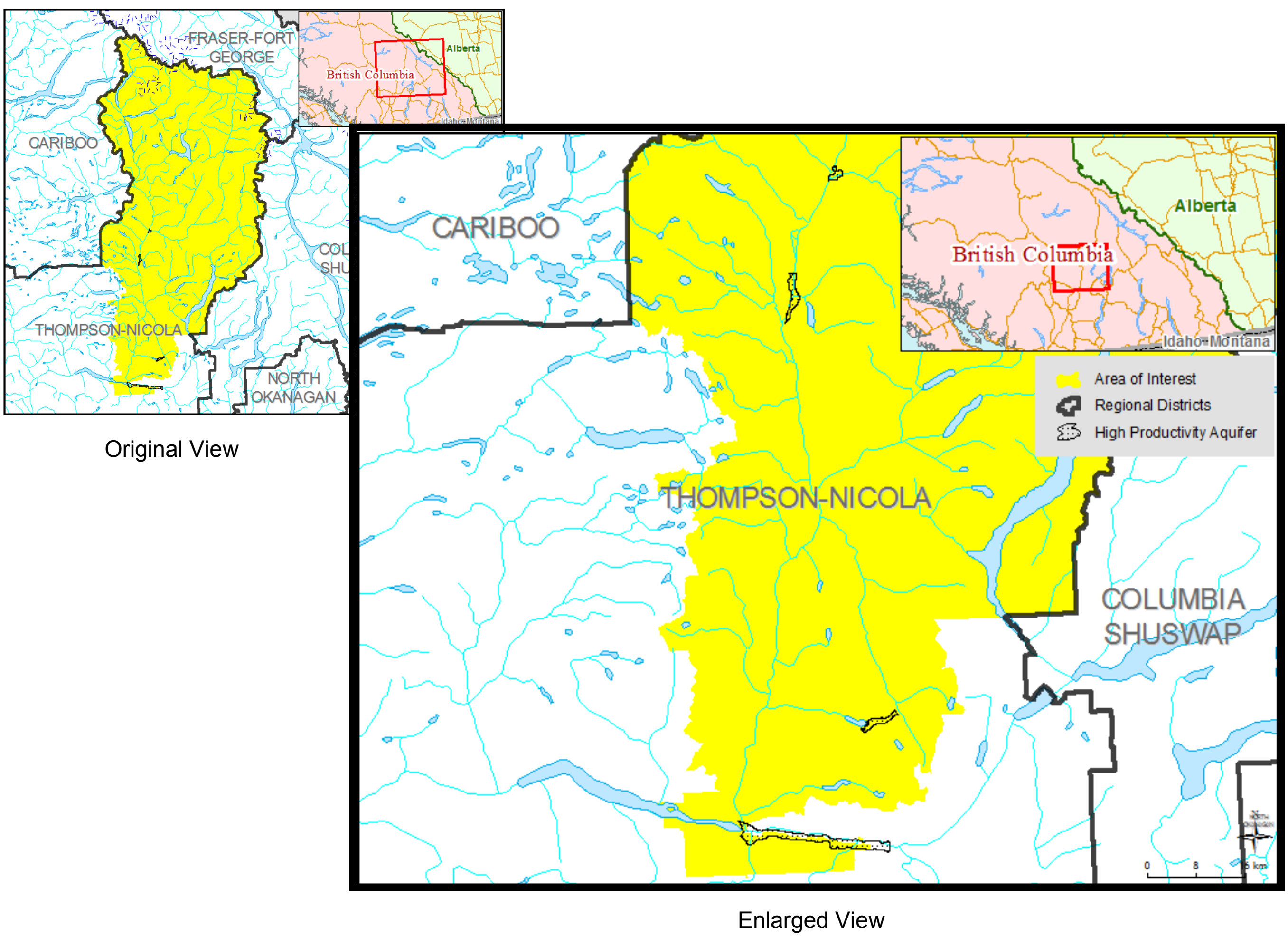

Figure 11 Higher Productive Groundwater Aquifers in the North Thompson

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 the North Thompson (including the City of Kamloops) is 6,639 hectares (ha), including 6,193 ha (93%) for forage crops (alfalfa, forage corn, grass, legume and pasture). In the North Thompson, 5,577 ha (84%) is supplied by licensed surface water sources, and 1,062 ha (16%) is irrigated with groundwater.

The total annual irrigation demand was 63,622,153 m^3 in 2003, and dropped to 31,535,280 m^3 in 1997. During a wet year like 1997, the demand was only 50% of a hot dry year like 2003. There were 608 ha of land surveyed that had an irrigation system but were deemed to be not in use.

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 759 ha (11%) in the North Thompson. Travelling guns, wheelline and handline irrigate 4,975 ha (75%) of the agricultural crops in North Thompson.

Annual Water Demand by Aquifer – Table D

The Model calculates water demand on a property-by-property basis, and can summarize the data for each aquifer in the North Thompson. Table D provides the groundwater demand separated for each aquifer. The amount of water extracted from the aquifers is shown under the groundwater column. Irrigation water extracted from surface water sources above each aquifer is also shown under the surface water column. The irrigated areas where no known aquifer is assigned to are categorized under "others".

