Climate Change Impact Risk Assessment Tool for Ponds Used as Livestock Water Sources

Final Report
ACKNOWLEDGEMENTS

Funding for this project has been provided in part by the Governments of Canada and British Columbia through the Investment Agriculture Foundation of BC under Growing Forward 2, a federal-provincial-territorial initiative. The project was delivered by the BC Agriculture & Food Climate Action Initiative.

The Governments of Canada and of British Columbia are committed to working with industry partners. Opinions expressed in this document are not necessarily those of the Governments of Canada and of British Columbia or the Investment Agriculture Foundation of BC.
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EXECUTIVE SUMMARY

Over the last century a large percentage of ponds and wetlands have been lost worldwide (Williams, 1999). Recently, in British Columbia (BC), a decline in the number and surface area of grassland ponds has been documented (Coelho, 2015). The 2015 study indicates that BC has lost over 50% of total ponds and pond surface area in the southern interior grasslands in the time period from 1990 to 2012 (Coelho, 2015). This is of particular concern to the ranching industry as grassland ponds are relied upon as a source of drinking water for cattle during grazing. Without a source of drinking water, cattle are not able to access the forage resources provided by the grasslands. Water development strategies such as dugouts, groundwater wells and spring development are often reactionary as natural water sources become unavailable. In order to assist the ranching industry and resource managers with proactive adaptation to changes in water availability, a prototype tool has been developed to forecast the risk of water loss for individual ponds. The tool is applicable to BC’s southern interior rangelands (Figure 1). The intent of the pond risk assessment tool is to provide the ranching industry and resource managers with information on ponds so they can target high risk areas for proactive water development. The tool can be used in the development of water source planning strategies in response to projected future trends in pond water supply.

In order to provide a risk assessment for individual ponds, two important factors of pond hydrology were incorporated into the tool, climate and groundwater – surface water (GW – SW) interactions. Two models were developed to address these factors.

1. Climate model – The climate model was developed through the correlation of historical climate data with historical pond surface area observations. The prototype model uses actual and projected climate data for the years from 1990 to 2020 in order to forecast the climate-related risk to pond decline.

2. Pond assessment model – The pond assessment model was developed using a survey that gathers information related to a pond’s history and physical aspects. This information is used to estimate the GW - SW interactions of the pond which are related to a pond’s sensitivity to changes in climate. The prototype model uses the answers to the survey questions to generate a risk assessment result for an individual pond.

Taken together, the two models provide an indication of climate trends in a selected area of interest and the sensitivity of individual ponds to the changes in climate.

In order to provide access to the pond risk assessment tool, the models were incorporated into prototype interactive online websites. There are separate websites for each model. The climate model is incorporated into a grid that is overlaid onto google earth imagery of BC’s southern interior. The website functions similar to google earth where the user can zoom to their area of interest and by clicking on the
nearest grid cell they are provided with the climate-related risk assessment for 2020. The pond assessment model is incorporated into an online survey in which the user answers a series of questions and are provided with the indication of the GW – SW interactions of the pond and an associated climate sensitivity risk assessment. See the links below to view the prototype online tool.

Interactive Climate Map Link:
https://urbansystems-maps.lightship.works/#/map/gqOHc69RhqlXsd5Z89-Ng

Pond Assessment Survey Link:
https://surveys.qualtrics.com/jfe/form/SV_cDdKwjUYyv67e7mL

As this project involved exploratory statistics and preliminary model development, the deliverable is considered a prototype. Throughout the process of developing the models, various limitations were encountered. The limitations are mainly statistical and can be overcome through the acquisition of more data. Other limitations include web page development and hosting.

Future work is needed to develop a full production tool for public use. For the climate model the following future work is recommended:

- Expand the pond surface area data set.
  - Gain access to historical aerial imagery for multiple time periods. If available, coverage of the entire study area would be ideal.
  - Develop an automated georeferencing model to geolocate the historical aerial imagery.
  - Conduct a supervised rule-based image classification procedure to delineate pond surface area for all ponds within aerial photo coverage.

- Develop a more robust model.
  - Conduct an automated model selection analysis using the pond surface area data and ClimateBC generated climate data. This would be a purely mathematical approach using strict statistical criteria.
  - The results of the automated model selection would inform climate variable selection for subsequent modelling based on mechanisms of pond hydrology. From this, multiple candidate models will be tested for predictive strength and significance.
  - The model developed using this above approach will be incorporated into the online climate map.

- Extend yearly pond risk forecasting to the year 2100.
  - Download projected climate data to the year 2100 for each grid cell in the study area.
- Apply the model to the yearly climate data to project the risk for each year from the present to the year 2100.

For the pond assessment model the following future work is recommended:

- Expand the pond GW – SW interaction data set.
  - Source information on pond data from government agencies and the ranching industry.
  - Conduct field research on ponds from multiple sites within the study area to determine GW – SW interactions. This would require an intensive study involving travel, installation of groundwater monitoring wells, observations of plant communities and reviewing aerial photos.

- Develop a more robust model.
  - Complete an analysis of the additional data to determine the strongest predictors of GW – SW interactions. Complete an automated model selection analysis to determine the strongest combination of predictors. Adjust the survey questions and answers based on the results of the statistical analysis.
  - Use additional data to validate and test the model.

- Facilitate a focus group consisting of ranchers and industry professionals to test the pond assessment tool.
  - Use feedback from the focus group to refine the survey questions and answers.

For the online tool the following future work is recommended:

- Develop a custom map interface to allow the incorporation of both the climate model and pond assessment model into a single website.

- Develop additional features.
  - Locational searching function for ease of navigation.
  - Individual pond selection to access pond assessment survey.
  - Timeline slider and animation to demonstrate the evolving risks.
  - Embedding links to resources related to water development strategies.

- Create printable report generating function to combine climate risk assessment and pond assessment results. This will include an aerial photo image of the pond, a figure showing change in climate risk over time and other information including coordinates of the pond.

- Develop a function for logging and spatial referencing results. The addition of this functionality could allow for the construction of a database of pond specific concerns across BC’s rangelands.
• Secure a permanent host server for the climate data, pond data and online tool interface.

Two engagement sessions with the ranching community were carried out during the project. The engagement sessions resulted in feedback from of the ranching community regarding the functionality and output of the prototype online tool. The feedback from the ranching community was incorporated into the final prototypes.

In addition, a press release was sent to various media agencies with the intent of informing the broader public about the project. This resulted in multiple news articles, a live radio appearance and ongoing communication with various interested groups including the Nicola Watershed Community Round Table (NWCRT) and Okanagan Basin Water Board (OBWB). Continued communication and engagement with the ranching community and other stakeholders will be essential for future development of the full production tool.

Once the future work is complete, the intent is for the full production tool to be available for public use. The aim is for the tool to assist the ranching community and industry professionals with proactive adaptation to changes in water availability. The tool will provide the ranching industry and resource managers with information on ponds so they can target high risk areas for proactive water development. The pond risk assessment tool can be used in the development of water source planning strategies in response to projected future trends in pond water supply. Used as a planning tool, it can assist with rangeland water management and adaptation to climate change.
1.0 INTRODUCTION

Over the last century a large percentage of ponds and wetlands have been lost worldwide (Williams, 1999). Recently, in British Columbia (BC), a decline in the number and surface area of grassland ponds has been documented (Coelho, 2015). The 2015 study indicates that BC has lost over 50% of total ponds and pond surface area in the southern interior grasslands in the time period from 1990 to 2012 (Coelho, 2015). This is of particular concern to the ranching industry as grassland ponds are relied upon as a source of drinking water for cattle during grazing. Without a source of drinking water, cattle are not able to access the forage resources provided by the grasslands. Water development strategies such as dugouts, groundwater wells and spring development are often reactionary as natural water sources become unavailable. In order to assist the ranching industry and resource managers with proactive adaptation to changes in water availability, a prototype tool has been developed to forecast the risk of water loss for individual ponds. The tool is applicable to BC’s southern interior rangelands (Figure 1). The intent of the pond risk assessment tool is to provide the ranching industry and resource managers with information on ponds so they can target high risk areas for proactive water development. The pond assessment tool can be used in the development of water source planning strategies in response to projected future trends in pond water supply.

