CLIMATE CHANGE ADAPTATION PROGRAM

Regional Strategies: Fraser Valley

Report

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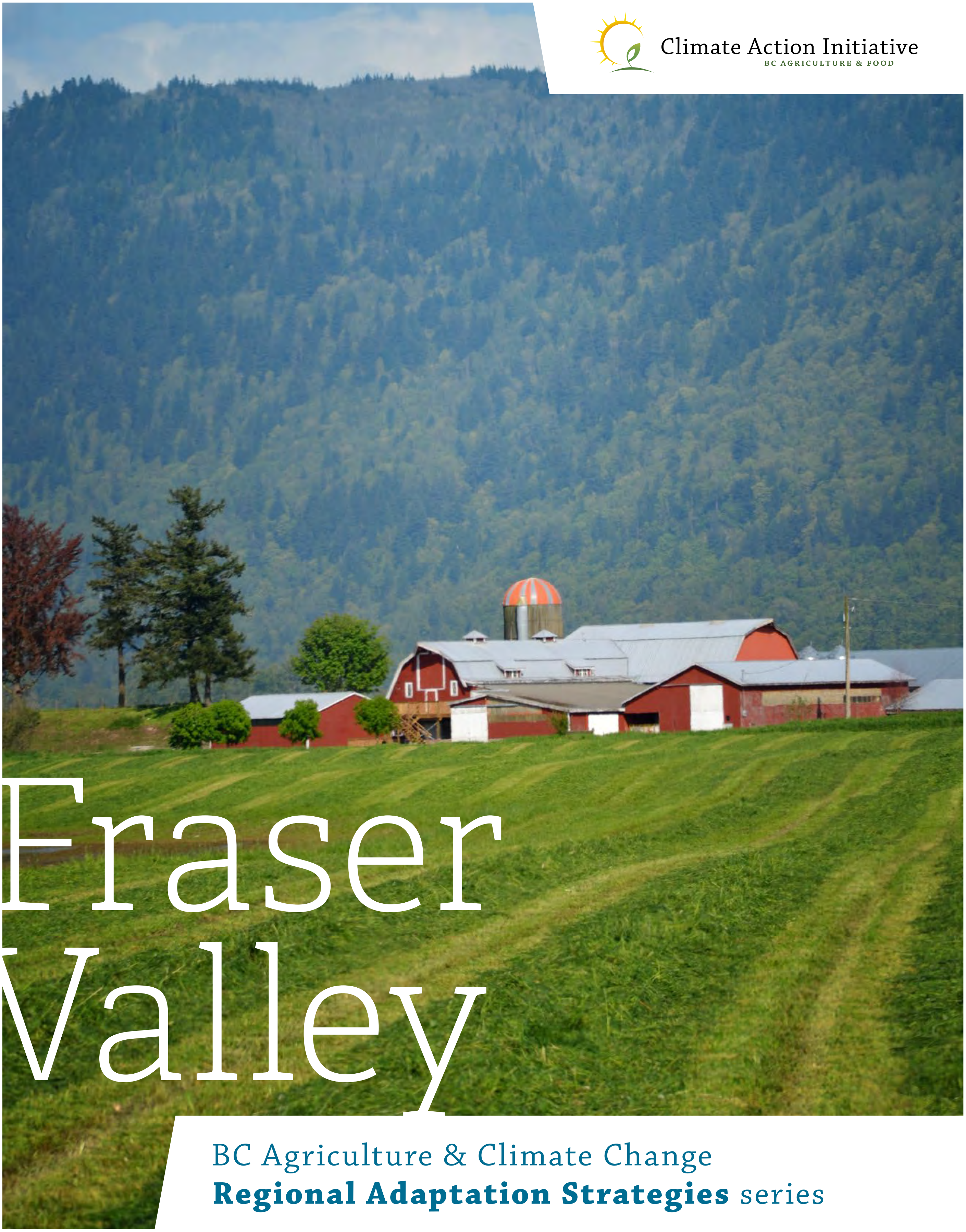

Climate Action Initiative
BC AGRICULTURE & FOOD

Fraser Valley

BC Agriculture & Climate Change
Regional Adaptation Strategies series

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The Regional Adaptation Enhancement Program is part of the BC Ministry of Agriculture's ongoing commitment to climate change adaptation in the agriculture sector while enhancing sustainability, growth, and competitiveness.

www.BCAgClimateAction.ca

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Cover photograph by Tamara Leigh.

Contents

Introduction

In the coming years, climate change will impact the agriculture sector in British Columbia in a range of different ways.

Although agricultural producers are accustomed to adjusting their practices to manage through difficult conditions, the scope and scale of climate change is anticipated to exceed anything previously experienced. Strategies and actions that will enhance agriculture's ability to adapt to climate change are the focus of this plan.

In 2011–2012, a province-wide assessment of climate change-related risks and opportunities evaluated the potential impacts of climate change on agricultural production and the sector's capacity to adapt.[1] The assessment made evident that, due to British Columbia's diversity (with respect to agriculture, ecology and climate), a regional approach to climate change adaptation is required. In addition, while some adaptation will occur at the farm level, the context beyond the farm and collaborative approaches, are critical for supporting agricultural adaptation.

Building on these findings, in 2012–2013 a pilot project was initiated with agricultural producers, agricultural organizations and local governments in Delta and the Peace River and Cowichan Valley regions. Each planning process resulted in a distinctive set of local sector impacts and priorities, as well as a series of strategies and actions for adapting and strengthening resilience. The plans are intended to offer clear actions suited to the specifics of the local context, both with respect to anticipated changes and local capacity and assets.

Following completion of the pilot, in 2013–2014 the ***Regional Adaptation Enhancement Program*** was launched. The Program is delivered by the BC Agriculture & Food Climate Action Initiative (CAI) and is part of the BC Ministry of Agriculture's Growing Forward 2 programming. Since the Program's inception, additional adaptation plans have been completed for the Cariboo region (2013–2014) and now for the Fraser Valley region (2014–2015).

Once regional adaptation plans are completed, up to $300,000 in Growing Forward 2 funding is available to regional partners (working with the CAI) to develop and implement collaborative priority projects. Implementation is underway in four regions and details are available at *www.bcagclimateaction.ca*.

Project Delivery

A local Advisory Committee for the Fraser Valley region was formed to provide input throughout the project. This Committee included participants from the Fraser Valley Regional District, local governments, the BC Ministry of Agriculture and a number of agricultural organizations. The agricultural producer participants volunteered their time throughout the project, representing six distinct local production systems. The Fraser Valley Regional District provided staff time and expertise and covered costs associated with the workshops. With funding from the Growing Forward 2 Program, the BC Agriculture & Food Climate Action Initiative provided core management and human resources for project delivery. Please see Acknowledgements for more details.

Project Methodology

The development of the Strategies involved three key stages:

1 ***Project Development***
A project plan was drafted and background research was conducted through a review of relevant documents and related activities. Seven preliminary meetings were held with producer organization and local government staff to discuss local issues and priorities. Two initial meetings were held with the local Advisory Committee to receive input on the project outline and the proposed approach for the first workshop.

2 ***Workshops***
Two sets of workshops were held (each set held in two locations — Chilliwack and Abbotsford) for a total of four workshops. The first set of workshops focused on reviewing climate change projections, discussing the associated agricultural impacts and identifying priority areas of risk. Developing strategies and actions for adapting to these priority areas then became the focus of the second set of workshops.

Prior to the second set of workshops, a series of overarching goals, strategies and sample actions was developed and reviewed by the Advisory Committee. These materials provided support for the workshop action planning process (which also incorporated consideration of local priorities, context and resources). Approximately 80 people attended one or both of the project workshops.

3 ***Implementation Meeting***
An implementation meeting was held with 25 participants representing many of the key local partners. The meeting involved prioritization of draft actions based on which were most important, which were easiest to implement and which would support enhancement of capacity for additional adaptation. The meeting also included discussion of steps to implement prioritized actions.

photo by Tamara Leigh, blueberries in the Fraser Valley region

Regional Context

Geography, Climate & Production Capacity

The Fraser Valley Regional District (FVRD) comprises the eastern half of BC's Lower Mainland region, extending from Abbotsford and Mission to about 40 kilometres beyond Hope. The region is bordered by the United States to the south; covering an area of 13,361 square kilometres.[2] The FVRD includes eight electoral areas (A through H) and six member municipalities: the City of Abbotsford, the City of Chilliwack, the District of Mission, the District of Hope, the District of Kent and the Village of Harrison Hot Springs.[3] There are also 31 First Nations communities in the region.[4] The population of the FVRD is 288,682.[5]

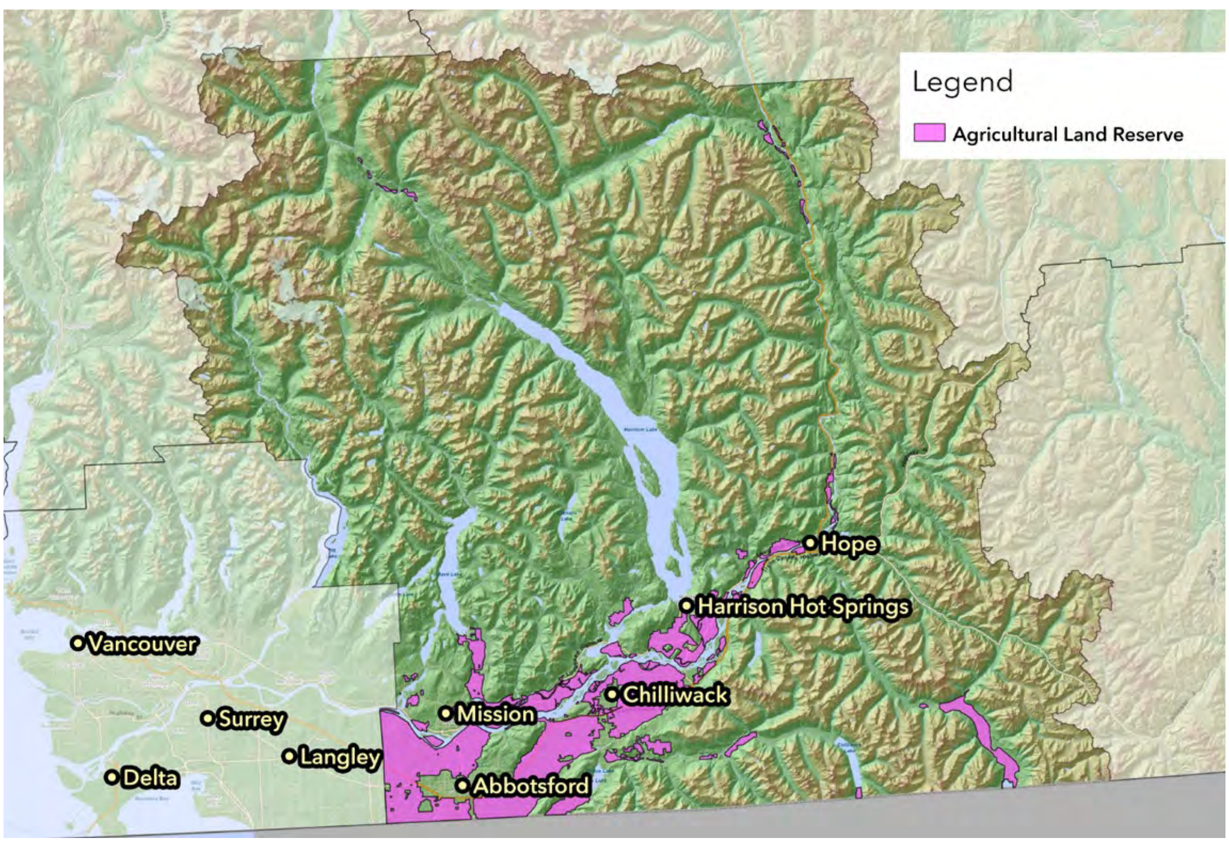


FIGURE 1 Map of Fraser Valley Regional District, showing Agricultural Land Reserve lands (violet areas)

The climate in the Fraser Valley varies with respect to average temperatures and rainfall and is broadly influenced by its location off the Pacific coast and proximity to the Coast and Cascade Mountains.[6] The Fraser Valley's agricultural areas have a relatively mild climate, with one of the longest frost-free periods in Canada. The temperature infrequently drops below zero degrees Celsius and summers are also mild, with average July daytime temperatures of 24ºC.[7,8]