Irrigated Area within Local Governments – Table E

Table E provides a breakdown of the agriculture irrigated areas within the boundaries of each local government. The majority (78%) of the irrigated area in the North Thompson belong to the Thompson-Nicola Regional District.

Irrigation Management Factors – Table F

Note that since soil texture data is not available at this time for the North Thompson, the irrigation management information shown in Table F is not represented accurately.

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 F 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 2% 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 H.

Table F also provides percolation rates based on good, average and poor management using 2003 climate data. In summary, good management is 6,263,130 m^3, average is 7,605,361 $m^3$and poor management is 8,947,593 m^3. Percolation rates for poor management are 43% higher than for good management.

Deep Percolation – Table G

Note that since soil texture data is not available at this time for the North Thompson, the irrigation management information shown in Table G is not represented accurately.

The percolation rates vary by crop, irrigation system type, soil and the management factor used. Table G 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 35 to 60% 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 H

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 H provides a scenario of water demand if all sprinkler systems are converted to drip systems for horticultural crops in the North Thompson, using good irrigation management. The water demand for 2003 would reduce from 63,622,153 m^3 to 61,801,728 m^3 if sprinkler systems were converted to drip and good management practices were implemented. Since 93% of the irrigated acreage is forage crops where sprinkler systems must be used, and that horticultural crops only consist of 3% of the total irrigated acreage, the reduction achieved is only under 3%.

Livestock Water Use – Table I

The Model provides an estimate of water use for livestock. The estimate is based on the number of animals in the North Thompson 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 I. For North Thompson, the amount of livestock water is estimated at 395,588 m^3.

Climate Change Water Demand for 2050 – Table J

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.