In order to provide a risk assessment for individual ponds, two important factors of pond hydrology were incorporated into the tool, climate and groundwater – surface water (GW – SW) interactions. Two models were developed to address these factors.

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assessment model is incorporated into an online survey in which the user answers a series of questions and are provided with the indication of the GW – SW interactions of the pond and an associated climate sensitivity risk assessment.

As this project involved exploratory statistics and preliminary model development, the deliverable is considered a prototype. Throughout the process of developing the models, various limitations were encountered. The limitations are mainly statistical and can be overcome through the acquisition of more data. Other limitations include web page development and hosting.

Future work is needed to develop a full production tool for public use. This would include data acquisition and advanced modelling, merging the online models into a single website with a user-friendly interface and development of a report generating feature.

This report provides the following information:

- Background information on the BC’s grasslands, BC’s beef cattle industry, pond hydrology, climate change and the hydrologic cycle, and rangeland water development strategies;
- Methods used to develop the climate model, pond assessment model and online tool;
- Limitations associated with the models and online tool prototype;
- Future work required to overcome the model limitations and improve the online tool; and,
- Summaries of engagement with the ranching community and media attention.
FIGURE 1.1

Study Area

Legend

Southern Interior Rangelands

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

Coordinate System: Canada Albers Equal Area Conic
Data Sources: Grassland biome and provincial boundary provided by DataBC
Scale: 1:7,500,000

Last updated by jcass on March 27, 2017 at 9:19:27 AM

Study Area
2.0 BACKGROUND INFORMATION

2.1 BC Grasslands and the Beef Cattle Industry

BC’s grasslands and the ranching industry are intimately linked as the majority of BC grasslands are working rangelands that provide a valuable source of forage for grazing livestock. Rangelands refer to any land supporting vegetation that can be consumed by domestic livestock and wildlife. Rangelands in BC extend beyond grasslands to other forested and wetland ecosystems. However, grasslands are the most limited of the rangeland ecosystems with respect to drinking water supply for livestock and wildlife. In grassland areas that lack a nearby river, stream or lake, fresh water is found mainly in ponds that form in depressions in the terrain. In some areas, ponds are the only source of drinking water for livestock during grazing. Drinking water supply for livestock can be a limiting factor affecting the ranching industry’s ability to access grassland forage.

2.1.1 BC Grasslands

In a province known for its forests, mountains and abundance of water, the grasslands represent a rare ecosystem, rich in biodiversity and high quality rangeland and low in water availability. Grasslands make up 1% of British Columbia’s land mass and are found mostly in the central and southern parts of the province (Wikeem and Wikeem 2004). Approximately 99% of BC’s grasslands are working rangelands. Within these regions, the grasslands are located between the Coast and Rocky mountain ranges in and around the valleys and plateaus of major rivers such as the Fraser, Thompson, Chilcotin, Okanagan and Kettle. The rain-shadow effect from the Coast Mountains has a pronounced effect on the climate of the interior plateau where annual precipitation is relatively low, ranging from 200 mm to 500 mm annually (Wikeem and Wikeem 2004). BC’s grasslands are classified as semi-arid and are typically hot, dry and water limited (Wikeem and Wikeem 2004).

Ecosystems in BC are divided into zones classified using the Biogeoclimatic Ecosystem Classification (BEC) pioneered by (Krajina and Brooke 1970) and expanded on by the BC Forest Service. The zones are distinguished using a combination of vegetation, climate and soil data (Pojar et al. 1987). There is a total of 16 BEC zones in BC which are classified into subzones and variants for specific sites. BC’s grasslands are found mainly within three BEC zones with similar climates: Interior-Douglas Fir (IDF), Ponderosa Pine (PP) and Bunchgrass (BG) (Gayton 2003). Another commonly used classification system in the Okanagan and Cariboo regions separates sites by elevation into lower grasslands, middle grasslands and upper grasslands (Tisdale 1947; Gayton 2003). This system is often useful within a site that varies greatly in elevation. At higher elevations temperatures are cooler and precipitation levels are often higher than those at lower elevations. This results in distinct vertical regions that differ in climate, soils and vegetation (Tisdale 1947).
The hydrologic processes in BC's grasslands are heavily influenced by precipitation, which is mostly confined to snowfall from November to January and rainfall in May and June with the rest of months being relatively dry (Wikeem and Wikeem 2004). The major source of water available for pond filling comes from melting snow packs that develop over the winter months (Hayashi and van der Kamp 2007). The depth and density of the snow pack is highly variable from year to year and has a large influence on groundwater and surface water recharge and summer flows (Hayashi and van der Kamp 2007). Ponds lose water mostly through evaporation and groundwater seepage. Evapotranspiration rates are directly related to air temperature (Allen et al. 2006) and are highest during the hot and dry summer months, July to September. During this period, potential evapotranspiration (PET) outweighs precipitation resulting in a net loss of water from grassland soils (van Ryswyk et al. 1966) and surface water (Riordan et al. 2006; Hayashi and van der Kamp 2007).

2.1.2 Beef Cattle Industry

In BC, there are approximately 4,086 cattle ranches that primarily consist of cow-calf operations. Cow-calf operations require large amounts of land with access to forage and water. BC ranches have tenure on 8.7 million hectares of crown rangeland and occupy a further 2 million hectares of private land with the average size of a cattle ranch being 435 hectares. The industry is diverse, with operations ranging from small hobby farms to large cattle ranches.

Many ranchers graze their cattle on grassland forage. In order to access grassland forage, cattle require a nearby source of drinking water. In some areas, ponds are the only source of drinking water. The ranching community has expressed a concern regarding an observed decline of ponds in BC's grasslands. Recently, an evaluation of changes to pond surface area in BC's southern interior grasslands was completed. The results indicate that there has been approximately a 50% decline in pond surface area from 1990 to 2012. The decline in water availability for cattle during grazing presents a challenge to the ranching industry and their ability to access grassland forage.

The continued success of ranching in BC is important to the economy. Many families and community businesses are supported by the beef cattle industry in BC. Approximately 8,700 people are employed in this industry and it provides an economic contribution of approximately $600 million annually. In addition, this industry provides a stable and sustainable food supply in BC and Canada.

2.2 Pond Hydrology

Ponds are typically located in depressions within the landscape. Their characteristics cover a range of depth, size and permanence, each with a unique water budget influenced by hydrological processes. Changes in surface water levels are dynamic and controlled by the balance between inputs and outputs of water (Hayashi and van der Kamp 2007). For example, in semi-arid grasslands evaporation tends to outweigh precipitation in the summer months which can cause pond levels to drawdown or even completely dry out (Jolly et al. 2008). Climate also affects the balance through yearly variations in
snowpack accumulation and the subsequent level of groundwater recharge during the spring melt (Barnett et al. 2005; Mote et al. 2005; Stewart et al. 2005). These hydrological processes are also complicated by their interaction with soil and vegetation. Therefore, anthropogenic changes to upland ecosystems, such as logging, cattle grazing and agriculture, which affect plant cover, plant composition and soil properties, can in turn affect the water balance of ponds within the watershed (Hayashi and van der Kamp 2007).