The FVRD receives annual precipitation of approximately 1,575 mm (1,483 mm at Abbotsford and 1,667 mm at Chilliwack), with the majority (75%) falling between October and April.[9] Precipitation varies across the region, increasing substantially from south to north and west to east. Summers tend to be dry — deficiencies in soil moisture are common and irrigation is required to maintain agricultural productivity.[10]

The soils within the Fraser Valley are some of the most fertile in Canada.[11] However, urban and residential development has occurred on, and in close proximity to, these prime agricultural lands. The majority of agricultural land is located along the broad floodplain of the Lower Fraser River, which drains westward to the sea.[12] Through much of the Valley, soils have a broad range of characteristics and capability ratings (there are 58 different soil types in Abbotsford alone), but the majority is class three or better and with proper drainage and/or irrigation, can be improved.[13]

Economic & Institutional Context

In addition to the region's climatic and environmental advantages, the Fraser Valley's proximity to large markets, transportation infrastructure and educational and research institutions make the region the provincial hub for agriculture. The FVRD generates the highest gross farm receipts of any region in the province, generating over $1.1 billion in gross farm receipts in 2010 on just 1.6% of the province's ALR lands.[14] Farm operating expense statistics also reflect the economic value of agriculture in the FVRD. In 2011, total farm operating expenses in the FVRD were over $950 million, much of this spent in the local economy through consumption of goods and services.[15]

The price of an acre of Fraser Valley farmland is estimated to be six times higher than in the rest of western Canada.[16] Dairy farms in the Chilliwack-Fraser Valley sell for up to $63,000 per acre and, in 2014, the lowest price for Fraser Valley farmland was $41,000 per acre. This is up to 40 times higher than other parts of the province, and well above provincial averages.[17] The cost of land is having a considerable impact on the types of agriculture in the region and will influence the sector's sustainability over the long-term. High agricultural land costs and decreasing profitability for some commodities can create challenges for investment and growth in the sector.[18]

The Cities of Abbotsford (2011) and Chilliwack (2012), and the District of Kent (2010) have all completed Agriculture Area Plans in recent years.[19] Both Kent and Chilliwack currently have Agricultural Advisory Committees to guide plan implementation, to review proposals and zoning changes affecting agriculture, and to provide input on sector-related programs. Abbotsford has an Agriculture, Dyking, Drainage and Irrigation Advisory Committee to create and maintain communication about relevant issues between Council, staff and the agricultural community.[20]

In 2002, the FVRD partnered with Metro Vancouver to develop an *Economic Strategy for Agriculture in the Lower Mainland*.[21] More recently, the FVRD provided funding and in-kind support for the most recent Agricultural Land Use Inventory (ALUI), which has been used as input for the Agriculture Water Demand Model for the Fraser Valley (AWDM). The AWDM will be used to determine current and future water demands for agriculture in the region.[22]

There are more organizational and informational resources focused on agriculture in the Fraser Valley than anywhere else in the province. Facilities include the Pacific Agri-Food Research Centre (AAFC), Abbotsford Agriculture Centre (BC Ministry of Agriculture), the UBC Dairy Education and Research Centre, and the University of the Fraser Valley's Agriculture Centre of Excellence. The region is also home to the BC Agriculture Council and a large number of commodity-specific industry associations and organizations representing members' interests.[23]

Agricultural Production

About 5.1% of the Fraser Valley region's overall area is suitable for agriculture with 71,780 ha hectares included in the Agricultural Land Reserve in 2012.[24] There are approximately 2,700 farms in the region and the average age of producers in the region is 52, slightly lower than the provincial average of 56.[25] The agriculture industry grew steadily in the Fraser Valley between 2001 and 2011. The total amount of land farmed in 2011 in the FVRD was 63,838 hectares, an increase of 10,235 hectares from 2006, and an increase of 15,168 hectares from 2001.[26] The average farm size in the Fraser Valley Regional District is 23 hectares, compared with the province-wide average of 132 hectares.[27]

The environment, soils and topography in the Fraser Valley enable the production of a very diverse array of agricultural goods. The FVRD is home to a relatively high proportion of the province's supply managed operations (60% of the dairy herd and 86% of poultry hatcheries).[28] Dairy, egg and poultry operations have relatively high and stable farm revenues and are significant contributors to overall gross farm receipts in the province.[29] However, the concentration of intensive livestock production in the region (driven by economics and proximity to markets) also places management pressures on the industry. Primarily associated with the dairy sector, the region also produces field crops for feed; with 26,348 hectares in the FVRD growing corn for silage, alfalfa and other hay and fodder crops.[30]

Regionally, the FVRD produces the second highest proportion of BC's field vegetables after Metro Vancouver.[31] More than 25 different types of field vegetables are grown throughout the region.[32] The field vegetable sector has faced a number of challenges in recent years; one of the greatest has been the reduction in vegetable processing capacity in the Lower Mainland. The processing and value-added components of the local industry are relatively small. External competition, achieving economies of scale, labour costs and supply and ensuring a long-term supply of agricultural inputs are on-going challenges facing the food processing industry in the region.[33,34]

Berry production is also prominent in the Fraser Valley. In recent years, blueberry production has increased dramatically, and hectares in other types of berries have dropped.[35] The shifts in crops and production reflect trends in profitability. The greenhouse and nursery sectors in the region are substantial, including 27% (greenhouse) and 37% (nursery) of the total production areas of these commodities in BC.[36] In addition to the commodities identified above, the Fraser Valley is home to many other types of farms including mushroom operations, organic farms of various kinds, other forms of livestock operations as well as farms producing a mix of commodities. Distribution of operation types varies across the region; there are more dairy, beef and greenhouse/nursery operations in Chilliwack and more poultry and fruit farms in Abbotsford.[37]

photo by Getty Images, a dairy barn in the Fraser Valley region

Regional Climate Science

Accessing the best possible information about climate change is the first step in determining the options for adaptation. For many years, climate scientists have been improving and refining climate models to produce more accurate future projections.[38] These models have been validated against observed climate records.[39] The resolution of the data and models continues to increase, enabling the kinds of regional projections that follow.

The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre at the University of Victoria that provides practical information on the physical impacts of climate variability and change, in support of long-term planning.[40] PCIC was a key partner in developing the pilot projects that preceded the Fraser Valley strategy, and has assisted in the production of the agriculturally relevant regional climate projections for the 2020s and 2050s that are presented here.

Additional information about regional climate projections, maps, and related definitions may be found in Appendix B and Appendix C, and in PCIC's South Coast climate summary.[41]

Fraser Valley Regional Climate Projections: 2020s to 2050s

Key climate projections for the Fraser Valley region in the 2020s to 2050s are summarized here. Projections are derived from PCIC's online tool, "Plan2Adapt." Numbers provided are the median of all model runs (black line in the graphs), and the shaded area on the graphs shows the range of projected possible future conditions.[42]

Temperature Projections

- Annual average is 1°C warmer by 2020s (+1.8°C by 2050s)
- 15 more frost-free days annually by 2020s (+26 days by 2050s)
- 184 more growing degree-days annually by 2020s (+353 days by 2050s)

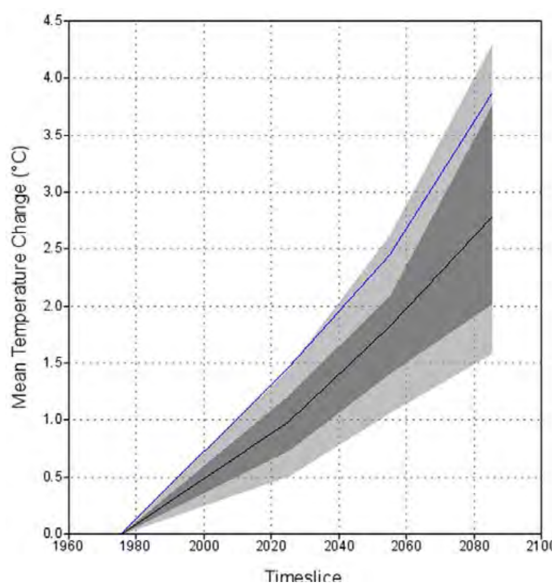


FIGURE 2 Mean Annual Temperature change, 1960s to 2080s

Temperature

Projections for key temperature variables show a strong increasing trend with all models projecting warming in all seasons (see text box and Figure 2, previous page). This trend is significant compared to historical variability, and summer is projected to warm slightly more than other seasons.

Precipitation

While models show the possibility for both increasing and decreasing future annual precipitation, the median annual trend is an increase of 4% above the 1990 baseline by 2020, and increasing by 7% by 2050.

The majority of models show a decrease in summer precipitation. There may be a slight increase in the amount of winter precipitation, with a marked decrease in the amount falling as snow (see Figure 3).

The distribution of these temperature and precipitation changes is greatly influenced by local geographic settings — temperature by elevation, and precipitation by topography. As Figure 4 shows, temperatures are higher in the valley bottoms of the Fraser Valley region, with cooler temperatures and wetter conditions in the mountainous northern and eastern perimeters. Agricultural areas are primarily located in the valley bottom sections and so therefore would be affected by these temperature increases.

Related Effects

The magnitude, frequency and intensity of extreme events, for both temperature and rainfall, are also forecast to increase with climate change. Unusually warm temperatures are very likely to occur more often, and cold temperatures less frequently. Projections are for 2.6 times the number of summer "warm days" (days in June, July and August that are warmer than the 90th percentile historic baseline temperature for that day) and 3.8 times the number of extremely hot days (days so hot they used to occur only once every 10 years). The intensity and magnitude of extreme rainfall events are also projected to increase. Detailed projections for 2050s extremes are provided in text box [following page].[43]

Precipitation Projections

- Annual precipitation: +4% by 2020s (+7% by 2050s)
- Summer: –5% by 2020s (–12% by 2050s)
- Winter: +3% (may increase) by 2020s (+6% by 2050s)
- Winter Snowfall: –12% decrease by 2020s (–24% by 2050s)