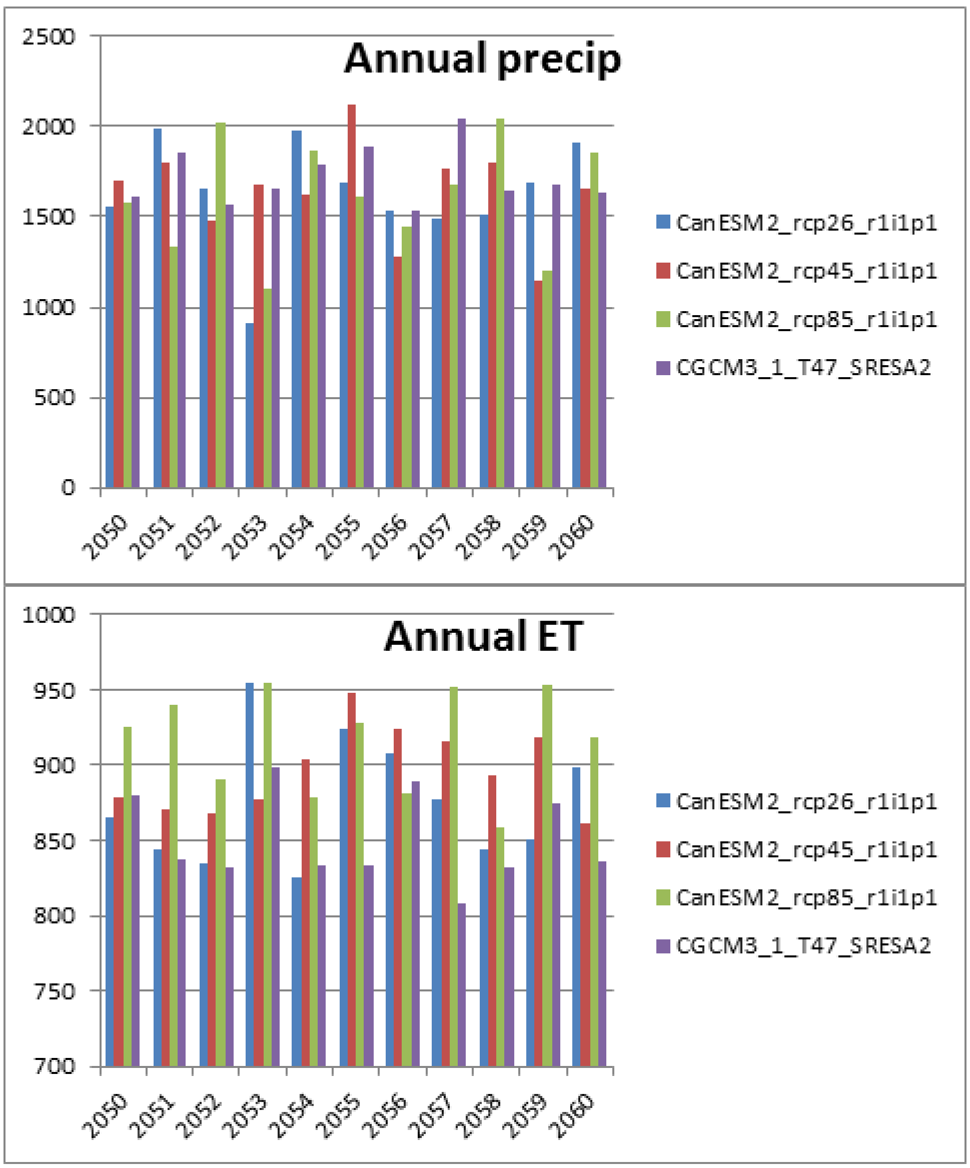

Figure 12 Annual ET and Effective Precipation in 2050's

Table J 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 Station. 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 RCP26, RCP45 and RCP85. Running only three climate change models on three selected future years in the North Thompson 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 17% higher than what was experienced in 2003 based on 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.

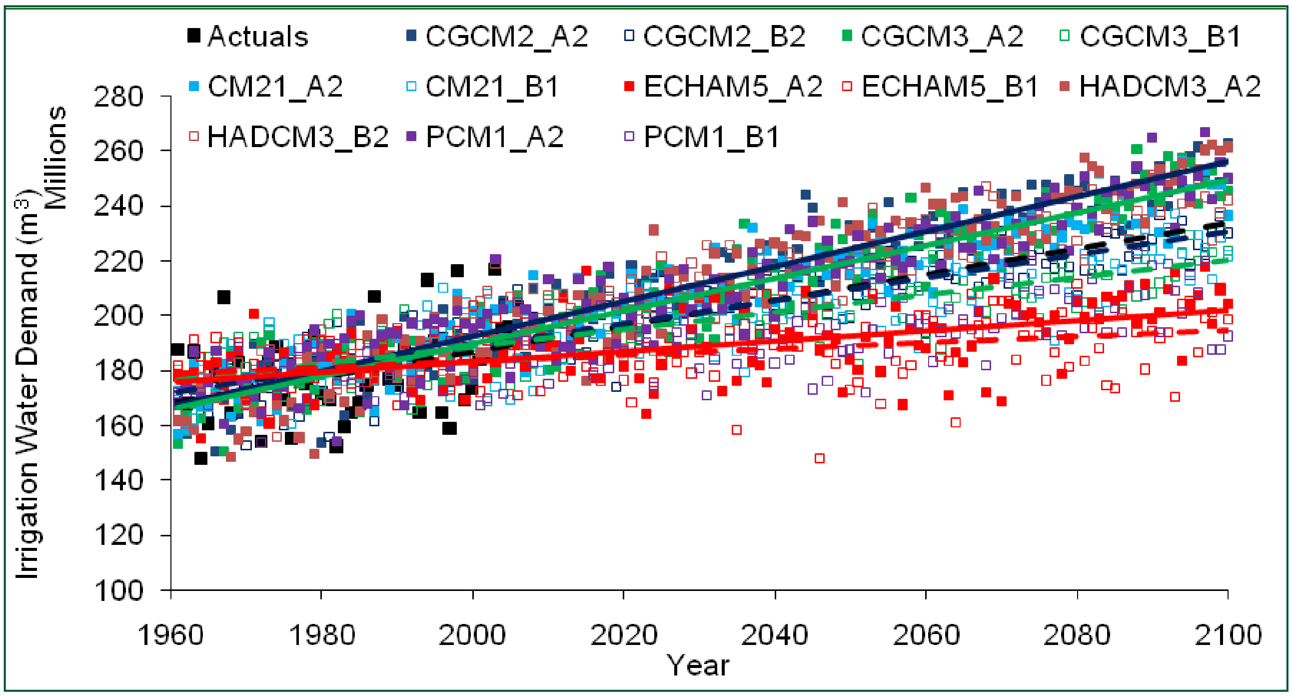

Figure 13 Future Irrigation Demand for All Outdoor Uses in the Okanagan in Response to Observed Climate Data (Actuals) and Future Climate Data Projected from a Range of Global Climate Models

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

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 650 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 irrigation system are assigned as per the criteria below:

- **Kamloops**:
  - **95% forage**: 20% with pivot (for properties over 20 ha in size), 25% with travelling gun, and 50% with wheelline
  - **5% vegetable**: 5% with drip irrigation

- **North Thompson**:
  - **100% forage**: 30% with pivot, 20% travelling gun, and 50% wheelline

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 North Thompson, the additional agricultural land that could be irrigated is 15,005 ha, which is an increase in irrigated acreage of 126%. The water demand for a year like 2003 would then be about 197 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