The water level of a pond is governed by a balance of inputs and outputs and can be described mathematically as:

$$\Delta V = P + S_i + G_i - ET - S_o - G_o$$

Where $\Delta V$ is the change in storage, $P$ is precipitation (rain and snow), $S_i$ is surface inflow, $G_i$ is groundwater inflow, $ET$ is evapotranspiration which is the combination of direct evaporation from the pond surface and transpiration from the surrounding vegetation, $S_o$ is surface outflow, and $G_o$ is groundwater outflow (Kendall and McDonnell 1998). Typically, grassland ponds operate as a closed system with no significant input or output to or from other surface water sources (i.e. lakes, rivers, streams) (Rains 2011). Therefore, the terms for surface water inflow ($S_i$) and surface water outflow ($S_o$) can be removed and the equation reduced to:

$$\Delta V = P + G_i - ET - G_o$$

The main input to ponds is precipitation in the form of rain and snow. However, the majority of rainfall in BC’s semi-arid grasslands falls in June and July and is mostly absorbed by dry soils and immediately taken up by vegetation (Tisdale 1947; van Ryswyk et al. 1966; Wikeem and Wikeem 2004). Therefore, rain is secondary to snow melt which can be considered the primary component of the precipitation term (Hayashi and van der Kamp 2007). The amount of water a pond receives from snow melt is dependent on the depth and density of the snowpack, the timing of the spring melt, soil infiltration rates and groundwater flow dynamics (Mote et al. 2005; Stewart et al. 2005; Jolly et al. 2008). These factors are influenced by weather. For instance, the presence of frozen soil beneath the snowpack combined with a fast melt would limit soil infiltration and increase run-off into ponds (Chamberlain and Gow 1979; Hayashi et al. 2003). Conversely, a slow melt would increase the potential loss of snowpack to sublimation and increase the probability of thawed soils during the latter part of the melt, both of which would decrease the water entering ponds (Chamberlain and Gow 1979; Hayashi et al. 2003; Mote et al. 2005). Snow melt also has a large influence on the groundwater table at both regional and local scales (Mote et al. 2005; Stewart et al. 2005), which in turn can affect the groundwater - surface water (GW – SW) interaction components of the pond water balance equation.

All ponds in semi-arid ecosystems have some level of input from precipitation and output from evapotranspiration, but where they tend to differ most is in their GW – SW interactions. Therefore, it is possible to classify ponds based on these interactions. Theoretical and field studies have shown that GW
- SW interactions can be broadly categorized into four types of flow regimes (Townley and Davidson 1988; Townley and Trefry 2000; Smith and Townley 2002, Jolly et al., 2008):

a) connected perched-precipitation pond – no groundwater input and surface water is lost by groundwater recharge to the saturated local groundwater system;

b) disconnected perched-precipitation pond – similar to (a) but surface water is lost by groundwater recharge to an unsaturated deep regional groundwater system;

c) groundwater discharge pond – receives water from the local groundwater system and provides no groundwater recharge; and,

d) flow-through pond – gains water by groundwater discharge from some parts of the pond and loses water by groundwater recharge at other parts.

Figure 2.1 provides a graphical representation of the GW – SW interactions of the four pond types.

**Figure 2.1: Conceptual Groundwater Flow Paths (Jolly et al. 2008).**

Groundwater inputs and outputs are important components of the pond water balance equation especially with respect to pond permanence. A pond’s connection to groundwater is strongly influenced by local geomorphology (i.e. location within a landscape) and the relative pressure heads between groundwater and surface water (Rosenberry and Winter 1997; Jolly et al. 2008). A deep pond found within a low lying depression is more likely to have groundwater inputs compared to a shallow pond found within a relatively flat depression. The latter tend to be perched-precipitation ponds; type (a) or (b) that are seasonally inundated. Their surface water originates from snow melt and often has a large surface area to volume ratio. The surface water of these ponds is typically lost by groundwater seepage and evapotranspiration. Conversely, the flow-through and groundwater discharge ponds, type (c) and (d) have either seasonal or perennial groundwater inputs which extend the permanence of their surface water through the dry
season. The extent and term of the groundwater input to these ponds depend on the relative height of the groundwater table to the surface area of the pond, the relative pressure heads and how they fluctuate throughout the year (Jolly et al. 2008).

The degree of interaction between groundwater and surface water at local scales is often dependent on the condition of the regional water table (Rosenberry and Winter 1997; Van der Kamp and Hayashi 1998; Jolly et al. 2008). The depth and density of the snow pack development in the winter determines the amount of water added to the entire system during the spring melt including the level of flows in areas where there is groundwater discharge to the surface (Mote et al. 2005; Stewart et al. 2005). This is also important for areas where groundwater discharge is seasonal because more water equivalent can result in discharge continuing later into the dry season. Therefore, groundwater recharge from spring snowmelt is an important factor in maintaining surface water throughout the year.

2.3 Climate Change and the Hydrologic Cycle

Global average air temperature increased during the 20th century and most assessments indicate a strong possibility of further warming in the future (Houghton et al. 2001; Houghton 2009). In Western North America, a 2 – 5 °C increase is predicted in the next century (Cubasch et al. 2001; Spittlehouse 2008). It is expected that increased air temperature will lead to increases in evapotranspiration and precipitation and an overall intensification of the water cycle (Loaiciga et al. 1996; Huntington 2006). Predictions associated with water cycle intensification at mid-latitudinal areas of North America include shorter winter seasons, larger winter floods, drier and more frequent summer weather and overall enhanced hydrologic variability (Loaiciga et al. 1996; Huntington 2006). Semi-arid ecosystems are projected to be most vulnerable to increasing air temperature and variations in precipitation patterns (MacKerron 2010; Stocker et al. 2013). Deteriorating conditions for water storage and water supply are predicted for semi-arid climates that are dependent on snowmelt (Loaiciga et al. 1996; Barnett et al. 2005; Mote et al. 2005; Stewart et al. 2005).

Snow pack represents a key component of the hydrologic cycle in Western North America. One of the primary consequences of climate warming is the reduction of snow accumulation and the water supplied by snow melt (Stewart et al. 2005). At high elevations in grassland watersheds, storage of water in the winter snowpack and its release in spring and early summer is especially important for semi-arid climates where demands are the greatest (Loaiciga et al. 1996). Changes in the amount of precipitation near the end of winter tend to affect the size of the snowpack and the volume of run-off (Stewart et al. 2005). Alternatively, temperature increases can affect the timing of the run-off which in turn will influence flows in the summer and fall (Mote et al. 2005).

Climate change is expected to alter the timing of hydrological processes in BC (Leith and Whitfield 1998). These changes include earlier snowmelt, lower late summer – early fall flows and higher early winter flows. The implications of these hydrological changes include increasingly long and dry summers and possible water shortages in the late summer (Leith and Whitfield 1998). This is consistent with other
studies in Western North America which found that increasing air temperature is affecting spring streamflow timing (Cayan et al. 2001; Mote et al. 2005; Stewart et al. 2005). The warming trends also affect precipitation and exacerbate earlier streamflow timing. Winter warming results in an increased fraction of the precipitation to fall as rain which in turn affects the size of the snowpack and timing of the spring melt (Stewart et al. 2005). Studies of changes in snowpack extent and depth over the last 50 years in Western North America valleys and plains have reported significant declines (Karl et al. 1993; Scott and Kaiser 2004). A recent climate change study in British Columbia reported a 0.71 °C increase in air temperature and a 0.5% decrease in precipitation from 2001 – 2009 (Wang 2013). If these current trends continue, it is likely that we can expect significant losses in snowpack and changes toward earlier streamflow timing (Mote et al. 2005; Stewart et al. 2005).

There is an abundance of evidence that suggests ongoing and future changes to the hydrologic cycle in response to climate change (Loaiciga et al. 1996; Cayan et al. 2001; Barnett et al. 2005; Mote et al. 2005; Stewart et al. 2005; Huntington 2006). The projected declines in snowpack and earlier streamflow timing will have profound consequences for water availability in climates that depend on spring snowmelt, like BC’s semi-arid grasslands. Springtime snowmelt is historically the most predictable part of the hydrologic cycle and is relied upon to supply 50 – 80 % of the annual flow volume in Western North America (Stewart et al. 2005). A decrease in this supply could have consequences that include potential declines in snow water equivalent available for groundwater and surface water recharge, declining regional groundwater tables that may affect GW - SW interactions and increased evaporative demand on surface water, all of which accentuate the typical seasonal summer drought.