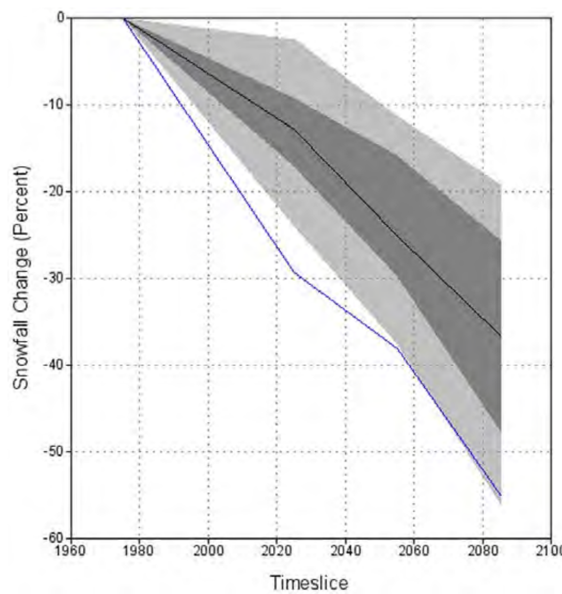


FIGURE 3 Precipitation as Snow, 1960s to 2080s

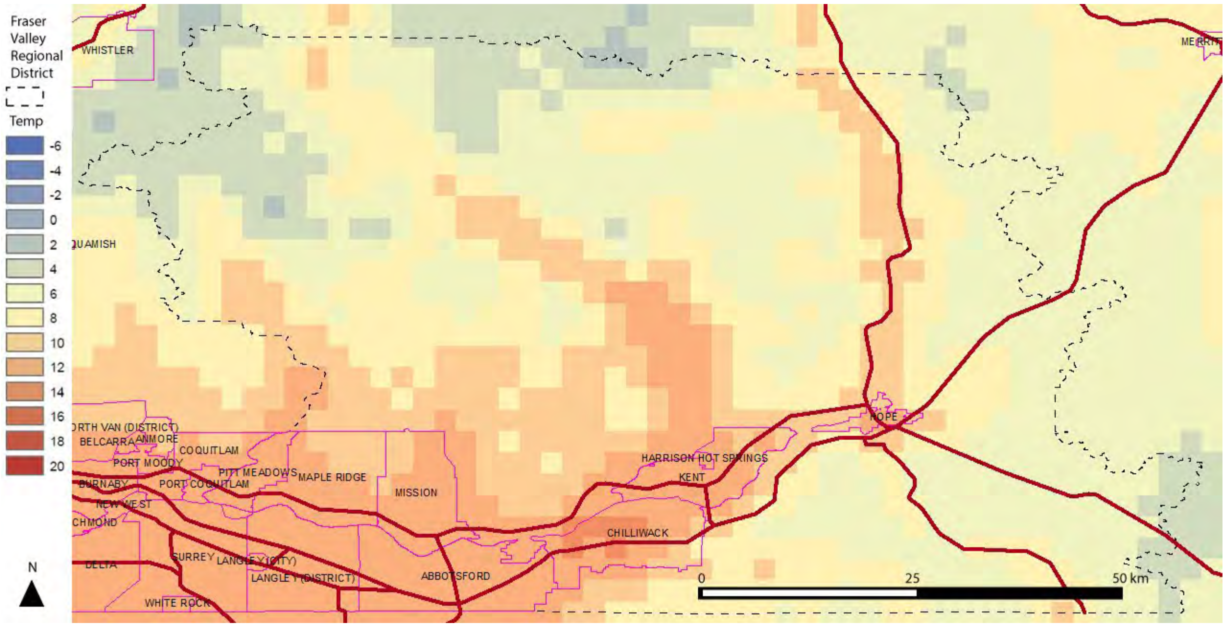


FIGURE 4 Fraser Valley Region Mean Annual Temperature, 2050s

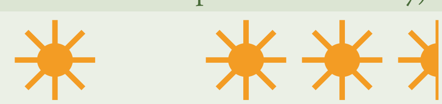
This map illustrates the spatial distribution of median value of all models of 2050s mean average temperature. The global model data has here been down-scaled to reflect regional temperature variation, driven largely by topography. As temperatures varied historically, so too will they in the future, with the mountainous zone to the north and east cooler (blue), and valley zone warmer (red) where most agricultural lands are located. Note that more local effects such as urban heat, vegetation changes, and dropping snow elevation may add to the trend in the valley.

As precipitation in the Fraser Valley and in upstream regions changes, Fraser River flows are expected to be affected. River systems in the region will likely see a shift to a more rain-dominated pattern, with less predictability and increased variability in timing and volume of flows. With changes to snowpack and temperatures, runoff peaks should occur earlier in the season, with lower discharge later in the summer.

The projected changes outlined in this section will affect the Fraser Valley's agricultural sector. The ecological effects and resulting agricultural impacts of these projected climate changes are summarized in the next section.

Extremes

- ***2.6 times*** the number of summer ***"warm days"*** (days in June, July and August that are warmer than the 90th percentile historic baseline temperature for that day)



- ***3.8 times*** the number of extremely hot days (days so hot they used to occur only once every 10 years)
- ***Increased*** frequency, intensity and magnitude of ***extreme rainfall***
- ***1.6 times*** the number of extremely wet days (days so wet that in the past they would only occur once every 10 years)

Agricultural Impacts

The changes in climate projected for the Fraser Valley region will have a range of impacts on the agriculture sector. These impacts are summarized in the table immediately below.

TABLE 1 Potential impacts of climate change on agricultural production in the Fraser Valley region

Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Increase in average temperatures ▪ Decrease in summer precipitation ▪ Increase in number of warm and extremely hot days	*Drier & hotter summers:* ▪ More frequent and extended dry periods in summer ▪ Lower river flows in summer (earlier peak flows)	*Challenging agricultural impacts:* ▪ Reduction in water supply availability ▪ Increase in irrigation demand ▪ Impacts to crop yields and quality – potential for multi-year impacts to perennial crops ▪ Impacts to livestock health/productivity ▪ Increase in complexity and costs associated with water (e.g., access to water, water storage, irrigation management) *Potential opportunities:* ▪ Better harvesting conditions
▪ Increase in average precipitation in winter ▪ Increase in intensity/ frequency of extreme rainfall events	*Increasing precipitation and extreme precipitation events (wetter winters):* ▪ Potential for more rain-driven flood events ▪ Increase in runoff ▪ Increase in excess moisture	*Challenging agricultural impacts:* ▪ Increase in excessive moisture and site-specific flood risk ▪ Erosion associated with runoff ▪ Increase in pressure on drainage infrastructure ▪ Impacts to plant and animal health and productivity ▪ Reduced windows for seasonal tasks ▪ Interruptions to pollination ▪ Increase in nutrient and input leaching ▪ Increase in manure storage requirements

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Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Warmer average temperatures ▪ Increase in winter precipitation ▪ Increase in extreme rainfall events	*Changing freshet flood risk:* ▪ Increasing river flows in winter and spring ▪ Shift to more rain-driven stream-flow (less predictable) ▪ Increasing rain on snow events ▪ Rising sea level	*Challenging agricultural impacts:* ▪ Damage to farm buildings and equipment ▪ Losses associated with annual and perennial crops ▪ Need for relocation and/or losses of livestock ▪ Erosion associated with runoff (and loss of arable land) ▪ Interruptions to supply lines and transportation (e.g., flooded roads) ▪ Impacts to stored hazardous materials and manure storage
▪ Increase in average temperatures ▪ Increase in growing degree days ▪ Increase in frost free days ▪ Shift in precipitation patterns	*Changing crop suitability ranges:* ▪ Changing seasonal conditions ▪ Changing production windows	*Challenging agricultural impacts:* ▪ Inconsistent yield and quality of previously suitable crops ▪ Shortened and/or less predictable production windows for some crops ▪ Increase in management complexity (e.g., with season extension) *Potential opportunities:* ▪ Increase in suitability for new varieties and new crops ▪ Opportunity for season extension and additional cropping
▪ Increase in annual temperatures ▪ Increase in spring precipitation and extreme rain events ▪ Drier summer conditions	*Changes in pests, diseases, invasive plants:* ▪ Increasing winter survival rates ▪ Increasing number of cycles in a year ▪ Introduction of new pests and diseases	*Challenging agricultural impacts:* ▪ More frequent and increased damage to crops ▪ Impacts to livestock health due to pests/diseases ▪ Increasing challenges with management of invasive species on agricultural lands ▪ Increase in costs for management of pests, diseases, invasive species
▪ Increase in extreme weather events	*Increase in warm and extremely hot days:* ▪ Sudden temperature increases ▪ Increasing number of consecutive warm and hot days	*Challenging agricultural impacts:* ▪ Decrease in productivity and quality of horticultural crops ▪ Decrease in germination and transplant success ▪ Impacts to livestock health and productivity (extreme heat) ▪ Increase in cooling and ventilation costs ▪ Increase in irrigation demand ▪ Reduction of windows for key agricultural activities

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Projected Climate Changes	Projected Effects	Potential Agricultural Impacts
▪ Climate change in other growing regions	*Variability of global agricultural production*	*Challenging agricultural impacts:* ▪ Increase in costs of imported feed and agricultural inputs ▪ Increase in demand and prices for food production/local food ▪ Potential for increased competition from new or changing agricultural areas *Potential opportunities:* ▪ Increase in demand and prices for food production/local food ▪ Potential competitive advantage in changing global markets ▪ Increase in farming diversity in the region
▪ Increase in variability of conditions	*Increasing variability:* ▪ fluctuating and unpredictable seasonal conditions	*Challenging agricultural impacts:* ▪ Winter damage to perennials due to repeated thaw and freeze cycles ▪ Variable/reduced windows for pollination ▪ Increase in diseases that are linked to damp conditions ▪ Increase in complexity of timing and management of nutrient/input applications ▪ Interruption or damage during planting, germination and harvesting

This set of "impact areas" (groupings of projected climate changes and their associated effects and agricultural impacts) formed the basis for discussions at the first set of workshops. These impact areas were explored in detail with participants, and ranked in order of importance for both the individual farm and regional levels. Based on this input, the highest priorities were identified and some impact areas in the table above were excluded from consideration at the second workshops. Those impacts that were excluded may prove to be problematic or advantageous in the Fraser Valley region in the future, and should continue to be monitored. Adaptation strategies may still be needed for agriculture to address excluded impact areas.

Priority Impact Areas, Strategies & Actions

The following five impact areas were identified as the highest priorities with respect to agricultural adaptation in the Fraser Valley region:

- **Impact Area 1**
  Warmer & drier summer conditions
- **Impact Area 2**
  Increasing precipitation & extreme precipitation events
- **Impact Area 3**
  Changing freshet flood risk
- **Impact Area 4**
  Changes to pests & pollinators[44]
- **Impact Area 5**
  Greater frequency & intensity of extreme heat events

photo by Samantha Charlton, flooded blueberry field in Agassiz area

In the following sections, background descriptions and adaptation goals are provided for each priority impact area. Along with the descriptions are the strategies and actions to support the Fraser Valley region agriculture sector with adapting to climate change.

The strategies and actions presented were developed to:

- Address the highest priority impact areas
- Reduce vulnerability to these impacts, and/or build capacity to adapt and respond to these impacts; and
- Define practical steps forward that address gaps and build on existing assets in the Fraser Valley region context.

Following the strategies and actions, the final section highlights those actions identified for near-term implementation. Implementation details, key participants, timeframes and cost ranges are provided for these near-term priority actions.

Impact Area 1
Warmer & Drier Summer Conditions

The Fraser Valley supports a diverse range of agricultural production systems and associated irrigation and water requirements. 38,000 hectares of agricultural land in the Fraser Valley is used primarily for agricultural purposes, of which 39% (15,000 hectares) is irrigated.[45] Approximately 57% of the irrigation water is estimated to be from groundwater sources, and about 43% from surface water sources.[46] Berry, greenhouse and nursery operations are more reliant on groundwater, while vegetable operations tend to rely more heavily on surface water sources.[47]

Relevant Climate Change Effects

- Increasing average summer temperature
- Increasing number of ***summer warm days*** and ***extremely hot days***
- Decreasing snowfall
- Decreasing precipitation in the summer

The Fraser Valley's typical (historical average) summer conditions are dry enough to cause soil moisture deficiencies, resulting in the need for irrigation to maintain healthy agricultural production.[48] With climate change, more extended hot and dry periods are anticipated along with changes in hydrology that will reduce surface water flows in summer. While winter precipitation is an important element of groundwater recharge, dry years currently result in insufficient recharge of shallower groundwater wells in the Fraser Valley.[49]

Some water sources in the region are already stretched to meet demand during dry seasons. For example, the Abbotsford Mission Water and Sewer Service relies on three different water sources and currently has difficulty meeting maximum daily demand.[50] The system has sufficient capacity to serve its users (residential, commercial, industrial and agricultural) until 2027, and alternate water sources (such as Stave Lake) are being considered to maintain sufficient future water supply.[51]

The warmer and drier summer conditions will result in increased rates of evapotranspiration and greater agricultural water demand to maintain production. The extent to which conditions impact agricultural water demand is visible through historical water demand patterns. The *Agriculture Water Demand Model: Fraser Valley Report* estimates that water demand during dry years has been almost double (192%) that of wet years.[52]

Agricultural producers are not only facing changes in water supply and demand, new provincial water regulations (the Water Sustainability Act) are expected to take effect in 2016.[53] Producers require a clearer understanding of how these changes will affect them, as well as information about how water supply and demand will change over time. To date, water supply has not been a typical constraint for producers in the Fraser Valley and addressing informational gaps (about the future of water in the region) will assist with appropriate management and investment decisions.

The strategies and actions in this section address the following ***adaptation goal***:

- ***Encourage adoption of water management practices and technologies suitable for changing conditions.***

Address critical information gaps to assist producers with water management decisions

Adaptive decisions about water management would be supported by accessible and clear information about the changing water context. Recent initiatives in this vein include the *Agricultural Water Demand Model* report[54] for the Fraser Valley and aquifer mapping undertaken by the Ministry of Environment.[55] These new resources, combined with climate change projections, fill information gaps relating to future water demand and supply in the region.