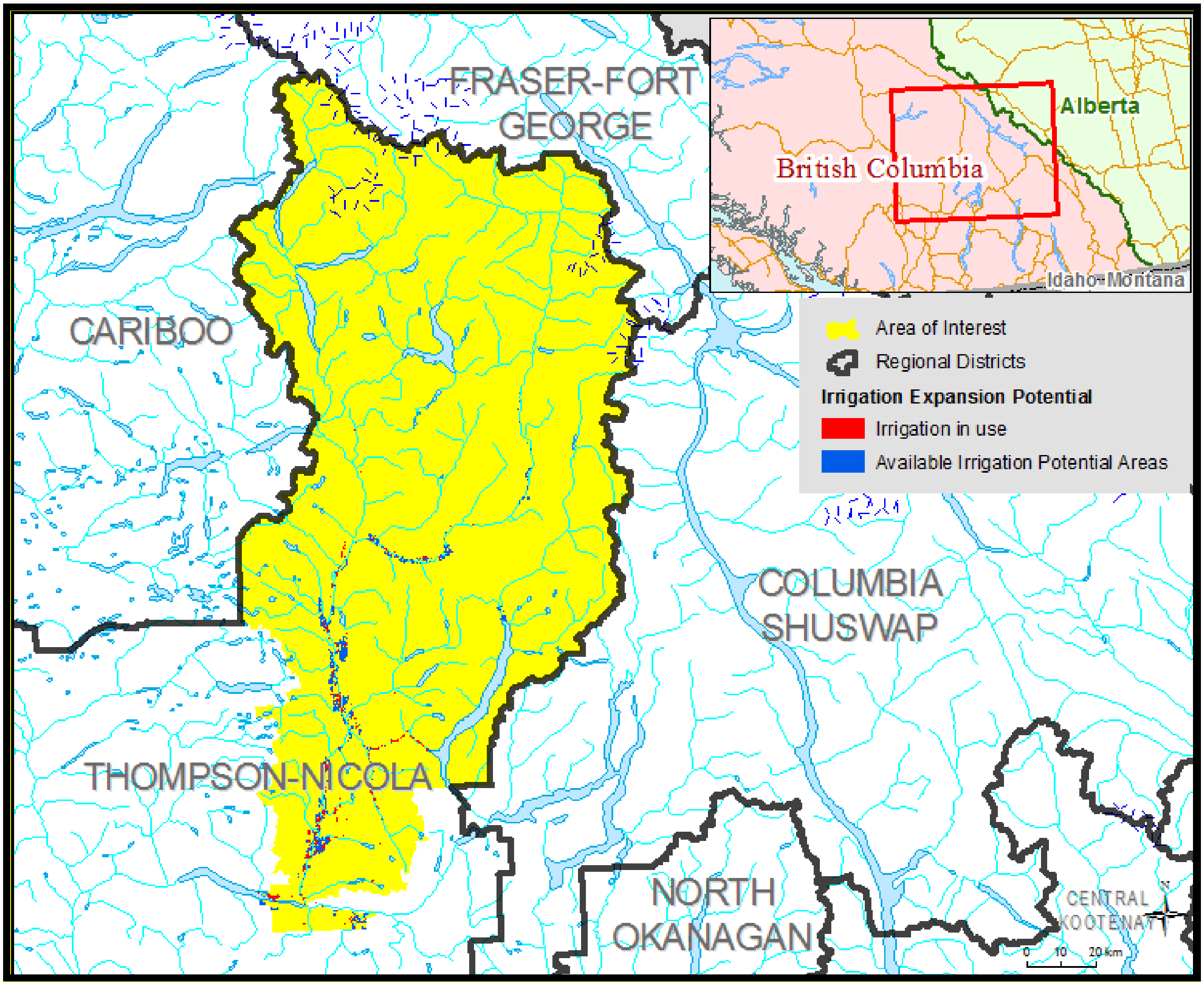

Figure 14 North Thompson Irrigation Expansion Potential

Agricultural Buildout Crop Water Demand for 2050 – Table L

The same irrigation expansion and cropping scenario used to generate the values in Table K were used to generate the climate change water demand shown in Table L. See discussion under Table J section. When climate change is added to the buildout scenario, the water demand increases from 197 million m^3 to 235 million m^3 (a further 20% increase) based on climate change model RCP85 in 2053 using the highest potential scenario.

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

Table M 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 Aquifer 2003 Climate Data – Table N

Table N provides the water demand within all the aquifers of the North Thompson for the buildout scenario used in this report. Comparing these values with the result in Table D 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 O

Table O provides the future water demand within local government boundaries using previous scenarios. Comparing these values with the result in Table E will provide information on the possible increased water demand within local governments if the buildout scenarios actually occurred in the future.

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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	0.7	6,700	941	-	-	-	1.1	9,752	888	1.8	**16,452**	909
Domestic Outdoor	3.5	34,621	980	-	-	-	10.2	95,647	942	13.7	**130,267**	951
Forage	5,209.5	48,884,444	938	-	-	-	983.4	10,680,067	1,086	6,192.9	**59,564,511**	962
Fruit	-	-	-	-	-	-	0.1	563	1,045	0.1	**563**	1,045
Golf	161.0	1,749,900	1,087	-	-	-	31.5	331,840	1,053	192.5	**2,081,740**	1,081
Nursery	15.2	199,826	1,319	-	-	-	0.3	6,388	2,413	15.5	**206,214**	1,319
Recreational Turf	17.5	164,305	936	-	-	-	2.3	24,108	1,036	19.9	**188,413**	948
Vegetable	169.2	1,174,097	694	-	-	-	33.6	259,897	773	202.9	**1,433,994**	707
TOTALS	5,576.7	**52,213,892**	936	-	-	-	1,062.4	**11,408,261**	1,074	6,639.1	**63,622,153**	958