2.4 Rangeland Water Development Strategies

In BC, grazing typically occurs in the semi-arid climates of BCs grasslands and dry forests where water can often be a limiting factor. Cattle require approximately 40 to 80 L of water per day and will not graze too far from a source of drinking water. In some areas, grassland ponds are the only source of drinking water. The recent decline of natural grassland ponds has resulted in challenges related to accessing the forage resources of BCs rangelands. Rangeland water development strategies are employed in order to provide drinking water to cattle.

Typical water development strategies include:

- Dugouts;
- Groundwater Wells;
- Spring Development; and,
- Hauling Water.

Summaries of these strategies are provided in Appendix A and are based on Factsheets found in the BC Livestock Watering Handbook (Ministry of Agriculture 2006).
3.0 POND RISK ASSESSMENT TOOL

The pond risk assessment tool is designed to assess the risk to ponds in BC’s southern interior rangelands based on projected changes in climate. The tool combines two models, a climate model and a pond assessment model. The climate model captures the effects of climate variables that influence pond hydrology. The pond assessment model aims to estimate the GW - SW interactions of individual ponds to determine the sensitivity of a pond to changes in climate. Both the climate model and pond assessment model provide a risk assessment which, collectively, provide the overall risk to an individual pond.

The models are built into a prototype online tool. The online tool is interactive and provides easy access to risk assessment information for an individual pond quickly and intuitively.

During the development of the prototype tool, various limitations associated with the models were observed. Future work is required to address the limitations and move from the prototype to a full production tool.

3.1 Climate Model

3.1.1 Statistical Modelling

Modelling was completed to forecast the risk to ponds based on projected changes to climate variables that are important to pond hydrology. The model was developed through the correlation of historical climate data with historical pond surface area data. The following data were used for the modelling:

- Historical pond surface area data for BC’s southern interior grasslands generated from air photos for six time periods from 1960 to 2012. Data were collected for 8 sites and a total of 64 ponds, 8 per site (Coelho 2015).

- Historical climate data for each of the 8 sites was generated using ClimateBC software (Wang et al. 2006; Wang et al. 2016). From the software, annual data for a variety of seasonal climate variables were obtained for the same time period as the pond surface area data.

For each pond, a regression analysis was completed using the measured surface areas over the six time periods. The slope of the regression line was determined for each pond. The slope indicates the rate of surface area change over time. A single pond slope value for each of the 8 sites was determined by taking the average of the 8 individual pond slope values from within a site. The 8 slope values were used as the response variables in the model.

Annual data for seasonal climate variables were generated from the ClimateBC software using the centroid coordinates and elevation for each site. A regression analysis of the climate variables was completed for each site over the time period of the pond surface area measurements. The slope of the
A regression line was determined for each climate variable in order to relate the climate variables to the rate of pond surface area change over time. The slope values of the climate variables were used as the explanatory variables for the model.

The ClimateBC software generates 14 climate variables for each of the 4 seasons for a total of 56 variables. A full list of the variables is included in Appendix B. From the 56 variables, 14 were chosen for model development based on their known potential for influencing pond hydrology. The 14 variables are listed below.

- Average winter temperature
- Average spring temperature
- Average summer temperature
- Average autumn temperature
- Total winter precipitation
- Total spring precipitation
- Total summer precipitation
- Total autumn precipitation
- Winter degree days below zero
- Winter precipitation as snow
- Spring precipitation as snow
- Spring Hargreaves reference evaporation (Hargreaves and Allen 2003)
- Summer Hargreaves reference evaporation
- Autumn Hargreaves reference evaporation

An exploratory ordinary least squares regression was run using ArcGIS to produce a list of candidate models from the 14 variables. A maximum allowable variance inflation factor of 10 was used to minimise multicollinearity effects. Of the candidate models that returned the highest adjusted R-squared and significance values, the model that best fit with the theory of pond hydrology included three variables, winter and spring precipitation as snow and summer average temperature. This result is reasonable as winter and spring precipitation as snow influence snowpack accumulation which is important for groundwater and surface water recharge and summer average temperature influences evaporation which impacts surface water loss. A statistical profile of the model was generated using R statistical software (R Development Core Team 2008). Table 2.1 summarises the statistical parameters of the model.

### Table 2.1: Model Statistical Parameters

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Adjusted R-squared</th>
<th>Variance Inflation Factor</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Precipitation as Snow</td>
<td>-</td>
<td>1.19</td>
<td>0.04</td>
</tr>
<tr>
<td>Spring Precipitation as Snow</td>
<td>-</td>
<td>6.86</td>
<td>0.11</td>
</tr>
<tr>
<td>Summer Average Temperature</td>
<td>-</td>
<td>6.65</td>
<td>0.26</td>
</tr>
<tr>
<td><strong>Model</strong></td>
<td><strong>0.54</strong></td>
<td>-</td>
<td>0.12</td>
</tr>
</tbody>
</table>

The adjusted R-square of the model is 0.54 indicating that it explains approximately 54% of the change in pond surface area. The adjusted R-squared is a modified version of R-squared that has been adjusted for
the number of predictors in the model. Considering that the model was developed from a low number of observations (n=8), adjusted R-squared is a more conservative measure of the extent to which the model explains the change in pond surface area.

The generally accepted cut off for variance inflation is a factor of 10. The variance inflation factors for the predictors in the model are less than 10 with a maximum of 6.86. Therefore, the model is not artificially inflated due to collinear predictors.

The p-values for winter precipitation as snow, spring precipitation as snow and summer average temperature are 0.04, 0.11 and 0.26, respectively. This indicates that the contribution of spring precipitation as snow and summer average temperature to the model may not be individually significant. However, this is likely due to limitations in sample size (n = 8) (see section 4.1). The p-value for the model is 0.12 which indicates that it is slightly higher than the accepted cut off of 0.10. Similar to the individual parameters, this is likely a result of sample size. Although the p-values for two of the individual parameters and for the model may not be significant, as a pilot study the model is promising and can be improved with additional data to increase the sample size.

3.1.2 Climate Grid and Model Application

The model is applied to BC’s southern interior rangelands using a climate grid. The climate grid is based on ClimateBC raster data (Wang et al. 2006; Wang et al. 2016). The study area is defined by the Grasslands Conservation Council rangeland data set. Using the fishnet tool in ArcGIS, a polygon was generated from the raster data which covers the entire study area with 800 m x 800 m grid cells. The centroid coordinates and elevations of each grid cell were used to generate actual and projected climate data for the years from 1990 to 2020 from the ClimateBC software. Slope values were calculated for winter precipitation as snow, spring precipitation as snow and summer average temperature and used as predictor variables for the model application.

The model is applied by multiplying the coefficient of variation by the slope values for each predictor to generate an estimated change in pond surface area. The resulting values from the climate grid were separated into five risk categories using Jenk’s natural breaks algorithm (Jenks 1967). Therefore, the results are not indicative of absolute change in pond surface area or absolute risk, but rather the relative risk of one grid cell to another. The final output of the model is one of the five risk categories.

The risk categories and associated descriptions were generated based on the explanatory variables of the model and are summarised below.

1. HIGH RISK – The climate trends in this area present a high risk to ponds. With a considerable decrease in winter and spring snowfall projected, a decrease in snowpack and a decrease in surface water and groundwater recharge is likely. As summer temperatures increase, a higher rate of
evaporation can be expected. These factors will limit pond water supply, particularly late in the dry season.