At the same time, the regulatory context for water is changing. The Water Sustainability Act extends the First In Time, First In Right (FITFIR) system of water allocation for groundwater users.[56] The new Act also introduces fees for groundwater licenses and water rental rates, and raises the question of allocation of water rights during times of scarcity. Although the Act also identifies the intent to enable dedicated water for agricultural purposes on agricultural lands, how this might be implemented remains unclear at this time.[57]

The need for information about how the Water Sustainability Act will affect farm operations was identified as a high priority by the producers that participated in the adaptation planning process. Projections about future water supply and demand, information about changing water regulations and promotion of alternate management tools and technologies, provide important context to support producers with adaptive investment decisions at the farm level.

ACTION 1.1A **Bring producers and key partners together for informational exchange regarding the Water Sustainability Act**	ACTION 1.1B **Develop producer-focused informational resources regarding agricultural water issues**
▪ Identifying key participants and informational gaps to be addressed ▪ Convening an agriculture-specific *Water Sustainability Act and Water Issues Forum* in the Fraser Valley ▪ Identifying any new actions and follow-up items arising from this informational exchange	▪ Compiling information on relevant agricultural water topics including: - How the Water Sustainability Act will affect agricultural users (supported by Action 1.1a) - Future water availability (versus agricultural demand) in critical agricultural aquifers - Anticipated changes to groundwater due to climate change - Results of relevant new studies (e.g., Agricultural Water Demand Model for the Fraser Valley) ▪ Consolidating and clearly defining how this information affects producers and their water use decisions ▪ Providing information to producers in accessible formats (summaries, workshops, industry events/ meetings etc.)

Impact Area 1 > Strategy 1.2

Strengthen knowledge transfer of water management tools, technologies and resources

As noted above, many producers in the Fraser Valley utilize irrigation to maintain the productivity of their crops. A broad range of irrigation systems and water management practices are employed. Dairy, poultry, mushroom and greenhouse operations also have water requirements that must be met to ensure the health and wellbeing of their livestock and products.

Some vegetable and berry producers in the Fraser Valley have already invested in high efficiency drip irrigation systems (particularly in the blueberry industry). For other production systems (e.g., forage) drip technology is not suitable, but efficiencies can be achieved through management.[58] However, with warmer and drier summers and simultaneously increasing water demands, agricultural adaptation will include additional measures to reduce water needs and increase efficiency. In some cases this may require new practices and/or technologies.

The *Agriculture Water Demand Model* indicates that with further adoption of good management technologies and practices, agricultural water demand in the Fraser Valley could be reduced. Increasing awareness and uptake of existing (BC-specific) tools, such as irrigation scheduling calculators, will assist some producers with taking initial low-cost steps to improve water management practices.[59] Also available are a range of irrigation manuals and guides for various technologies and production systems,[60] as well as cost-shared irrigation management plans (and limited cost-shares for implementation) through the Environmental Farm Plan and Beneficial Management Practices Programs.[61]

In some cases, it may be helpful to look beyond technologies and tools already used in the Fraser Valley. A coordinated approach to identification and assessment of new technologies and management practices will reduce upfront research costs that would otherwise be borne by producers. Fraser Valley workshop participants expressed interest in testing technologies to improve irrigation decision-making (such as wireless in-field soil moisture sensors which can be linked to real-time weather data).

At present, producers can access cost-share funding through the Beneficial Management Practices Program to install weather stations, soil moisture sensors and moisture meters. While this type of incentive has the potential to encourage uptake, local testing and demonstration can efficiently spur adoption by documenting and communicating information about results and benefits.[62]

Other approaches — including rainwater capture and storage, water recycling, and new crop varieties — may also support adaptation to future water supply challenges in the Fraser Valley. Given the diversity of production systems in the region, a coordinated approach to assessing the economic and technical aspects of various innovations could help to fill information gaps and share information across commodity types.

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ACTION 1.2A **Promote the use of (BC-specific) water management tools and resources**	ACTION 1.2B **Share information regarding innovative water management technologies and practices**	ACTION 1.2C **Demonstrate/ evaluate potential of agricultural water management innovations not commonly used in the Fraser Valley**
▪ Assessing opportunities to improve use of existing tools and resources ▪ Increasing awareness of existing tools through sector communication (newsletters, producer meetings) ▪ Offering workshops to share and demonstrate tools (e.g., irrigation calculator and manuals) ▪ Promoting uptake of Irrigation Management Plans through the Environmental Farm Plan Program	▪ Researching innovative water management technologies and practices (within BC and in other jurisdictions) and identifying those with the most relevance to the Fraser Valley ▪ Documenting the economic and environmental conditions that make these innovations viable (and evaluating potential for local context) ▪ Encouraging knowledge transfer through speakers, workshops, trade shows etc.	▪ Prioritizing the technologies/and or practices to be evaluated (to be identified in Action 1.2b) ▪ Developing demonstration projects to test and evaluate water management innovations and tools ▪ Sharing results through project summaries, field days, workshops etc.

Impact Area 2
Increasing Precipitation & Extreme Precipitation Events

Relevant Climate Change Effects

- → Increasing overall average temperatures
- → Increasing frequency and intensity of extreme rainfall events
- → Shifting precipitation patterns (increasing rain in winter, spring and autumn, rain on snow)

With climate change, there will be an overall increase in annual precipitation in the Fraser Valley region with much of this falling as rain (and less as snow) during the winter, spring and autumn. Rain will also be concentrated in more frequent and intense precipitation events, resulting in greater challenges with managing runoff (both onto and off) the predominantly low-lying agricultural land base.

Many agricultural areas in the Fraser Valley rely on drainage infrastructure such as drain tiles and constructed ditches to manage excessive precipitation and runoff. When properly managed and maintained, drainage infrastructure improves the productivity of agricultural soil through removal of excess moisture. Adequately drained soils will accommodate earlier crop planting schedules, provide better underfoot support for livestock and farm equipment, and can bolster crop health.[63]

In addition to farm-level infrastructure and practices, runoff quantity and drainage capacity are also strongly influenced by local infrastructure and its maintenance. Farm level drainage often links into broader systems (typically constructed ditches and other watercourses that drain water away from the farm).[64] The City of Chilliwack, the City of Abbotsford and the District of Kent all have active ditch and drainage maintenance programs. Each local government has its own approach to these activities.

Depending on the activities and watercourse involved, other government agencies are required to be involved in actions pertaining to drainage management (e.g., Fisheries & Oceans Canada, BC Ministry of Environment).[65] This creates a complex system and, as challenges with runoff management increase, effective coordination and collaboration between agencies will be required.

With increasing runoff issues, upland development has the potential to place lowlands (often agricultural) at risk of flooding. Municipal governments in the Fraser Valley are active in addressing this issue through stormwater management plans. For example, Chilliwack has developed its *Policy & Design Criteria for Stormwater Management*, focused on addressing rainfall-related runoff challenges by reducing the rate and volume of runoff at the source.[66]

Increased precipitation will also create additional challenges for producers to manage runoff from their farms (which can cause erosion, input and nutrient management challenges and associated impacts to water quality). As runoff becomes more problematic, both upland and farm level solutions will be needed, as well as coordination across these levels. Best practices, implemented locally and in other jurisdictions, may point the way with examples of effective approaches to reducing and managing increasing runoff.

The strategies and actions in this section address the following ***adaptation goals:***

- → ***Minimizing negative impacts of extreme precipitation and associated runoff.***
- → ***Developing agricultural management approaches suitable for wet conditions.***

Impact Area 2 > Strategy 2.1
Develop a coordinated cross-agency approach to agricultural ditch and drainage management

With increasing runoff, there is a growing need for ditches and drainage systems that are functioning optimally. Effective management of these systems is an on-going challenge for producers in the Fraser Valley — not only from a cost and technical perspective, but also due to the complexity of navigating the requirements for taking action. This complexity reflects the intersecting interests and priorities involved in watercourse health and maintenance.

Although installation of drainage and management of ditches on their property is the responsibility of individual producers, there are numerous rules and regulations that govern the maintenance of agricultural ditches. As noted above, each local government has its own approach and both provincial and federal government agencies are also involved with ditch maintenance. Some of the issues pertaining to higher levels of government include fish habitat and, more recently, species at risk (e.g., Salish sucker, Nooksack dace and Oregon spotted frog).[67]

Currently, producers do have access to drainage management planning and written guides through the Environmental Farm Plan Program.[68] However, the available written resources require updating and, by themselves, are complex to interpret and apply. For producers seeking to address issues on their own, the steps and processes involved can be daunting.

It can also be difficult for municipalities to effectively maintain their systems due to resourcing constraints and the need for cooperation from other stakeholders. Ensuring that processes are clear and consistent — and that both individual and municipal ditching and runoff management are working effectively — will be increasingly important as runoff issues become more acute. Improving coordination and consistency of the approach to dealing with agricultural drainage would assist producers with maintenance of these systems.

ACTION 2.1A **Assess the current state of agricultural ditches and drainage across the FVRD**	ACTION 2.1B **Develop options to improve coordination of ditch and drainage management**
▪ Consulting with producers, specialists and local governments to identify priority issues and geographic areas ▪ Reviewing the potential effects of climate change to the functioning of ditches and drainage systems ▪ Reviewing relevant standards, policies and practices across the region ▪ Identifying common issues and specific areas of greatest concern and/or vulnerability ▪ Developing a summary of findings and sharing with key partners and agencies	▪ Inviting participation of key partners and agencies in structured, facilitated workshops ▪ Identifying options for coordinating and streamlining approaches to agricultural ditch and drainage management ▪ Coordinating between municipalities and regional districts on best practices ▪ Creating a primary/single information source for current and consistent information for producers about ditch and drainage maintenance

Impact Area 2 > Strategy 2.2
Identify, pilot & evaluate mechanisms to reduce runoff onto & off agricultural lands

As average precipitation (particularly extreme precipitation events) increases, current strategies and approaches will no longer be sufficient for runoff management. Planning, infrastructure and management practices will need to incorporate mechanisms for reducing runoff onto, and off, the agricultural land base.

A recent example of a local government process to evaluate mechanisms for reducing runoff is the City of Abbotsford's *Clayburn Creek Integrated Stormwater Management Plan*.[69] This plan acknowledges that run-off related flooding impacts are happening on agricultural lowlands (and other areas), and that these conditions are worsening due to extreme precipitation events — and provides a number of options to manage and redirect runoff.

At the farm level, a range of approaches for runoff management are possible — both for limiting impacts of runoff coming onto the farm and for reducing runoff away from the farm. However, these measures require investment and producers would value local demonstration that also evaluates effectiveness and benefits. Which approaches are suitable for the Fraser Valley and for the individual farm level will depend on the specific circumstance. Identifying a range of options and piloting and evaluating their applicability in local situations, would be a valuable step forward. This not only provides a local example that people can see, but also enables gathering of important information about efficacy and cost-benefit.

ACTION 2.2A **Conduct background research to identify most promising options for runoff reduction**	ACTION 2.2B **Implement pilot projects to evaluate runoff management approaches**
▪ Inventorying existing approaches for runoff reduction in BC and other jurisdictions including options for: - Reducing upland runoff - Addressing existing lowland flooding - Farm level management (e.g., avoiding, controlling and trapping runoff) ▪ Evaluating suitability of runoff reduction approaches for the Fraser Valley context	▪ Identifying potential partners and suitable options for collaborative drainage/stormwater management pilot projects ▪ Implementing runoff management pilot projects that incorporate: - Findings from Action 2.2a - Producer organizations and cooperators - Existing agricultural programming (and potential to incorporate pilot findings) ▪ Implementing pilot projects including monitoring and evaluation of results and transferability

Impact Area 2 > Strategy 2.3

Develop adaptive & coordinated nutrient management strategies for the region

Climate change — both changing temperatures and precipitation — will impact the windows for operational activities for all farm types. In addition, climate change will affect the biophysical processes upon which farm systems depend, such as nutrient uptake in crops.[70] Therefore, the complexity of nutrient management will increase in two respects — suitable storage of nutrient "products" such as manure, as well as the timing for application of nutrients for efficacy and minimal runoff and nutrient losses.

An overall scan to evaluate how current nutrient management approaches might be impacted by climate change would help to establish a baseline of knowledge. Given the extent of variability and uncertainty, this is a challenging topic — but improving knowledge of linkages between management practices and weather and climate conditions will support adaptive decisions.