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	0.7	3,319	466	-	-	-	1.1	4,607	419	1.8	**7,926**	438
Domestic Outdoor	3.5	21,907	620	-	-	-	10.2	59,809	589	13.7	**81,717**	597
Forage	5,209.5	23,602,172	453	-	-	-	983.4	5,603,957	570	6,192.9	**29,206,129**	472
Fruit	-	-	-	-	-	-	0.1	316	587	0.1	**316**	587
Golf	161.0	1,096,229	681	-	-	-	31.5	196,184	622	192.5	**1,292,414**	671
Nursery	15.2	94,075	621	-	-	-	0.3	5,630	2,126	15.5	**99,705**	621
Recreational Turf	17.5	104,065	593	-	-	-	2.3	15,808	679	19.9	**119,873**	603
Vegetable	169.2	613,733	363	-	-	-	33.6	113,469	337	202.9	**727,202**	358
TOTALS	5,576.7	**25,535,501**	458	-	-	-	1,062.4	**5,999,780**	565	6,639.1	**31,535,280**	475

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)**
Flood	138.6	2,196,748	1,585	-	-	-	91.3	1,560,140	1,710	229.9	**3,756,888**	1,634
Golfsprinkler	128.1	1,402,220	1,094	-	-	-	21.3	216,821	1,019	149.4	**1,619,041**	1,084
Gun	145.6	1,823,174	1,252	-	-	-	26.5	355,436	1,342	172.1	**2,178,610**	1,266
Handline	1,932.3	17,011,100	880	-	-	-	193.5	1,830,931	946	2,125.9	**18,842,031**	886
Landscapesprinkler	2.9	32,190	1,114	-	-	-	17.2	182,033	1,057	20.1	**214,223**	1,065
Pivot	53.3	517,549	971	-	-	-	-	-	-	53.3	**517,549**	971
PivotLP	635.3	5,178,009	815	-	-	-	123.4	1,102,897	894	758.7	**6,280,906**	828
Sprinkler	84.1	805,766	958	-	-	-	10.0	91,920	916	94.1	**897,686**	954
SSGun	1.2	14,252	1,205	-	-	-	-	-	-	1.2	**14,252**	1,205
Ssovertree	-	-	-	-	-	-	0.3	2,607	954	0.3	**2,607**	954
Sssprinkler	93.3	805,469	863	-	-	-	78.8	643,480	816	172.1	**1,448,949**	842
Subirrig	13.5	109,419	813	-	-	-	-	-	-	13.5	**109,419**	813
Travgun	850.6	8,361,421	983	-	-	-	235.8	2,743,013	1,163	1,086.3	**11,104,434**	1,022
Wheelline	1,497.9	13,956,574	932	-	-	-	264.4	2,678,983	1,013	1,762.3	**16,635,557**	944
TOTALS	5,576.7	**52,213,892**	936	-	-	-	1,062.4	**11,408,261**	1,074	6,639.1	**63,622,153**	958

Appendix Table D 2003 Water Demand by Aquifer with Average Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Aquifer	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)
Others	1,836.0	16,558,385	902	-	-	-	253.5	3,019,701	1,191	2,089.5	**19,578,086**	937
2 km west of Barnhartvale	0.9	8,098	883	-	-	-	6.9	59,728	863	7.8	**67,826**	865
Buse Lake	27.0	242,368	897	-	-	-	0.9	7,451	842	27.9	**249,820**	895
Campbell Creek	47.2	476,376	1,010	-	-	-	20.0	184,204	920	67.2	**660,580**	983
Christian Creek Valley	21.3	155,214	730	-	-	-	-	-	-	21.3	**155,214**	730
Clearwater North of Kamloops	66.7	613,713	902	-	-	-	0.3	1,880	665	67.0	**615,592**	767
Dixon and Sargent Creek Valley	147.4	1,419,656	963	-	-	-	6.6	57,276	866	154.0	**1,476,931**	959
Dixon, Sargent and Jet Creek	20.5	192,083	937	-	-	-	3.5	30,549	882	24.0	**222,632**	929
Heffley and Edward Creek	0.1	755	800	-	-	-	1.5	10,501	711	1.6	**11,256**	717
Kamloops Airport	165.0	1,892,261	1,147	-	-	-	252.4	2,971,150	1,177	417.4	**4,863,411**	1,165
Little Fort	95.9	886,246	924	-	-	-	18.6	182,137	980	114.5	**1,068,383**	933
Louis and Fraser Creek Valley	455.9	3,824,464	839	-	-	-	12.4	105,895	857	468.3	**3,930,359**	839
Lower Barriere River Valley	0.1	497	910	-	-	-	3.2	25,466	804	3.2	**25,963**	806
Lower South Thompson River	44.9	470,673	1,048	-	-	-	9.1	102,246	1,121	54.1	**572,919**	1,060
N Thompson River	162.9	1,205,245	740	-	-	-	5.5	65,330	1,184	168.5	**1,270,575**	754
North Thompson River flood	28.6	259,352	908	-	-	-	0.5	4,839	908	29.1	**264,191**	908
North Thompson River North	1,751.5	17,393,139	1,001	-	-	-	369.2	3,635,851	973	2,120.7	**21,028,991**	997
North-east of Kamloops	555.9	5,270,014	948	-	-	-	46.8	465,743	995	602.7	**5,735,757**	952
Pinantan Lake / Pritchard	15.6	109,758	706	-	-	-	-	-	-	15.6	**109,758**	706
Rose Hill / Barnhartvale	118.6	1,104,263	931	-	-	-	51.3	476,048	928	169.9	**1,580,311**	930
Sugarloaf Hill Southwest	14.6	131,332	897	-	-	-	0.3	2,266	813	14.9	**133,598**	896
TOTALS	5,576.7	**52,213,892**	936	-	-	-	1,062.4	**11,408,261**	1,074	6,639.1	**63,622,153**	958