2. MODERATE-HIGH RISK – The climate trends in this area present a moderate-high risk to ponds. With a decrease in winter and spring snowfall projected, a decrease in snowpack and a decrease in surface water and groundwater recharge is possible. As summer temperatures increase a higher rate of evaporation can be expected. These factors will likely limit pond water supply, particularly late in the dry season.

3. MODERATE RISK – The climate trends in this area present a medium risk to ponds. There is some evidence of changes in winter and spring snowfall and summer evaporation which could have impacts on pond recharge and evaporative losses, respectively. The sensitivity of a pond to these changes will likely depend on other factors such as surface area to volume ratio and groundwater-surface water interactions.

4. MODERATE-LOW RISK – The climate trends in this area present a moderate-low risk to ponds. Projected changes to winter and spring snowfall and summer evaporation are minimal. Considerable climate driven changes in pond water supply are not expected. However, moderate changes to water supply can be expected for highly sensitive ponds with high surface area to volume ratios and minimal groundwater inputs.

5. LOW RISK – The climate trends in this area present a low risk to ponds. The climate variables associated with pond hydrology are stable. Climate driven changes in pond water supply are not expected.

The climate model is most limited by the number of pond surface area observations. As the 64 pond observations are clustered within eight climate grid sites (eight ponds per site) the functional number of samples for modelling is limited to eight (n=8). The recommended sample size for multiple linear regression modelling can be calculated based on the number of predictor variables and the squared multiple correlation coefficient with the minimum recommended sample size typically being n = 30 (Knofczynski and Mundfrom 2008). With a sample size of eight, the ability to use additional predictor variables to expand the complexity of the model is restricted. In addition, the p-values of the current prototype model are slightly above the generally accepted significance cut off of 0.10 indicating a low statistical confidence in the model despite a good fit with pond hydrology theory.

3.2 Pond Assessment Model

The pond assessment model estimates pond GW – SW interactions in order to evaluate the sensitivity of ponds to changes in climate. As indicated by the climate model, climate variables can only explain a portion of the predicted risk of declining water levels. GW - SW interactions are also important factors of pond hydrology. However, accurately assessing these interactions for individual ponds requires intensive field based research. In order to capture this important information, a method was developed to estimate GW - SW interactions for individual ponds.
The method is in the form of a survey, in which the user answers a series of questions about an individual pond. Answers to the questions are weighted and produce a score that estimates GW – SW interactions. This is then translated to a risk assessment, with groundwater connected ponds being lower risk and disconnected ponds being higher risk.

### 3.2.1 Survey Development

In order to develop the pond assessment questions and answers, the project team assessed four ponds in the Lac du Bois grasslands with known GW – SW interactions. In a study completed in 2015, the GW – SW interactions of the four ponds were evaluated using a series of groundwater monitoring wells and piezometers (Coelho, 2015). From the four ponds, three GW - SW pond types from Figure 2.1 were observed.

1. Flow through pond – perennially connected to groundwater
2. Connected/disconnected perched precipitation pond – seasonally connected to groundwater (i.e. connected in the spring and early summer and disconnected in the late summer, fall and winter)
3. Disconnected perched precipitation pond – not connected to groundwater

The only pond type from Figure 2.1 not represented is groundwater discharge ponds. However, the characteristics of groundwater discharge ponds tend to be similar to the characteristics of flow-through ponds as both are perennially connected to groundwater and have relatively stable water levels. Therefore, little difference in the history and physical aspects are expected between flow-through and groundwater discharge ponds.

The project team, including Tom Pypker, TRU; Reg Newman, MFLNRO; Andrew Petersen, MOA; Rhonda Maskiewich and Aaron Coelho, Urban Systems Ltd. conducted a field study of the four ponds to determine the differences in the physical factors of the pond types. Observations focused on vegetation growth characteristics in and around the ponds, including species identification, soils and topography and surface area to volume ratio estimates. The history of pond size was also evaluated from historical air photos. From the study, several questions were developed to gather information on the history of the pond, pond depth and the vegetation growing in and around the pond.

The following is the list of questions and answers and a description of the theory behind the question.

**Question #1:** Is there consistently surface water in the pond year-round?

**Answers:**

a) Yes  b) No  c) Unknown

This question is meant to gauge the history of the pond and whether it has ever been dry. If, to the knowledge of the user, the pond has always had some level of surface water, this implies that the pond is relatively stable. If the pond has been dry in the past, it implies that there is a higher risk of it going dry
again in the future. If the user is not familiar with the history of the pond they can choose unknown and the question will be removed from the risk calculation.

**Question #2:** How would you describe seasonal fluctuations in water depth and/or surface area?

**Answers:**

- a) Greater than 50%
- b) 25% to 50%
- c) Less than 25%

If, on an annual basis, the pond depth and/or surface area fluctuations are greater than 50%, this implies that the pond is sensitive to annual variations in weather. It is likely dependent on runoff/precipitation inputs and rates of evaporation. If the fluctuations are between 25% and 50%, there is likely moderate sensitivity to weather variation and possibly seasonal groundwater inputs. If a pond fluctuates less than 20%, it implies that it is relatively stable and likely has a consistent source of groundwater supply keeping it in balance despite changes to runoff/precipitation inputs and evaporation rates.

**Question #3:** Have you ever noticed surface runoff flowing into the pond?

**Answers:**

- a) Yes
- b) No
- c) Unknown

Surface runoff can be a sign of connectedness to other waterbodies or groundwater springs. This connectedness can impact the short-term and long-term stability of a pond with respect to changing climate factors.

**Question #4:** What is the approximate maximum depth of the pond?

**Answers:**

- a) Great than 2 m
- b) Between 1 m and 2 m
- c) Less than 1 m

The surface area to volume ratio of a pond can have a large impact on seasonal fluctuations and the sensitivity of a pond to changes in climate. A deep pond is more likely to have groundwater inputs than a shallow pond as the topography of a deep pond basin is more likely to fall below the local water table. In addition, a deep pond will lose a smaller percentage of its water to evaporation due to the low surface area to volume ratio. Shallow ponds tend to be perched above the water table and are highly sensitive to changes in runoff/precipitation inputs and evaporation.

**Question #5:** How would you describe the vegetation growing in the pond?

**Answers:**

- a) Emergent at the perimeter
- b) No emergent vegetation in the pond
- c) Emergent vegetation throughout the pond

How vegetation grows in a pond can provide information on how much the pond level fluctuates and how stable it is. Ponds with vegetation growing in a distinct ring around the pond, emerging from the water at the pond perimeter, are often relatively stable ponds. The vegetation growing at the perimeter will grow
within a specific range of water depth. Vegetation will not grow past the perimeter towards the middle of
the pond as the water level is too deep. If the pond experienced large annual fluctuations in water level,
the vegetation would not survive as the water level would be too deep or too shallow. Therefore, this pond
is relatively stable and likely receives consistent groundwater inputs along with snowmelt runoff and direct
precipitation.

If the pond has no emergent vegetation this implies that that the pond rarely, if ever, goes dry as
vegetation would eventually emerge. The absences of vegetation at the perimeter suggests that the water
level fluctuates enough to prevent the establishment of perimeter vegetation that like stable water levels.
This type of pond may have some groundwater inputs but still has some sensitivity to climate changes
likely due to a high surface area to volume ratio.

If there is emergent vegetation throughout a pond, this implies that the pond fills and empties on an
annual basis. Depending on the vegetation type, these ponds are likely seasonally connected to
groundwater or disconnected perched ponds.

Question #6: Are any of these plant species present in or around the pond?

Answers: a) Bulrush, cattails, sedges, pond lily, willow (trees nearby)
           b) Silver weed, foxtail barley, nuttals alkali grass
           c) Red glass wort or evidence of salt rings around the pond

Figure 3.1 shows photos of the plant species. The photos are included in the survey to assist the user
with species identification.