As there are already some on-going challenges with nutrient management in the Fraser Valley — particularly with livestock manure — there is also value in taking near-term steps to explore options for collaborative nutrient management. There have already been efforts to explore solutions — predominantly technologies (such as anaerobic digesters) or commodity-specific studies such as the 2003 study of options for utilization of Fraser Valley poultry manure.[71] These efforts provide resources to build on to undertake a broader (i.e. cross-sector) evaluation of the issue and to explore regional-scale solutions. Conducting such a review with climate change in mind could support long-term adaptive solutions.

ACTION 2.3A **Evaluate the relationship between climate change and nutrient management in the Fraser Valley**	ACTION 2.3B **Develop and pilot strategic approaches for nutrient management**
▪ Assessing how nutrient management practices and results are likely to be impacted by climate change (e.g., warmer/drier summers and more extreme rainfall events) including: - Impacts to manure storage, spreading and management - Impacts to nutrient availability and nutrient cycles (with linkages to weather, soils, climate variables)	▪ Evaluating and testing the potential of local nutrient "trading" relationships (coordinate nutrient availability and nutrient needs) ▪ Improving approaches for manure storage and processing including collaborative/multi-operational solutions (e.g., collectively fed anaerobic digestion facility) ▪ Researching and demonstrating the efficacy and economics of nutrient management related practices including: crop residue management, composting and compost use, green manure and cover crops

Impact Area 3
Changing Freshet Flood Risk

The potential for spring flooding off the Fraser River caused by a rapid melt of snowpack (freshet) is a seasonal threat for communities in the floodplain. There have been two major freshet floods in the Fraser Valley in relatively recent history (1894 and 1948).[72] In addition, in 2007 there was significant concern about freshet flooding in the Fraser Valley and in 2012 evacuation alerts were issued to some residents in the region.[73]

Relevant Climate Change Impacts

- → Increasing average temperatures
- → Increased precipitation in winter and spring
- → Increased extreme rainfall events

There is uncertainty about how climate change will affect the freshet on the Fraser River and more research is needed (a new study — through the Pacific Climate Impacts Consortium — is anticipated in the near future).[74] However, a recent hydraulics study — published in 2014 by the BC Ministry of Forests, Lands and Natural Resource Operations — indicates that with climate change "the magnitude and frequency of large floods on the Fraser will most likely increase."[75] Sea level rise is also expected to have a substantial influence on flood levels as far up the river as the Sumas River confluence (15km upstream of Mission).[76]

A freshet flood would have severe consequences for agricultural operations in the Fraser Valley. With so much intensive production, as well as much of the province's food storage, food processing and agricultural spin-off industry, a freshet flood in this region would affect the entire province's food supply and infrastructure. The timing of a freshet flood would also result in significant losses for all production systems.

The increasing risk of freshet flooding means that agricultural organizations and individual producers need to take proactive steps to engage in flood planning and management. At the commodity and individual operation levels, proactive investment in planning and adaptation could help to mitigate some types of losses and speed recovery in the event of a flood.

The strategies and actions in this section address the following ***adaptation goal:***

- → ***Strengthening sector awareness, engagement and preparedness regarding flood risk in the Fraser Valley.***

Impact Area 3 > Strategy 3.1

Increase awareness of flood risk & potential impacts to agriculture

While flood risk is an on-going reality for agricultural operations located in the flood plain, most producers are necessarily focused on their day-to-day individual business and production issues. Contemplating the potential impacts of flooding at an individual farm business level is also immensely difficult, which is why developing common educational resources and informational materials would be a valuable first step. Raising the overall level of awareness of flood risk will also help to increase willingness to take action to mitigate flooding impacts.

At present there is a broader regional initiative underway to evaluate vulnerabilities to flooding impacts and to develop a Lower Mainland Flood Management Strategy.[77] This initiative is being coordinated by the Fraser Basin Council and includes the regional districts, local governments and other concerned local agencies and partners from across the Lower Mainland. While agriculture will be included in the evaluation, the regional scope and mandate will limit the resourcing and attention for any particular sector.

A study focused specifically on agricultural impacts of freshet flooding would help to evaluate the issue in more detail (and at a greater level of complexity) as well as to assess steps to mitigate losses and speed recovery. Another recently completed study to assess potential economic impacts of climate change flooding on agriculture (in the Fraser delta) could provide an initial framework.[78] Such a study would be of value to producer organizations and governments that are grappling with planning for flooding impacts and recovery, and would also help to generate informational resources specific to agriculture.

ACTION 3.1A **Evaluate the potential impacts and costs to agriculture associated with freshet flooding**	ACTION 3.1B **Provide informational materials to enhance producer awareness of flood risk and available resources and supports**
▪ Identifying and approaching partners with an interest in impacts to agriculture associated with freshet flooding (and coordinating with related efforts) ▪ Reviewing existing studies for development of a suitable analysis framework ▪ Identifying variables for inclusion in the evaluation such as: - Agricultural assets (crops, infrastructure) - Agricultural soils/productive capacity (immediate and longer term) - Secondary impacts and food security impacts (food storage, processing, supply interruptions) - Steps to mitigate losses and speed recovery ▪ Sharing findings with First Nations, local, provincial and federal partners for inclusion in flood planning and management	Ideas for priority areas include: ▪ Raising producer awareness about flood risks and flooding initiatives/resources through effective means such as industry events, meetings and publications ▪ Providing informational materials addressing key issues such as: - Results of recent flooding-related studies such as Action 3.1a - Current initiatives to support flood planning and management in the region (e.g., Lower Mainland Flood Management Strategy) - Existing tools and resources as well as supports available in the case of flooding

Impact Area 3 > Strategy 3.2

Coordinate sector, commodity & individual producer flood risk responses & planning

A freshet flood would impact all types of agricultural production within the floodplain area. While there are some losses and costs that will be impossible to avoid, for some production systems adaptive actions and proactive planning could help to mitigate the worst potential losses and scenarios. The necessary actions will vary greatly depending on the production system.

Although joint planning may not be of value to all producer groups, livestock producers are likely to require a more intensive collaborative planning process. In advance of a flood, these industries will face the complex challenge of evacuations and/or other critical livestock management decisions. Having a commodity level plan in place will assist the industry as a whole to take steps to minimize or manage losses. Farm-level planning is also needed to encourage and advise producers about their specific areas of vulnerability and strategies that would reduce potential losses (e.g., raising up stored crops or costly equipment). An individual farm planning toolkit and process has been piloted in Delta and could undergo further testing for suitability and value in the Fraser Valley context.[79]

ACTION 3.2A **Develop a mechanism for active/on-going sector participation in flood protection and flood management planning**	ACTION 3.2B **Pilot commodity-level flooding preparedness, mitigation and recovery planning**	ACTION 3.2C **Refine and deliver planning for individual producer flooding preparedness/mitigation and recovery**
▪ Convening key partners to discuss representation and participation of agriculture in local and regional level flood protection and flood management planning process ▪ Determining the most effective (and efficient) means for maintaining consistent sector participation ▪ Ensuring regular communication and updates are provided to agricultural organizations about flood protection and flood management planning	▪ Identifying priority groups for participation in a planning pilot (i.e. groups with greatest vulnerability/risk) ▪ Developing a pilot planning process with commodity/sector groups ▪ Supporting sector organizations with leading flooding preparedness, mitigation and recovery planning for their membership (including evacuation planning when needed)	▪ Adjusting the existing planning tool and process (developed and piloted in Delta) for the Fraser Valley context ▪ Piloting the revised planning tool with Fraser Valley operations (a small but diverse group of farms) ▪ Exploring mechanisms for broad delivery of the planning tool and process

Impact Area 4
Changes to Pests & Pollinators*

**Pests refers to insects, weeds, diseases and invasive species with potential to negatively impact agricultural production*

As average annual temperatures increase, particularly winter temperatures, the range and prevalence of pests, diseases and invasive species is anticipated to shift. These changes may enable existing problem species to increase and new species to move into the region. Extreme weather events also have the potential to introduce new pests from distant areas.[80]

Spotted wing drosophila (SWD) is an example of a new pest that moved into BC (first identified in 2009) and has since become established in a number of parts of southern BC.[81] SWD threatens all berry and fruit crops and in the Fraser Valley is of particular concern to blueberry growers. SWD was particularly damaging in 2013[82] and may become more problematic with the warming conditions associated with climate change. Other emerging pests in the Fraser Valley include: brown marmorated stink bug, swede midge, potato/tomato pysillid, tomato leafminer (*Tuta absoluta*) and European pepper moth (*Duponchelia fovealis*).[83]

Insect pests are only one area of concern with climate change. Shifts are also anticipated with distribution, virulence and frequency of diseases — both in plants and livestock — as well as weeds and invasive plants. To prepare and respond appropriately, producers require up-to-date information about current, new and emerging pests of all kinds. Information and tools to address pest outbreaks are also needed; this includes resources for pest identification as well as suitable management and control.

Currently, many producers access information about pests through their commodity organizations. Some producers hire consulting companies to assist them with monitoring and management. The BC Ministry of Agriculture provides pest alerts and assists with production guides that include information about pest management for specific crops. Various local organizations — including the Fraser Valley Invasive Plant Council[84] and the FVRD noxious weed program[85] — play roles in pest risk assessment, monitoring and management.

Relevant Climate Change Impacts

- → Increasing annual temperatures
- → Increasing growing degree-days/heat units, growing season length
- → Increasing winter/spring precipitation and extreme rain events
- → Drier summer conditions

In addition to affecting the distribution and prevalence of pests, climate change may negatively impact pollinators. Pollinators play a critical role in seed and fruit production, as well as in crop yields and quality. Climate change may reduce already narrow windows for pollination. These impacts will compound current threats to pollinators including loss of habitat, proliferation of disease and, impacts of pollution and pesticides.

For both pest management and pollinator enhancement, collaboration to strengthen the available resources will be necessary as climate change exacerbates existing challenges.

The strategies in this section work toward the *adaptation goals* of:

- → ***Strengthening monitoring and resources to manage changes in insect, disease, weed and invasive plant populations, and***
- → ***Improving baseline knowledge of climate, plant and pollinator interactions.***

Impact Area 4 > Strategy 4.1
Pilot a cooperative pest surveillance program for priority risks

As noted above, pest surveillance activity does occur in the Fraser Valley through individuals, government and sector organizations. However, broader monitoring and surveillance initiatives are almost always short-term projects and tend to be focused on specific crops or pests.

For example, from 2009 to 2011, monitoring for swede midge in cole crops was carried out through a partnership between the Ministry of Agriculture and the Fraser Valley Cole Crop Growers' Association.[86] Berry sector groups such as the BC Blueberry Council have also undertaken numerous initiatives pertaining to pest and disease monitoring and management.

Despite these efforts, there has never been a broader pan-agricultural initiative for pest monitoring across the Fraser Valley region. In addition, there is no centralized mechanism for sharing or compiling pest data that is collected. It will also be increasingly important to cross-reference pest data with weather data, as this will be key to understanding how pest populations are affected by various conditions. This type of coordination is a particularly challenging issue in an area as agriculturally diverse as the Fraser Valley.

A more integrated and cross-sector approach could be mutually beneficial to address common concerns and begin to more effectively track the relationships between pests and climate. Collaboration could facilitate more comprehensive and consistent monitoring and management and would also enable resource sharing to address the most critical threats. The first step would be an assessment to identify and prioritize shared threats and to explore options for compiling data and coordinating to fill monitoring gaps.

ACTION 4.1A **Conduct an assessment of immediate and near-term pest threats to the sector**	ACTION 4.1B **Develop partnerships and mechanisms for coordinated, regional and cross-commodity monitoring**
▪ Consulting with sector groups and government agencies involved in monitoring to gather key information such as: - Existing pest alert and risk assessment information and how it is filtered/shared - Current areas of priority, existing resources and gaps in surveillance or knowledge ▪ Identifying new and emerging (pest-related) threats for agriculture in the Fraser Valley ▪ Bringing together agricultural groups (commodities) to review assessment findings and prioritize shared threats	▪ Identifying sector, government and community partners (for coordinated regional approach) ▪ Identifying mechanisms for centralizing pest data and cross-referencing with weather data ▪ Coordinating across partners to address any identified gaps ▪ Providing regular monitoring updates to producers and other interested stakeholders

Increase research and information transfer regarding pest lifecycles, identification and management

Identifying shared priorities and increasing cooperative monitoring are important first steps for effective tracking of emerging pests, diseases and invasive species. However, producers also require the tools and resources for management and control of pests to maintain crop and livestock health and productivity.