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

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Local Government Name	**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)**
Barriere	15.5	149,568	965	-	-	-	5.8	48,603	842	21.3	**198,171**	932
Clearwater	148.7	1,263,823	850	-	-	-	0.3	1,880	628	149.0	**1,265,703**	849
Kamloops	864.7	8,565,819	991	-	-	-	428.3	4,703,898	1,098	1,293.0	**13,269,716**	1,026
Kamloops First Nation	128.2	1,312,528	1,024	-	-	-	20.4	220,267	1,080	148.6	**1,532,795**	1,031
Thompson-Nicola	4,419.6	40,922,154	926	-	-	-	607.6	6,433,614	1,059	5,027.3	**47,355,768**	942
TOTALS	5,576.7	**52,213,892**	936	-	-	-	1,062.4	**11,408,261**	1,074	6,639.1	**63,622,153**	958

Appendix Table F 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	5,576.7	53,319,187	956	7,246,784	-	-	-	-	1,062.4	11,645,198	1,096	1,700,809	6,639.1	64,964,385	979	8,947,593	1,348
Avg	5,576.7	52,213,892	936	6,141,489	-	-	-	-	1,062.4	11,408,261	1,074	1,463,872	6,639.1	63,622,153	958	7,605,361	1,146
Good	5,576.7	51,108,598	916	5,036,194	-	-	-	-	1,062.4	11,171,324	1,051	1,226,936	6,639.1	62,279,922	938	6,263,130	943

Appendix Table G 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)**
Flood	138.6	2,196,748	560,560	-	-	-	91.3	1,560,140	318,900	229.9	3,756,888	**879,460**	3,825
Golfsprinkler	128.1	1,402,220	298,985	-	-	-	21.3	216,821	46,192	149.4	1,619,041	**345,177**	2,310
Gun	145.6	1,823,174	288,424	-	-	-	26.5	355,436	70,010	172.1	2,178,610	**358,435**	2,083
Handline	1,932.3	17,011,100	1,849,234	-	-	-	193.5	1,830,931	206,430	2,125.9	18,842,031	**2,055,664**	967
Landscapesprinkler	2.9	32,190	6,808	-	-	-	17.2	182,033	37,766	20.1	214,223	**44,574**	2,218
Pivot	53.3	517,549	44,523	-	-	-	-	-	-	53.3	517,549	**44,523**	835
PivotLP	635.3	5,178,009	455,132	-	-	-	123.4	1,102,897	93,324	758.7	6,280,906	**548,456**	723
Sprinkler	84.1	805,766	106,707	-	-	-	10.0	91,920	15,672	94.1	897,686	**122,379**	1,301
SSGun	1.2	14,252	2,014	-	-	-	-	-	-	1.2	14,252	**2,014**	1,678
Ssovertree	-	-	-	-	-	-	0.3	2,607	376	0.3	2,607	**376**	1,253
Sssprinkler	93.3	805,469	132,319	-	-	-	78.8	643,480	94,859	172.1	1,448,949	**227,179**	1,320
Subirrig	13.5	109,419	13,089	-	-	-	-	-	-	13.5	109,419	**13,089**	970
Travgun	850.6	8,361,421	914,071	-	-	-	235.8	2,743,013	299,836	1,086.3	11,104,434	**1,213,907**	1,117
Wheelline	1,497.9	13,956,574	1,469,621	-	-	-	264.4	2,678,983	280,508	1,762.3	16,635,557	**1,750,129**	993
TOTALS	5,576.7	52,213,892	**6,141,489**	-	-	-	1,062.4	11,408,261	**1,463,872**	6,639.1	63,622,153	**7,605,361**	1,146