Plant species can give an indication of the hydrologic regime of a pond. Bulrush, cattails, sedges and
pond lilies are often emergent at the perimeter of ponds with stable water levels and are not tolerant of
high salt content soils and water. Silver weed, foxtail barley and nuttals alkali grass are typically found
around the outside perimeter of ponds that fluctuate considerably in water level or throughout ponds that
fill and empty on an annual basis. They tolerate soils with moderate salt content. Ponds with salt rings
and red glass wort growing outside of the pond are typically perched ponds with no groundwater inputs.
They fill in the spring with runoff/precipitation and evaporate over the summer. As they evaporate, the salt
concentration of the water increases and eventually deposits in the soils. Salt loving vegetation, such as
red glass wort, tend to grow in the perimeter soils and in some cases salt deposits are visible as a white
ring around the pond.
Figure 3.1 – Plant Species Photos

- Bullrushes
- Cattails
- Sedges
- Pond Lilly
- Willow (trees nearby)
- Silverweed
- Foxtail Barley
- Nuttal’s Alkaligrass
- Red Glass Wort
- Salt Rings around the Pond
3.2.2 Risk Scores and Risk Assessment Descriptions

The answers to the questions were given a weighted score. The scores were determined by the professional opinions of the project team and were tested in the field on the four known ponds and on four unknown ponds. As the four known ponds were used as the training data set for the model development, they cannot be used for validation and testing of model accuracy. This would require another set of ponds with known GW – SW interactions. This is a limitation of the current prototype model. However, the test on the 4 unknown ponds returned reasonable results based on the known history of the ponds and professional opinions of the project team.

When all questions have been answered, the model calculates an overall score for the pond and converts the score to a number between 0 and 100. Higher scores indicate a greater likelihood of a groundwater connection whereas lower scores indicate a seasonal or disconnected pond type. Table 3.2 summarises the weighted scores for the answers to each question.

Table 3.2: Weighted Score Matrix

<table>
<thead>
<tr>
<th>Question Number</th>
<th>Weighted Score for Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

1 If answer ‘C’ is chosen for questions 1 or 3, the question is removed from the final calculation.

Based on the final calculated score, the model returns a risk assessment description for the pond. The risk categories and associated descriptions were generated based on the estimated GW – SW interactions and are summarised below.

1. Score 0 – 32
   a. HIGH RISK – Based on some of the physical aspects of the pond, this pond is considered high risk. It is likely that this pond has little to no groundwater inputs. With pond volume dependent on filling from spring snow melt, this pond is likely sensitive to changes in climate. This pond is not considered dependable, particularly late in the dry season.
2. Score 33 – 66
   
a. MODERATE RISK – Based on some of the physical aspects of the pond, this pond is considered moderate risk. Groundwater inputs, if any, are likely seasonal and therefore it is expected that the pond is particularly sensitive to extended dry seasons as a result of early stream/groundwater flow timing and dry season evaporation. This pond is likely dependable in the spring and early summer; however, late season water supply is less dependable and will rely on climatic factors.

3. Score 67 – 100
   
a. LOW RISK – Based on some of the physical aspects of the pond, this pond is considered low risk. It is likely that this pond has groundwater inputs which contribute to its stability throughout the year. Groundwater inputs and other factors likely result in a reduced sensitivity to changes in climate. Therefore, the pond is expected to be relatively dependable throughout the year including late in the dry season.

The pond assessment model is most limited by the number of ponds with known GW – SW interactions. The four ponds in the Lac du Bois grasslands with known GW – SW interactions were used as the training set to build the model. This consisted of only one or two replicates of each pond type. There are no data available to validate and test the model.

3.3 Prototype Online Tool

Both the climate model and pond assessment model have been incorporated into a prototype online interactive tool. The tool consists of two websites. The climate model results are overlaid on google satellite imagery creating an interactive online map with the pond assessment model built into a separate online survey.

The climate map utilizes an online GIS platform called Lightship Works web mapping (Lightship Works Inc. 2017). This platform is user-friendly and can be accessed by all devices with an internet connection. A link to the prototype climate map is provided below. The online GIS platform allows for the risk category for each climate grid cell to be displayed on the interactive website. The risk category results were linked to each climate grid cell using ESRI ArcGIS and then uploaded to the Lightship Works website. The grid cells are colour coded according to their risk category (Figure 3.2). When a grid cell is selected the associated risk category description is displayed. The risk assessment in the prototype online tool is the projected risk for the year 2020. Note that the grid cells on the website appear rectangular due to the projection used by the Lightship Works platform.

Interactive Climate Map Link:  
https://urbansystems-maps.lightship.works/#/map/ggOHC696RhqlXsd5Z89-Nq
The pond assessment model was incorporated into a web questionnaire format using Qualtrics surveys (Qualtrics 2016). The interface is a web based, mobile friendly survey which includes the plant species photos (Figure 3.3). A link to the survey is provided below.

Pond Assessment Survey Link:
https://surveys.qualtrics.com/jfe1/form/SV_cDdKwjUYv67e7ml

It is important to note that the above websites are prototypes and are not meant for public use at this time. Future work is required to address the limitations of the models and improve the user interface and outputs of the online tool.

The main limitations of the online tool are related to the cost and time required for the development of the user interface and reporting functions. These limitations will be addressed in future work.

Figure 3.2: Screenshots of Prototype Online Climate Map
Figure 3.3: Screenshot of Online Pond Assessment Survey

Are any of these species present in or around the pond?

- Bulrush, cattails, water lily, sedges, willow (other trees in close proximity)

- Silver-weed, fox-tail barley, nuttals alkali grass
4.0 FUTURE WORK

4.1 Climate Model

In order to address the limitations of the climate model future work is needed. The following is a list of priority actions and improvements:

- Expand the pond surface area data set.
  - Gain access to historical aerial imagery for multiple time periods. If available, coverage of the entire study area would be ideal.
  - Develop an automated georeferencing model to geolocate the historical aerial imagery.
  - Conduct a supervised rule-based image classification procedure to delineate pond surface area for all ponds within aerial photo coverage.

- Develop a more robust model.
  - Conduct an automated model selection analysis using the pond surface area data and ClimateBC generated climate data. This would be a purely mathematical approach using strict statistical criteria.
  - The results of the automated model selection would inform climate variable selection for subsequent modelling based on mechanisms of pond hydrology. From this, multiple candidate models will be tested for predictive strength and significance.
  - The model developed using this above approach will be incorporated into the online climate map.

- Extend yearly pond risk forecasting to the year 2100.
  - Download projected climate data to the year 2100 for each grid cell in the study area.
  - Apply the model to the yearly climate data to project the risk for each year from the present to the year 2100.

4.2 Pond Assessment Model

More data on pond GW – SW interactions and the associated histories and physical aspects of individual ponds are needed to create a database that can be used for statistical analysis. The additional data can be used to build a statistically robust model. In addition, the data can be used as validation datasets and test datasets for evaluating the discovered relationships from the training dataset. The following is a list of priority actions:

- Expand the pond GW – SW interaction data set.
  - Source information on pond data from government agencies and the ranching industry.
- Conduct field research on ponds from multiple sites within the study area to determine GW – SW interactions. This would require an intensive study involving travel, installation of groundwater monitoring wells, observations of plant communities and reviewing aerial photos.

- Develop a more robust model.
  - Complete an analysis of the additional data to determine the strongest predictors of GW – SW interactions. Complete an automated model selection analysis to determine the strongest combination of predictors. Adjust the survey questions and answers based on the results of the statistical analysis.
  - Use additional data to validate and test the model.

- Facilitate a focus group consisting of ranchers and industry professionals to test the pond assessment tool.
  - Use feedback from the focus group to refine the survey questions and answers.

4.3 Online Tool

The vision for the full production online tool requires future work beyond the scope of the prototype project. The following is a list future work needed to develop the user interface and reporting functions.

- Develop a custom map interface to allow the incorporation of both the climate model and pond assessment model into a single website.