Climate change is likely to increase the need for rapid responses and new management strategies. Local research can provide producers with locally relevant information and assist in identifying suitable and effective controls. In some cases, management approaches utilized in other jurisdictions may be transferable since pests new to the Fraser Valley will already be established and managed elsewhere.

In some cases, research has been completed and information already exists but knowledge transfer is a gap. Ensuring that existing information is supplied in accessible formats will begin to shrink this gap. Informational materials could be shared via website, smart phone applications and through producer events and meetings. As with Action 4.1, cross-commodity approaches could increase the value of investment in research and informational materials — ultimately more effectively reducing the spread of pests and invasive species.

ACTION 4.2A **Support local basic pest (and climate change) research**	ACTION 4.2B **Provide effective informational materials for producers for pest identification, management and control options (particularly for emerging pests)**
▪ Bringing local industry, research and government partners together to review prioritized pests for the Fraser Valley (as per Action 4.1a) ▪ Identifying significant gaps in knowledge regarding priority pests (biology, management and control) ▪ Developing a (human resources and funding) strategy for undertaking the necessary research to address gaps	▪ Developing accessible resources for quick pest identification (e.g., pest-specific ID "keys", phone apps etc.) ▪ Developing a mechanism to confirm sightings of regulated pests with government agencies ▪ Increasing the availability of producer-oriented informational resources regarding pest lifecycles, biology, management and control options including: - Summary documents - Apps and web-based materials - Workshops and educational events

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ACTION 4.2C **Educate the public on pest detection, invasive plant management and pest host species**	ACTION 4.2D **Support local governments to improve weed and invasive species management on public lands (including ditch maintenance)**
▪ Identifying and building partnerships with groups already working to educate the public about these issues (e.g., local and regional governments, community groups, gardening groups) ▪ Supporting and supplementing existing outreach/ communication efforts with materials focused on agricultural pests ▪ Developing a collaborative strategy for creating and distributing informational resources for the public including: - Key target audiences (local homeowners, gardening groups etc.) - Agricultural pests of common concern (and likely to be present in urban/residential areas) - Effective approaches for reaching key audiences - Approaches to share Canadian Food Inspection Agency alerts more broadly	▪ Bringing agricultural groups and local governments together to identify priority areas for improved management (e.g., public lands adjacent to farm operations) ▪ Developing a calendar with local partners for coordination of weed and ditch maintenance ▪ Piloting innovative low-cost mechanisms for removal of weeds/invasive species (e.g., community "broom pulls")

Impact Area 4 > Strategy 4.3

Evaluate the impacts of weather conditions and management practices on pollinators and pollinator/crop interactions

Due to a variety of factors, there are on-going challenges with maintaining healthy pollinator populations. This is a serious concern for producers with crops that require pollination. At present, many producers (in particular for berry crops) rent hives from bee keepers on an annual basis to support pollination during critical windows.[87] How climate change will affect pollinators (both native and non-native) is not well understood. However, warming temperatures and more extreme conditions (precipitation and heat) will influence the "cues" for both plants and pollinators and may alter critical windows for interaction.[88]

The relationships between pollinators (their temperature and weather sensitivities) and local cropping systems are highly complex and require local observation and data collection. However, a basic risk assessment to explore vulnerability to climate-driven effects on pollination could be a valuable first step.[89] Ultimately, a much clearer understanding of the linkages between climate change, local cropping systems and pollinators — as well as management regimes and pollinator health — is required for suitable adaptive actions to be taken.

There are a number of local partners and groups in the Fraser Valley with an interest in pollinator health including: bee-keeping associations and clubs, gardening groups and environmental groups. These groups might have an interest in supporting both a high-level initial risk assessment and broader data collection and knowledge transfer as knowledge about pollinators and climate change grows.

ACTION 4.3A **Undertake a vulnerability assessment of climate change impacts on pollinators**	ACTION 4.3B **Evaluate the interactions between weather, cropping systems and pollinators**
▪ Determining a feasible and cost-effective approach to undertake an initial pollinator vulnerability assessment in the Fraser Valley (e.g., Food and Agriculture Organization of the United Nations assessment tool) ▪ Undertaking a regional vulnerability assessment with local cropping systems/pollinators ▪ Sharing the results of the assessment with interested partners to determine next steps (e.g., Action 4.3b)	▪ Identifying potential partners and producer cooperators to undertake data collection across a range of cropping systems including: - Potential linkages to specific pollination dependent crops - Potential to combine pollinator and pest monitoring data collection - Potential to work with local partners with an interest in pollinators ▪ Developing a multi-year pilot project for collection of data around weather/pollinator/plant interactions

Impact Area 5
Greater Frequency & Intensity of Extreme Heat Events

Climate change is anticipated to increase both the intensity and frequency of periods of extreme heat (see Regional Climate Science section for details). Very warm to extremely hot temperatures already occur during Fraser Valley summers, and in recent years, producers have experienced associated production challenges. A number of single day high temperature records have been broken across the Fraser Valley in the last ten years.[90,91]

> ### *Relevant Climate Change Impacts*
>
> → Increasing average annual temperatures
>
> → Decreasing precipitation in summer resulting in drier conditions
>
> → Increasing number of ***summer warm days*** and ***extremely hot days***

High temperatures early in the season can affect germination and establishment rates for some vegetables and sudden increases in temperature can cause damage to berry crops. Higher temperatures also increase evapotranspiration rates and lead to greater irrigation demand. Heat also influences windows for management of time-sensitive inputs. While some pests thrive in dry heat, spraying for pest control is not advisable when air temperature is above 25°C (largely due to evaporation rates and drift).[92]

High summer temperatures cause crops to mature earlier and more quickly, resulting in pressure to harvest quickly to prevent damage to product quality. High temperatures during harvest also make it more difficult to cool produce to an optimal temperature to prevent spoilage. This is of particular concern for export crops with strict quality control requirements (e.g., blueberries).

Extreme heat events can also cause significant stress for livestock and poultry. High temperatures may adversely affect milk production, meat quality and animal reproduction.[93] Recent research shows that cows prefer cooler temperatures and can exhibit signs of heat stress when temperatures are as low as 22 degrees Celsius (if humidity is high).[94] Heat stress in broiler chickens can reduce growth, decrease feed intake, decrease egg production and — in extreme cases — cause animal mortality.[95]

Farm worker health and comfort is also a concern as more intensive farm work may be required during more extended periods of high temperatures. The unpredictability of extreme heat also exacerbates underlying labour supply issues, by creating unanticipated spikes in labour demand during critical production windows. As noted above, not having access to sufficient labour when needed can result in crop losses or reduction in quality.

Given the diversity of production systems in the Fraser Valley, a better understanding of the vulnerabilities of different systems to extreme heat, as well as the timing and nature of the these vulnerabilities, is an important first step in building resilience to extreme heat events.

The strategies in this section work toward the ***adaptation goal*** of:

→ ***Reduce the vulnerability of agricultural operations to losses and costs associated with extreme heat***

Impact Area 5 > Strategy 5.1

Identify suitable approaches for minimizing impacts of extreme heat to product quality/ health

Fraser Valley producers are familiar with adjusting to variable conditions; however, more frequent and prolonged extreme heat events will create new challenges. Changing conditions may necessitate adoption of new management practices and technologies. Some Fraser Valley producers have already adopted technologies to mitigate the effects of extreme heat, such as installation of tunnel venting and misters or sprinklers for cooling in dairy barns. Where local adaptation is already underway in the Fraser Valley, it can be built upon through demonstration and/or evaluation of cost-benefit of adoption.

In addition to local solutions, there are many nearby jurisdictions — within BC, Canada and the United States — with potentially transferable technologies and practices for adaptation to more extreme heat events. Some existing tools may not only be transferable but may also provide improved means for sharing knowledge and information. For example, in Ontario a heat stress phone app has been developed that enables livestock and poultry producers to calculate the heat stress index on their smart phones by inputting temperatures and humidity, and the tool then provides management options.[96]

Prior to investing in knowledge transfer, it is important to determine the local value of resources, technologies and practices through consultation, demonstration and/or evaluation within the Fraser Valley context to ensure local suitability.

ACTION 5.1A **Identify suitable approaches for minimizing impacts of extreme heat to product quality/health**	ACTION 5.1B **Develop commodity-specific informational materials to support adoption of new technologies and practices**
▪ Identifying and prioritizing vulnerabilities to extreme heat impacts (across sector) ▪ Conducting a scan of relevant technologies and practices such as: - Crop selection (new varieties and new crops) - Optimal timing of harvest under extreme heat and new technologies for harvest (commodity specific) - Livestock management and cooling systems - Storage and transportation options for export and domestic crops ▪ Assessing technologies and practices for applicability (including economics) to the Fraser Valley context including trials/pilots as needed	▪ Summarizing the most suitable extreme heat adaptation options (Action 5.1a) outreach materials including: - Printed materials/newsletters - Forums/workshops/speakers - Success stories from other producers (case studies and possible site visits) - Online support, including 'how to' videos, apps etc. ▪ Encouraging on-going monitoring and evaluation of any technologies and practices adopted ▪ Facilitating knowledge transfer from any trials/pilots undertaken by producers

Impact Area 5 > Strategy 5.2
Evaluate opportunities for addressing labour supply during periods of peak demand

As noted above, an overall increase in variability and extremes has the potential to alter and/or compress operational windows for critical production activities (such as planting and harvesting). This will create more challenges with farm labour management — including sudden spikes in labour demand or unpredictable timing for labour needs (e.g., an early or delayed harvest) which can translate into lost profits if labour supply is inadequate.

Sudden changes in temperature during the production season, in particular periods of extreme heat, can result in the need to harvest very rapidly. A sudden heat wave in the summer of 2014 caused some Fraser Valley berry, pea and bean growers to lose up to 50% of their crops when they couldn't access sufficient labour to harvest produce that had matured rapidly due to the high heat.[97] The specific timing of these increases in labour demand will depend on the production system and typical points of greater demand, and how this timing may be influenced by both the variability and the extremes anticipated with climate change.

A number of farms in the Fraser Valley rely on the Seasonal Agricultural Workers Program for labour.[98] However, this program has limited flexibility to accommodate unexpected shifts in labour requirements. Technological solutions (to replace labour) may be more suitable for some production systems as they lessen reliance on labour altogether, but research is needed to identify and evaluate technologies and their relevance and cost-effectiveness in the Fraser Valley context.

ACTION 5.2A **Assess potential effects of climate change on agricultural labour demand in the Fraser Valley**	ACTION 5.2B **Evaluate and pilot options for addressing unanticipated seasonal shifts in labour demand**
▪ Undertaking a study to assess how climate change (and extreme conditions) may impact labour demand and management including: - Current labour needs and timing for key operational activities (e.g., pruning, harvesting etc.) - How operational windows and labour needs may shift due to extreme heat and other extreme conditions (e.g., harvesting in compressed timeframes) - Evaluating potential impacts of labour supply challenges associated with extreme conditions (e.g., impacts to costs, product quality etc.)	▪ Identifying and evaluating options for ensuring adequate labour during periods of high demand including: - Cross sector labour sharing - Partnering with local agencies potential to assist with short-term labour supply ▪ Identifying and evaluating technological or management solutions which lessen reliance on farm labour ▪ Convening key organizations/agencies to share findings and identify priorities ▪ Supporting piloting of solutions over multiple production seasons

Implementation & Monitoring

While all of the actions contained in this plan are important for the Fraser Valley agriculture sector to adapt to climate change, the actions on the following pages are identified as "next steps." This is not only due to their importance, but also because they are either relatively easy to implement and/or they will build capacity for further adaptation actions (see text box on this page). Building momentum and capacity for collective action, and addressing the most important issues, will help to ensure implementation of all of the identified actions.

As the final stage in plan development, an implementation meeting was held with key partners (25 individuals) to prioritize actions and determine how to move forward with them. The input received at this meeting informs the content below.

In some cases, individual actions have been merged into single projects because this is the most effective and efficient way to accomplish them. Implementation considerations, such as potential partners and cost range, are identified for each of the next steps.