Appendix Table H 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	0.7	4,053	570	-	-	-	1.1	6,299	573	1.8	**10,352**	572
Domestic Outdoor	3.5	33,423	946	-	-	-	10.2	93,109	917	13.7	**126,532**	924
Forage	5,209.5	47,869,378	919	-	-	-	983.4	10,469,073	1,065	6,192.9	**58,338,451**	942
Fruit	-	-	-	-	-	-	0.1	347	644	0.1	**347**	644
Golf	161.0	1,709,609	1,062	-	-	-	31.5	325,410	1,032	192.5	**2,035,019**	1,057
Nursery	15.2	195,823	1,292	-	-	-	0.3	6,388	2,413	15.5	**202,211**	1,292
Recreational Turf	17.5	173,236	987	-	-	-	2.3	23,641	1,016	19.9	**196,877**	991
Vegetable	169.2	746,944	441	-	-	-	33.6	144,994	431	202.9	**891,938**	440
TOTALS	5,576.7	**50,732,467**	910	-	-	-	1,062.4	**11,069,261**	1,042	6,639.1	**61,801,728**	931

Appendix Table I 2003 Water Demand by Animal Type

Animal Type	**Demand (m^3)**
Beef	363,139
Bison	365
Dairy - dry	2,446
Dairy - milking	4,157
Goats	374
Horses	19,345
Poultry - broiler	222
Poultry - laying	118
Sheep	5,040
Swine	383
TOTALS	395,588

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

Climate Change	rcp26			rcp45			rcp85			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	6,639.1	68,487,560	1,032	6,639.1	59,710,874	899	6,639.1	74,847,379	1,127	6,639.1	67,681,938	1,019
2056	6,639.1	61,064,883	920	6,639.1	70,600,520	1,063	6,639.1	48,924,104	737	6,639.1	60,196,502	907
2059	6,639.1	35,909,617	541	6,639.1	78,808,666	1,187	6,639.1	68,019,132	1,025	6,639.1	60,912,472	918
Average	6,639.1	55,154,020	831	6,639.1	69,706,687	1,050	6,639.1	63,930,205	963	6,639.1	62,930,304	948

Appendix Table K 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)**
Apple	0.7	6,422	902	-	-	-	1.1	9,262	843	1.8	**15,685**	866
Domestic Outdoor	3.5	33,423	946	-	-	-	10.2	93,109	917	13.7	**126,532**	924
Forage	14,860.0	132,210,850	890	-	-	-	6,279.1	61,398,903	978	21,139.2	**193,609,753**	916
Fruit	-	-	-	-	-	-	0.1	539	1,001	0.1	**539**	1,001
Golf	161.0	1,709,609	1,062	-	-	-	31.5	325,410	1,032	192.5	**2,035,019**	1,057
Nursery	15.2	195,823	1,292	-	-	-	0.3	6,388	2,413	15.5	**202,211**	1,292
Recreational Turf	17.5	158,414	903	-	-	-	2.3	23,641	1,016	19.9	**182,055**	916
Vegetable	197.1	1,261,776	640	-	-	-	64.7	382,065	590	261.9	**1,643,841**	628
TOTALS	15,255.1	**135,576,317**	889	-	-	-	6,389.3	**62,239,319**	974	21,644.4	**197,815,636**	914

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

Climate Change	rcp26			rcp45			rcp85			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	21,644.4	217,459,791	1,005	21,644.4	189,933,900	878	21,644.4	235,296,136	1,087	21,644.4	**214,229,942**	990
2056	21,644.4	192,860,773	891	21,644.4	224,010,912	1,035	21,644.4	155,466,118	718	21,644.4	**190,779,268**	881
2059	21,644.4	111,411,364	515	21,644.4	248,320,235	1,147	21,644.4	213,410,262	986	21,644.4	**191,047,287**	883
Average	21,644.4	**173,910,643**	804	21,644.4	**220,755,016**	1,020	21,644.4	**201,390,839**	930	21,644.4	**198,685,499**	918

Appendix Table M 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	27.9	123,901	444	-	-	-	31.1	138,088	444	59.0	**261,989**	444
Flood	138.6	2,196,748	1,585	-	-	-	91.3	1,560,140	1,710	229.9	**3,756,888**	1,634
Golfsprinkler	128.1	1,375,039	1,073	-	-	-	21.3	212,622	999	149.4	**1,587,662**	1,063
Gun	145.6	1,786,505	1,227	-	-	-	26.5	348,530	1,316	172.1	**2,135,034**	1,240
Handline	1,932.3	16,588,189	858	-	-	-	193.5	1,777,650	919	2,125.9	**18,365,839**	864
Landscapesprinkler	2.9	31,531	1,091	-	-	-	17.2	177,865	1,033	20.1	**209,396**	1,041
Pivot	5,516.5	46,437,510	842	-	-	-	2,725.4	25,053,675	919	8,241.8	**71,491,185**	867
PivotLP	635.3	5,192,045	817	-	-	-	123.4	1,110,026	900	758.7	**6,302,070**	831
Sprinkler	84.1	770,061	916	-	-	-	10.0	88,491	881	94.1	**858,552**	912
SSGun	1.2	13,964	1,181	-	-	-	-	-	-	1.2	**13,964**	1,181
Ssovertree	-	-	-	-	-	-	0.3	2,446	895	0.3	**2,446**	895
Sssprinkler	93.3	764,909	820	-	-	-	78.8	604,406	767	172.1	**1,369,315**	796
Subirrig	13.5	105,336	782	-	-	-	-	-	-	13.5	**105,336**	782
Travgun	2,459.4	23,486,117	955	-	-	-	1,153.5	12,265,591	1,063	3,612.9	**35,751,707**	990
Wheelline	4,076.4	36,704,462	900	-	-	-	1,917.1	18,899,789	986	5,993.5	**55,604,252**	928
TOTALS	15,255.1	**135,576,317**	889	-	-	-	6,389.3	**62,239,319**	974	21,644.4	**197,815,636**	914