- Develop additional features.
  - Locational searching function for ease of navigation.
  - Individual pond selection to access pond assessment survey.
  - Timeline slider and animation to demonstrate the evolving risks.
  - Embedding links to resources related to water development strategies.

- Create printable report generating function to combine climate risk assessment and pond assessment results. This will include an aerial photo image of the pond, a figure showing change in climate risk over time and other information including coordinates of the pond.

- Develop a function for logging and spatial referencing results. The addition of this functionality could allow for the construction of a database of pond specific concerns across BC’s rangelands.

- Secure a permanent host server for the climate data, pond data and online tool interface.
5.0 ENGAGEMENT

Two engagement sessions with the ranching community were carried out during the project. The objectives of the engagement sessions were to illicit the feedback of the ranching community regarding the functionality and output of the prototype online tool. The engagement sessions were scheduled during development of the prototype so that feedback from the ranching community could be incorporated into the final deliverable.

In addition, a press release was sent to various media agencies with the intent of informing the broader public about the project. This resulted in multiple news articles and a live radio appearance.

5.1 Kamloops Stockmen’s Association Semi-Annual General Meeting

On Thursday, November 24th, 2016, Tom Pypker, TRU, and Aaron Coelho, Jesse Cass and Rhonda Maskiewich, Urban Systems Ltd., attended the Kamloops Stockmen’s Association Semi-Annual General Meeting. Prior to the event, a summary of the project along with a preliminary version of the pond assessment survey was sent to the association membership as part of the agenda package. A copy of the summary and survey can be found in Appendix C.

Approximately 40 people attended. Most of the attendees were members of the Kamloops ranching community with a few people from the Ministry of Forests, Lands and Natural Resource Operations.

Urban Systems Ltd. set up a display booth with info graphics about the project. The info graphics can be found in Appendix C. The display also included a table with two computers loaded with the preliminary online climate model and online pond assessment survey. Figure 5.1 shows photos of the engagement display. The display booth and computers were available for the entirety of the meeting and provided opportunities for live demonstrations of the online tool.

Aaron Coelho, Urban Systems Ltd. provided a 30-minute PowerPoint presentation summarising the tool followed by a question and answer period. The presentation slides can be found in Appendix C.

Feedback forms were distributed to the audience for anonymous comments. However, very few forms were turned in with members of the audience preferring to provide comments through face to face discussions. Approximately 7 individuals discussed the project with the project team and went through the online demonstration.
Figure 5.1: Photos of Engagement Display
From these conversations, the team identified several key messages:

- The preliminary version of the tool provided the current risk to ponds based on known data. Ranchers who work the land feel they already know this and the tool would be more helpful if it projected future risk to ponds using climate change projections.
- The tool needs to provide a certain level of confidence in its predictions in order to be considered reliable. Another rancher asked, “Can you estimate my pond with accuracy, and more reliable than my observations?”
- The MFLRNO may be interested in the tool with possible links to groundwater/surface water licensing practices and forestry and logging recovery cycles.
- A number of ranchers commented on the importance of the tool to them. For example, one rancher mentioned: “This tool would have been useful 15 years ago, as a lot of ponds have dried up since then.”
- The team also received feedback on how to improve the questions in the pond assessment survey.

These key messages influenced the subsequent development of the models and final prototype tool. Further statistical tests were conducted on the climate model to improve reliability of predictions. The prototype model was adjusted to predict the risk to ponds in the year 2020 as opposed to current risk. The pond assessment survey questions were refined to provide more clarity for the reader.

### 5.2 6th Annual Forest & Range Joint Industry Meeting

On Wednesday, January 18th, 2017, Tom Pypker, TRU, and Aaron Coelho, Urban Systems Ltd. attended the 6th Annual Forest and Range Joint Industry Meeting. There were approximately 120 people in attendance, the majority of which were from the regional ranching community.

Urban Systems Ltd. set up a display booth with info graphics about the project. The info graphics can be found in Appendix C. The display also included a table with one computer loaded with the preliminary online climate model and online pond assessment survey. The preliminary online tool provided only the current risk to ponds. The display booth and computers were available for the entire of the meeting and provided opportunities for live demonstrations of the online tool.

Feedback forms were available at the display booth. However, very few forms were turned in with members of the audience preferring to provide comments through face to face discussions. Approximately six individuals discussed the project with the project teams and went through the online demonstration.

From these conversations, the key feedback received included the following:
• “I am concerned about a particular pond on my range. I am interested in what this tool has to say about it,” said one rancher.

• This tool could provide supporting information for new groundwater licence applications by identifying high risk areas.

• One rancher said, “Some of the questions in the pond assessment survey are unclear.”

The comments received were supportive of the tool as the majority of the ranchers who provided comments were concerned about ponds on their range that are used for livestock watering. Further conversation is needed with MFLNRO to discuss the possible link between the tool and water licencing. The pond assessment survey questions were refined to provide more clarity for the reader.

5.3 Media Attention

On December 13th, 2017, a press release was distributed by Urban Systems Ltd. to the following media agencies:

• Kamloops This Week
• CFJC Today
• CBC Kamloops
• Infotel News
• The Province
• Radio NL
• Shaw Kamloops
• Kelowna Now
• GlobalTV Okanagan
• Kelowna Capital News
• Kelowna Daily Courier
• Castanet
• Vancouver Sun
• The Tyee
• The Daily Hive
• Vancouver courier
• Globe and Mail BC/AB
• The Penticton Herald
• The Osoyoos Times

This resulted in the following news articles and live radio interview:

• Castanet – December 15th, 2016 – Ranchers go online
• Kamloops This Week – December 20th, 2016 – Ranching water management? There will be an app for that
• CBC News – December 20th, 2016 – Daybreak Kamloops live radio interview
• CBC News – December 21st, 2016 – Online tool could help B.C. ranchers prepare for drought
• Urban Systems Webpage – January 21st, 2017 – New Online Tool Helps Predict Pond Drying Patterns in BC’s Rangelands

A copy of the press release and the news articles can be found in Appendix D.

5.4 Ongoing Communication

The press coverage generated interest from the Nicola Watershed Community Round Table (NWCRT) and Okanagan Basin Water Board (OBWB). Al Mackay-Smith, chairperson for the NWCRT, indicated that there are a number of ranchers in the group that would be interested in receiving a presentation about the tool at one of their 2017 meetings. Don Gayton, contract project manager for the OBWB, is interested in tracking wetland loss in the Okanagan and is interested in the tool and possible links to the Okanagan Wetland Strategy, which is currently being developed.
6.0 SUMMARY

A prototype climate change impact risk assessment tool for ponds used as livestock water sources has been developed. The tool uses both a climate model and pond assessment model to provide risk information for individual ponds. The climate model uses projected climate data to forecast the risk of declining water levels in ponds. The pond assessment model uses the answers to survey questions that are related to the physical aspects of a pond to estimate GW – SW interactions and the sensitivity of a pond to changes in climate. The two models have been incorporated into online websites to showcase the concept of the online tool. In order to produce a full production online tool for public use, further work is needed to address the limitations of the prototype tool.

The focus of future work will include:

- Expanding the pond surface area data set;
- Developing a more robust climate model;
- Expanding the GW – SW interaction data set;
- Validating the pond assessment model;
- Developing the user interface and reporting functions of the online tool; and,
- Engaging the ranching community and industry professionals for input on the development of the tool.

Once completed, the intent is for the full production tool to be available for public use. The aim is for the tool to assist the ranching community and industry professionals with proactive adaptation to changes in water availability. The tool will provide the ranching industry and resource managers with information on ponds so they can target high risk areas for proactive water development. The pond risk assessment tool can be used in the development of water source planning strategies in response to projected future trends in pond water supply. Used as a planning tool, it can assist with rangeland water management and adaptation to climate change.
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APPENDIX A

Water Development Strategies
The following is a summary of water development strategies based on Factsheets found in the BC Livestock Watering Handbook (Ministry of Agriculture 2006). The strategies covered are:

- Dugouts;
- Groundwater Wells;
- Spring Development;
- Storage; and,
- Hauling water.