In order to move forward with project implementation, members of the Advisory Committee that supported the development of this plan will transition into a local working group to oversee implementation and monitor progress. This group will continue to include agricultural organizations, local government and provincial government representatives. The Climate Action Initiative will function as the overall coordinator for this group and will also lead project development and assist with monitoring progress and reporting.

For each Action in the Next Steps below, potential partners are identified. Potential partners were identified through workshops and subsequent draft development, but no formal commitments have been made regarding roles in various strategies and actions. Development of partnerships will be a preliminary activity in project development.

- ***Important*** actions are those that address the highest priority impacts or critical gaps for building resilience.

- ***Ease of implementation*** refers to actions that can be initiated without delay because there is a window of opportunity, there are clear co-benefits with other actors or programs, or there are minimal barriers to address. These actions can also create momentum to help to move more difficult or longer term actions forward.

- ***Capacity building*** actions support the sector by strengthening the ability of producers and producer organizations to take effective action. This may include filling knowledge gaps or developing resources that strengthen the ability to act collectively or individually.

Next Steps for ACTION 1.1A

Actions

- Bring producers and key partners together for informational exchange regarding the Water Sustainability Act

Implementation details

- Explore potential for partnership with Ministry of Environment and Ministry of Agriculture (as there is intention to do outreach on the new Act)
- Include most recent information about water supply and demand in the FVRD
- Consult with agricultural organizations to determine the critical areas of focus, informational gaps and concerns
- Agricultural groups from other parts of BC might also wish to attend/participate

Potential partners

- → Agricultural organizations
- → Ministry of Environment
- → Ministry of Agriculture
- → Fraser Valley Regional District
- → Municipal governments (Abbotsford, Chilliwack, District of Kent)

Timeframe

- Short-term (less than 2 years)

Cost

- Low (less than $50,000)

Next Steps for ACTION 1.2A

Actions

- Promote the use of (BC specific) water management tools and resources

Implementation details

- Identify current barriers to uptake as an important initial step
- Link with other groups who may have an interest in participating or leading in promoting existing tools (e.g., irrigation association)
- Share resources through existing industry education and outreach. This would be relatively simple and low cost (producer meetings, field days, newsletters, workshops, Pacific Agriculture Show)

Potential partners

- → Agricultural organizations
- → Ministry of Agriculture
- → Irrigation Industry Association of BC
- → Partnership for Water Sustainability
- → Fraser Valley Regional District
- → Municipal governments

Timeframe

- Short-term (less than 2 years)

Cost

- Low (less than $50,000)

Next Steps for ACTION 1.2C

Actions

- Demonstrate/evaluate potential of agricultural water management innovations not commonly used in the Fraser Valley

Implementation details

- Identify technologies/practices within the Fraser Valley or from elsewhere that could be evaluated and shared more broadly through an initial screening process
- Identify opportunities to link with existing research and research capacity (industry, government and post-secondary institutions) for pilots/ demonstrations
- Innovations likely require multi-year testing and evaluation

Potential partners

- → Agricultural organizations
- → Post secondary institutions
- → Pacific Agri-Food Research Centre (Agriculture & Agri-Food Canada)
- → Irrigation Industry Association of BC
- → Ministry of Agriculture
- → Fraser Valley Regional District
- → Municipal governments

Timeframe

- First pilot – Medium-term (2–4 years)
- Multiple pilots – Long-term (4+ years)

Cost

- First pilot / knowledge transfer – Medium ($50,000–$100,000)
- Multiple pilots – High ($100,000+)

Next Steps for ACTIONS 2.1A & 2.1B

Action

- Assess the current state of agricultural ditches and drainage across the FVRD
- Develop options to improve coordination of ditch and drainage management

Implementation details

- Existing efforts and bodies (local government operational and agricultural committees) are logical partners/places to start
- Mechanisms need to be included to evaluate and address the situation in electoral areas (may need more immediate attention)

Potential partners

- → Agricultural organizations
- → Ministry of Agriculture
- → Ministry of Environment
- → Municipal governments, Agricultural Advisory Committees
- → Fraser Valley Regional District
- → Fisheries and Oceans Canada

Timeframe

- Phase 1: Assessment – Short-term (less than 2 years)
- Phase 2: Collaborative solutions – Medium-term (2–4 years)

Cost

- Phase 1: Assessment – Low (less than $50,000)
- Phase 2: Collaborative solutions – Low to Medium (Less than $50,000) to ($50,000–$100,000)

Next Steps for ACTION 3.1A

Action

- Evaluate the potential impacts and costs to agriculture associated with freshet flooding

Implementation details

- A similar study was commissioned for Delta/Surrey/Richmond and can provide a framework for analysis
- This study should be freshet focused (rather than runoff/precipitation flood risk which is also an issue in the Fraser Valley)
- This study should incorporate and make use of existing resources:
  - Abbotsford flooding model scenarios
  - Lower Mainland Flood Management Strategy output/outcomes
  - Agricultural Land Use Inventory (as per Fraser delta study)

Potential partners

→ Municipal governments
→ Fraser Valley Regional District
→ Fraser Basin Council
→ Ministry of Agriculture
→ Real Estate Foundation of BC

Timeframe

- Short-term (less than 2 years)

Cost

- Medium ($50,000–$100,000)

Steps for ACTIONS 3.2B & 3.2C

Action

- Pilot commodity-level flooding preparedness, mitigation and recovery planning
- Refine and deliver planning for individual producer flooding preparedness/mitigation and recovery

Implementation details

- Start by evaluating risk/vulnerability and confirming commodities for pilot focus
- Dairy evacuation and preparedness has been identified as a major concern including availability of feed during a flood
- An individual flood preparedness/mitigation tool can be modelled on Delta flood preparedness tool, adjusted to the Fraser Valley context

Potential partners

→ Agricultural organizations (commodity groups)
→ Individual producers
→ Municipal governments
→ Fraser Valley Regional District
→ Ministry of Agriculture

Timeframe

- Commodity-level pilot – Short-term (less than 2 years)
- Individual Flood Preparedness Tool – Short-term (less than 2 years)

Cost

- Commodity-level pilot – Medium ($50,000–$100,000)
- Individual Flood Preparedness Tool – Medium ($50,000–$100,000)

Next Steps for ACTIONS 4.1A & 4.1B

Action

- Conduct an assessment of immediate and near-term pest threats to the industry
- Partner with other interested agencies to develop mechanisms for coordinated, regional and cross-commodity monitoring

Implementation details

- Begin by bringing groups together to identify priority management issues and common issues (define focus, gaps, collaborative opportunities)
- Ensure that climate projections are included in risk assessments
- Pilot a process with a few groups interested in working together (e.g., pilot between potatoes, berries and nursery operations)

Potential partners

→ Agricultural organizations
→ Ministry of Agriculture
→ Agriculture and Agri-Food Canada
→ Canadian Food Inspection Agency
→ Pest monitoring/IPM specialists
→ Invasive Species Council of BC
→ Fraser Valley Invasive Plant Council

Timeframe

- Assessment – Short-term (less than 2 years)
- Pilot – Medium-term (2–4 years)

Cost

- Assessment – Low (less than $50,000)
- Pilot – Medium ($50,000–$100,000)

Next Steps for ACTION 4.2B

Action

- Provide effective informational materials for producers for pest ID, management and control options (particularly for emerging pests)

Implementation details

- Use research from Action 4.1A to identify priority pests, although some additional research on current pests may be required
- Identify innovative ways to reach producers – apps and web-based tools have been suggested as producers' top choice for dissemination of information
- Materials need to be action-based (e.g., *if you see this pest, call this #*)

Potential partners

→ Ministry of Agriculture
→ Agricultural organizations
→ AAFC (Agriculture and Agri-Food Canada)
→ Pest monitoring/IPM companies
→ Invasive Species Council of BC
→ Fraser Valley Invasive Plant Council
→ FVRD Noxious Weed Program
→ Post-secondary institutions

Timeframe

- Short-term to Medium-term (less than 2 years to 2–4 years), dependent on types of outreach material developed

Cost

- Medium to High ($50,000–$100,000+), dependent on types of outreach material developed

Next Steps for
ACTIONS 5.1A & 5.1B

Action

- Research and evaluate technologies and practices for reducing extreme heat impacts
- Develop commodity-specific informational materials to support adoption of new technologies and practices

Implementation details

- Begin by identifying commodities at greatest risk of negative impacts and identification of suitable technologies/practices
- Develop case studies and pilots to demonstrate and evaluate technologies and practices (including cost-benefit analysis) directed at highest risk commodities identified above
- Bring post-secondary institutions into the process to assist with pilots and evaluations

Potential partners

- → Agricultural organizations
- → Ministry of Agriculture
- → Post-secondary institutions
- → Producers

Timeframe

- Phase 1: Assessment – Medium-term (2–4 years)
- Phase 2: Pilot & Information Transfer – Medium-term to Long-term (2–4 years to 4+ years)

Cost

- Phase 1: Assessment – Low (less than $50,000)
- Phase 2: Pilot & Information Transfer – High ($100,000+)

Appendix A
Weather, Climate & Variability

Weather is what happens on a particular day at a particular location. Farmers are continually required to adapt to weather conditions to effectively plan and manage their businesses. In contrast, climate refers to long-term trends, patterns and averages over time. These are more difficult to notice through day-to-day or year-to-year experiences, or short-term records of weather. However, over a period of decades, recorded observations can characterize the climate and identify trends.

Anyone who pays close attention to weather forecasts appreciates that predictions of weather are often limited in their accuracy. This is partly because of the many factors that impact weather. Turning to longer, climate-related timescales, in BC we are familiar with the 3–7 year cycles of El Niño and La Niña ("ENSO"), which dramatically impact the climate of individual seasons and years (see Figure 5). Compared to La Niña years, conditions in BC during El Niño years are typically warmer and drier in winter and spring, and less stormy in southern BC.

Adding to the complexity, the Pacific Decadal Oscillation (PDO) is a known pattern that shifts over longer time periods (20–30 years) and this is associated with different temperature and precipitation conditions here in BC. It also has a warm and cool phase, and so it can either enhance or dampen the impacts of El Niño and La Niña conditions in a given year.

Figure 5 shows the difference between climate variability, oscillations, and climate change. The many factors that impact the weather create significant variation in what we experience from year to year. However, we are still able to chart averages over long periods of time.

For additional resources see *BC Agriculture Climate Change Adaptation Risk & Opportunity Assessment Series* (*www.bcagclimateaction.ca/regional/overview/risks-opportunities/*).

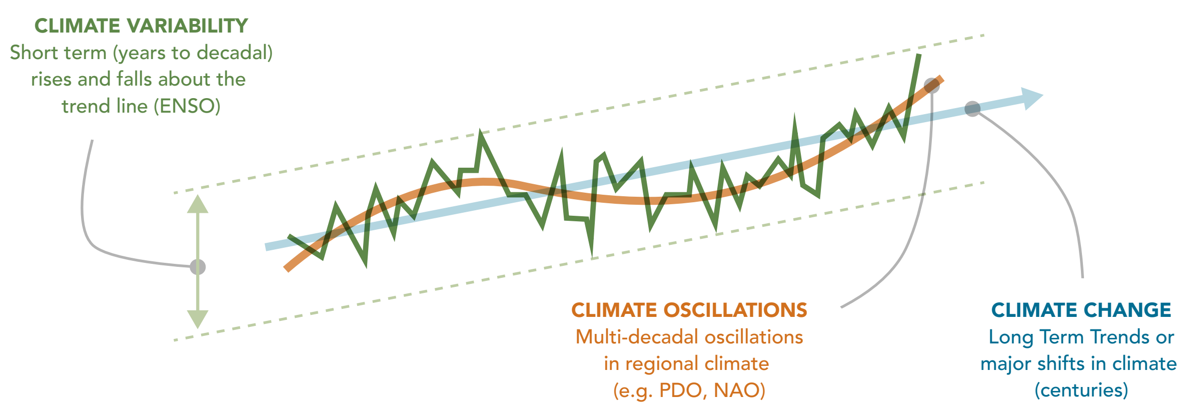


Figure 5 Climate Variability, Oscillations & Change

Diagram showing difference between climate variability, oscillations, and climate change. Adapted from original, courtesy of Pacific Climate Impacts Consortium, www.pacificclimate.org