Appendix Table N Buildout Demand by Aquifer for 2003 Climate Data and Good Management

Water Source	Surface Water			Reclaimed Water			Groundwater			Total		
Aquifer	**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)**
Others	8,755.9	73,699,704	842	-	-	-	2,087.1	19,886,636	953	10,843.0	**93,586,340**	863
2 km west of Barnhartvale	0.9	7,597	829	-	-	-	6.9	56,934	822	7.8	**64,531**	823
Buse Lake	57.8	530,592	918	-	-	-	28.9	252,200	874	86.7	**782,792**	903
Campbell Creek	91.2	896,478	983	-	-	-	35.6	327,381	921	126.7	**1,223,859**	966
Christian Creek Valley	21.3	145,688	685	-	-	-	-	-	-	21.3	**145,688**	685
Clearwater North of Kamloops	99.3	872,601	857	-	-	-	89.9	845,932	918	189.1	**1,718,533**	881
Dixon and Sargent Creek Valley	196.2	1,873,213	955	-	-	-	97.1	904,926	932	293.2	**2,778,139**	947
Dixon, Sargent and Jet Creek	168.5	1,440,058	855	-	-	-	309.6	2,674,540	864	478.1	**4,114,598**	861
Heffley and Edward Creek	0.1	739	784	-	-	-	1.5	9,857	668	1.6	**10,597**	675
Kamloops Airport	356.0	3,901,127	1,096	-	-	-	403.2	4,558,025	1,131	759.2	**8,459,152**	1,114
Little Fort	217.7	2,008,581	923	-	-	-	122.5	1,138,322	929	340.2	**3,146,903**	925
Louis and Fraser Creek Valley	541.6	4,498,431	831	-	-	-	25.8	221,234	859	567.4	**4,719,665**	832
Louis Creek and North Thompson	24.3	230,412	948	-	-	-	17.9	184,412	1,027	42.3	**414,824**	982
Lower Barriere River Valley	7.6	77,792	1,024	-	-	-	42.1	413,876	982	49.7	**491,667**	989
Lower South Thompson River	59.3	604,116	1,019	-	-	-	140.1	1,489,217	1,063	199.4	**2,093,333**	1,050
N Thompson River	462.2	3,585,572	776	-	-	-	251.1	1,929,482	768	713.3	**5,515,054**	773
North Thompson River flood	62.6	597,432	955	-	-	-	134.0	1,279,440	955	196.6	**1,876,872**	955
North Thompson River North	2,769.6	27,696,672	1,000	-	-	-	1,384.6	14,159,674	1,002	4,154.2	**41,856,346**	1,003
North-east of Kamloops	966.7	9,235,018	955	-	-	-	987.1	9,816,112	994	1,953.8	**19,051,130**	975
Pinantan Lake / Pritchard	15.6	107,477	691	-	-	-	-	-	-	15.6	**107,477**	691
Rose Hill / Barnhartvale	366.3	3,438,591	939	-	-	-	224.1	2,088,991	932	590.4	**5,527,582**	936
Sugarloaf Hill Southwest	14.6	128,426	878	-	-	-	0.3	2,127	763	14.9	**130,552**	875
TOTALS	15,255.1	**135,576,317**	889	-	-	-	6,389.3	**62,239,319**	974	21,644.4	**197,815,636**	914

Appendix Table O 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)**
Barriere	82.2	813,829	990	-	-	-	268.5	2,508,741	934	350.7	**3,322,570**	947
Clearwater	485.3	4,169,752	859	-	-	-	288.0	2,334,856	811	773.3	**6,504,608**	841
Kamloops	2,102.0	21,010,067	1,000	-	-	-	1,835.3	18,819,328	1,025	3,937.4	**39,829,395**	1,012
Kamloops First Nation	128.2	1,264,375	986	-	-	-	20.4	215,653	1,057	148.6	**1,480,027**	996
Thompson-Nicola	12,457.4	108,318,294	870	-	-	-	3,977.1	38,360,740	965	16,434.5	**146,679,035**	893
TOTALS	15,255.1	**135,576,317**	889	-	-	-	6,389.3	**62,239,319**	974	21,644.4	**197,815,636**	914