Appendix B
Future Projections: Climate Maps & PCIC Tables

TABLE 2 Fraser Valley Regional District Climate Projections — 2020s

Climate Variable	Time of Year	Projected Change from 1961–1990 Baseline to 2020s		
		Fraser Valley (Range)	Fraser Valley (Median)	BC (Average)
Mean Temperature (°C)	Annual	+0.5 °C to +1.4 °C	+1.0 °C	+1.0 °C
Precipitation (%)	Annual	–1% to +8%	+4%	+4%
	Summer	–15% to +10%	-7%	0%
	Winter	–3% to +9%	+3%	+4%
Snowfall (%)	Winter	–29% to –3%	-12%	–2%
	Spring	–61% to –2%	–32%	–30%
Growing Degree Days (degree days)	Annual	+83 to +267	+184	+153
Heating Degree Days (degree days)	Annual	–514 to –186	–352	–354
Frost-Free Days (days)	Annual	+8 to +23	+15	+10

TABLE 3 Fraser Valley Regional District Climate Projections — 2050s

Climate Variable	Time of Year	Projected Change from 1961–1990 Baseline to 2050s		
		Fraser Valley (Range)	Fraser Valley (Median)	BC (Average)
Mean Temperature (°C)	Annual	+1.1 °C to +2.6 °C	+1.8 °C	+1.8 °C
Precipitation (%)	Annual	–2% to +11%	+7%	+6%
	Summer	–25% to +5%	-13%	–1%
	Winter	–4% to +15%	+6%	+8%
Snowfall (%)	Winter	–40% to –11%	–24%	–10%
	Spring	–74% to –15%	–55%	–58%
Growing Degree Days (degree days)	Annual	+208 to +529	+353	+283
Heating Degree Days (degree days)	Annual	–925 to –383	–648	–648
Frost-Free Days (days)	Annual	+15 to +39	+26	+20

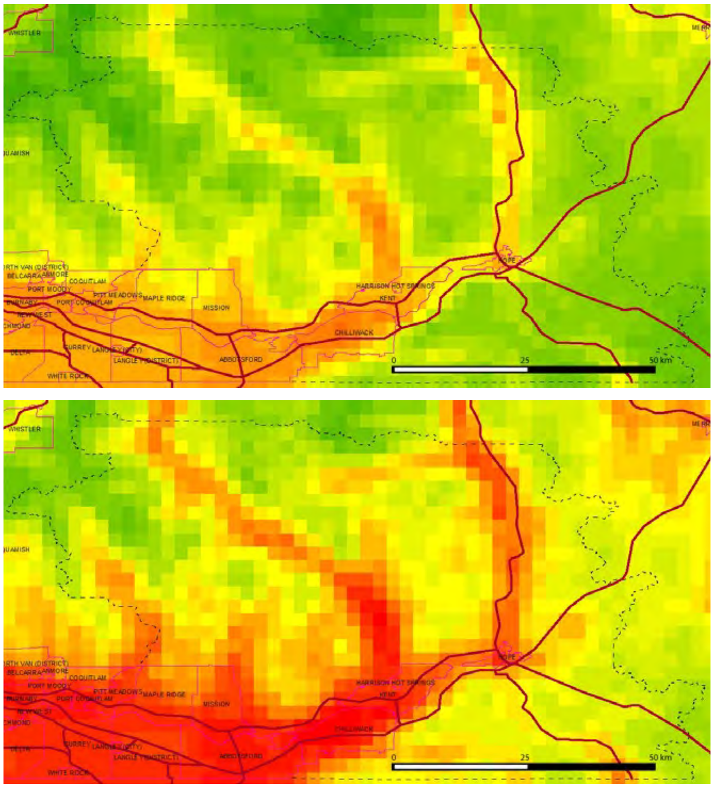
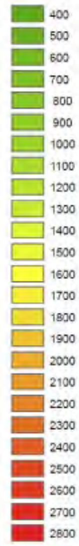


FIGURE 6 Growing Degree-Days, Baseline (top) and 2050s Projection (bottom)



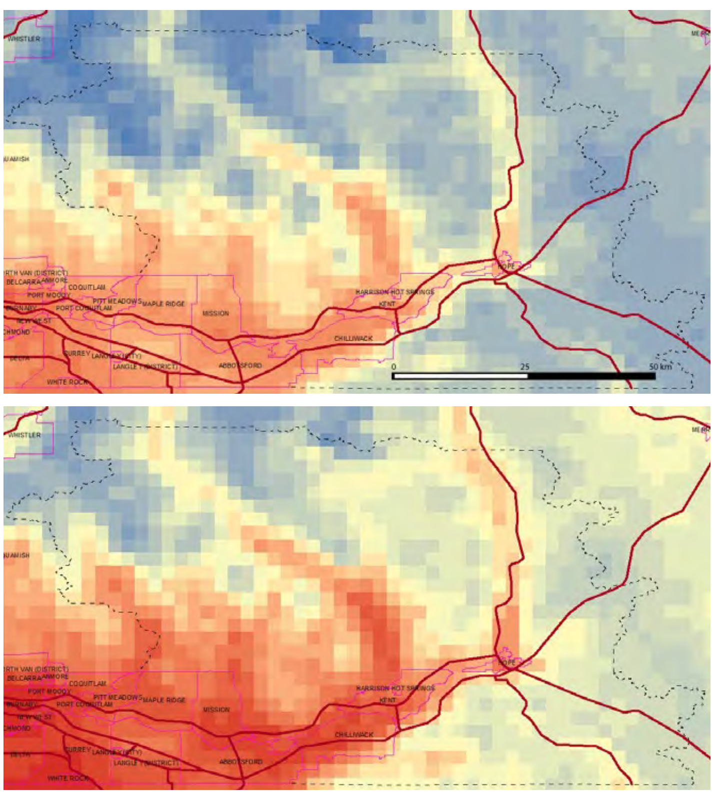


FIGURE 7 Frost-Free Period, Baseline (top) and 2050s Projection (bottom)

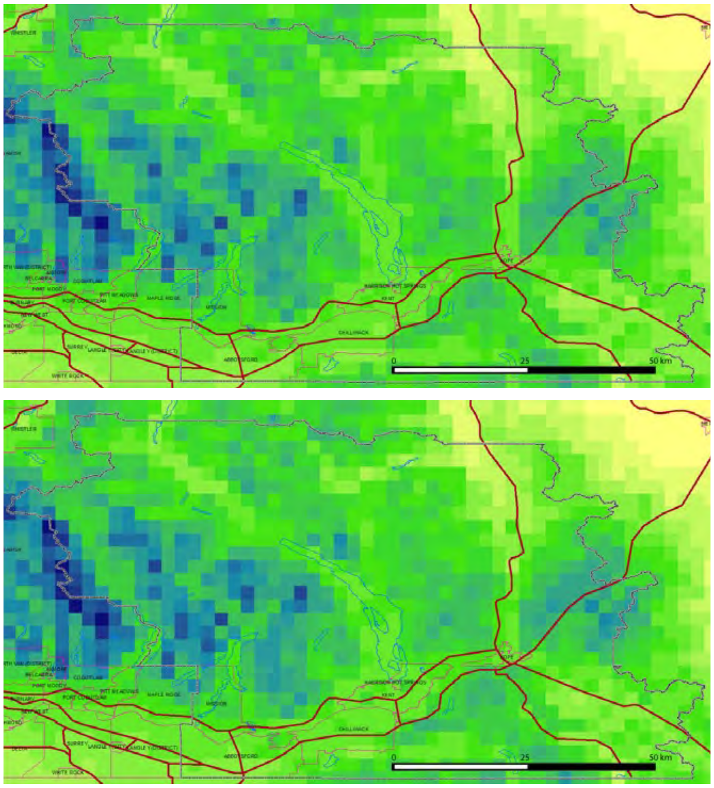
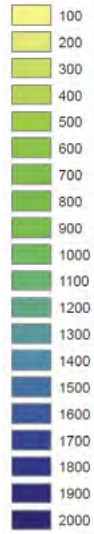


FIGURE 8 Winter Precipitation (mm), Baseline (top) and 2050s Projection (bottom)



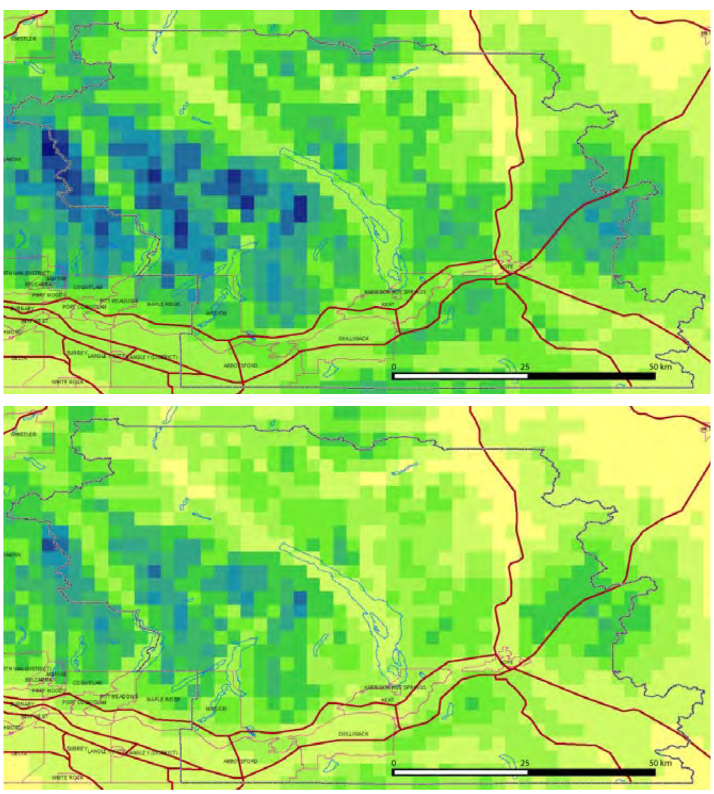
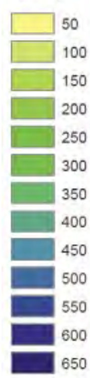


FIGURE 9 Summer Precipitation (mm), Baseline (top) and 2050s Projection (bottom)



Note that for legibility, winter and summer use different legends and so cannot be directly compared.

Appendix C
Definitions

- ***Growing Degree-Days (GDD)***
  are a measure of heat accumulation, and represent the cumulative number of degrees that the average daily temperature is above a base temperature of 5 degrees, for all days of the year.

- ***Frost Free Days (FFD)***
  are the number of days the temperature is above freezing.

- ***Frost Free Period (FFP)***
  is the consecutive number of days between first frost in fall and last frost in spring.

- ***Heating Degree-Days***
  are a measure of energy demand, and represent the cumulative number of degrees that the average daily temperature is below a base temperature of 18 degrees (when heating is required), for all days of the year.

- ***Cooling Degree-Days***
  represent the cumulative number of degrees above a base temperature of 18 degrees (when cooling is required), and is the opposite of Heating Degree-Days.

Appendix D
Adaptive Management of Climate Change Impacts

Climate change adaptation decision-making is an inherently complex task that requires ongoing learning and reflection to adjust to changing information, events and conditions. As learning progresses, new solutions as well as new challenges will be identified. The following questions are provided as tools for navigating this evolving landscape and determining priorities for action.

Additional considerations when determining how to implement priority actions would include:

- → Barriers (e.g., legislation, lack of working relationships)
- → Assets/Enablers (e.g., leadership, integrating into existing plans/programs)
- → Implementation costs
- → Operation and maintenance costs
- → Financing and resources
- → Timeframe

TABLE 4 Developing & Prioritizing Adaptation Actions

Effectiveness	To what degree does this action reduce risk/vulnerability, and/or enhance resilience?
Adaptability	Can this action (and resources dedicated to it) be changed or redirected as conditions change?
Urgency	When does action need to be taken on this issue, in order to be effective by the time an impact is projected to occur?
Gaps & Assets	How does this action address identified gaps or barriers? How can it build on existing assets and resources?
Co-benefits ("no-regrets")	What other benefits would this action have, even if climate change impacts do not occur as projected?
Consequences	What could be the unintended and/or undesirable effects of taking this action? Can these be avoided or mitigated?
Extent	Do the benefits apply broadly in the region, or to specific individuals?
Relevance	Does this action have the support of the agricultural community?

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Urls in these Endnotes were current as of March 2015.