1.0 DUGOUTS

During times when local water resources are inadequate to meet ranching demand, a constructed dugout reservoir can help meet water requirements. Dugouts are intended to retain the temporary surplus of surface water that occurs during spring run-off. Prior to constructing a dugout, it is important to understand the climate, landscape and natural hydrological features of the area as these factors directly influence a dugout’s ability to capture and store water.

There are four types of dugouts:

**Type I** – Filled entirely by surface run-off and snow melt from surrounding topography.

**Type 2** - Located adjacent to a stream and filled by either pumping or diverting water from that stream.

**Type 3** – Constructed within a stream (in-line) and generally not recommended as it would constitute a Dam which requires an engineered design and storage licence.

**Type 4** – Groundwater-fed dugout or a dugout filled by a groundwater well.

**Determination of Water Requirements**

The amount of water required (by the type and quantity of livestock) must be determined first. A site for a dugout is selected based on the following criteria:

- Type of soil;
- Land use;
- Topography; and
- Vegetative cover.

**Dugout Management Practices**

The following techniques may be utilized to maintain water quality within dugouts:

- Continuous aeration (most effective technique);
- Physical sediment removal;
- Removal of animals;
- Copper sulphate (controls blue-green algae);
- Coagulation (addition of activated carbon to remove dissolved organic matter);
- Herbicides;
- Reservoir covers;
- Disinfectants; and
- Plants (some aquatic plants may improve summer water quality by taking up excess nutrients).

2.0 GROUNDWATER WELLS

Groundwater may occur in both bedrock and unconsolidated materials (i.e. sand and gravel). Water in bedrock tends to occur in fractures, within inter-granular openings and, in the case of limestone, in cavities and channels. Unconsolidated materials generally produce larger amounts of groundwater as they may draw water from surface precipitation or nearby surface watercourses. Wells are installed to access groundwater. The yield of a groundwater well depends on the following factors:

- Permeability of the materials;
- Thickness of the saturated material through which the well passes; and
- Well construction.

There are four different types of wells:

**Vertical Wells** – This is the most common type of well used for livestock watering. A pump, wire and piping are lowered down the well. An energy source is required to power the pump, and this is often the limiting factor to the use of wells in remote areas.

**Horizontal Wells** – This type of well is drilled horizontally into specific geologic formations where water may be trapped. Once drilled, this type of well could be considered a “spring” as water flow will occur by gravity without the need for pumping. A valve is used to control water flow. Horizontal well drilling is a specialized service and may not be available in all parts of BC.

**Shallow Wells** - These wells are less than 10 m (33 ft) deep and depend on subsurface conditions. They may be easily affected by surface conditions such as contaminated runoff and drought.

**Deep Wells** - These wells require drilling and are usually less prone to contamination and drought. However, the water quality may be hard compared to shallow wells as the water has had a long exposure to minerals.

There are several construction methods available for drilling wells. Site conditions, desired yield and cost are all factors which determine which methodology to use. A description of each well drilling methodology is provided below:

**Dug Wells** - Old wells were hand dug and lined with suitable wooden cribbing. Currently, dug wells are constructed using an excavator for shallow wells or sumps of less than 6 m (20 feet). Upright steel culverts are used for lining the well.

**Driven Wells** - Driven wells, also referred to as sand points, gravel points or well points, are often used for farm water supplies when the water table is close to the surface (10 m or less) and where the aquifer is
relatively permeable. Sand points are usually 30 – 50 mm in diameter. A sand point consists of a short length of screened pipe equipped with a sharp point. The point and attached pipe are driven into the ground to the necessary depth with pipe being added to the top end as needed. Well points may be arranged in groups, coupled to a common suction header, to increase the capacity required. Unless a jet pump is to be used, it is essential that the water table be shallow enough (less than 6 m) so that a shallow well pump on the ground surface can develop sufficient suction.

**Churn (Cable-Tool) Drilled Wells** - Drilling by this method is accomplished by raising and dropping a heavy "tool string" equipped with a bit. The tools are suspended by a wire rope. Drilling is done with water in the hole and cuttings are removed by means of a bailer. In deep holes, several sizes of well casings may be required, which increases the cost. Although somewhat slower than rotary drilling, churn drilled wells may detect water in thin or low producing aquifers.

**Rotary Drilled Wells** - In this method, drill pipe, equipped with a cutter called a bit, is turned in the hole. During drilling, a fluid is pumped down the drill pipe and through the bit in order to transport the well cuttings back to the surface. Mud rotary drilling is inexpensive and rapid, particularly in unconsolidated materials. Whereas, air rotary drilling is well suited for drilling into rock.

The following best practices for well construction and operation are provided to minimize potential environmental issues and to increase the likelihood of a successful groundwater well:

- locate wells in slightly elevated areas, wherever possible, to prevent runoff from collecting at the well head and seeping into the water supply;
- construct wells with durable materials;
- construct well casing 0.3 m (1 ft) above the level of the surrounding land;
- construct well casing above 100-year-flood levels;
- construct upland berms and/or grade the land to prevent runoff from contaminating the well;
- plant and maintain grass cover around well heads to slow and filter runoff;
- use a full-length casing with a pitless adapter where water lines may freeze (rather than terminating the casing in the ground below frost level);
- To reduce overuse of ground water, monitor the water table by measuring the static water level in the well at the same time of year (some variations are normal). Minimize the use of wells near watercourses, especially when their levels are low; and,
- All new and existing groundwater wells are to be registered with the Province of BC through the Water Sustainability Act.

**Well casings and screens** – In general, bedrock wells do not require a screen or casing, with the exception of a short section of surface seal casing and a means to support the pump and pipe. Wells installed in unconsolidated materials should be screened. Aquifer materials should be sized and a suitable sized screen matched to the aquifer layers. Once screens have been installed, the well can then be developed.

**Well Development and Testing** – This process involves the removal of fine particles from the area around the well screen. Once the small particles are removed from around the well, a coarse layer of materials will be left in place to promote increased flow (with lower turbidity) into the well. Upon completion of development, the capacity of the well should be determined. If the well is producing far more water than required, this step may not be necessary. However, in many cases the well output must be known, especially when sizing a pumping system. In testing a well, by either bailing or pumping, the amount of
water removed in a given time is compared to the measured change in the water level in the well. The time it takes for the water to return to its original level after bailing or pumping has stopped, is the well recovery or capacity.

**Well Decommissioning** - Improperly closed or abandoned wells can be sources of groundwater pollution and must be sealed as required by the BC Groundwater Protection Regulation.

### 3.0 SPRING DEVELOPMENT

A spring occurs when the groundwater table is at the ground surface, often along a hillside or in a low-lying area. Although water flow from the spring may vary greatly over the course of a year, even low flow springs can be worth developing. There are two different types of springs. Each is described below:

**Artesian Spring** – These springs have free flowing water due to the presence of an aquifer. They are typically the easiest to develop and require no collection. The only requirement is an intake for piping.

**Seep Spring** – These springs have little to no aquifer pressure. They are visible only as a wet area or by a change in vegetation (i.e. cattails), which indicates that water is present. These springs usually require a collection system connected to a distribution pipe.

To determine flow from a spring, it is preferable to measure the water flow rate during the season in which the spring is intended to be used. Using a temporary dam and pipe, collect the flow and record the time required to fill a container of a known volume. If the flow rate meets the daily requirement and the peak use rate, the development of the spring is worthwhile. If the flow over 24 hours meets the requirement for livestock, but the peak use flow does not, then a water storage system will be required.

The infrastructure needed to develop a spring may either be partially or completely buried in-ground. The actual area in which water reaches the surface may be a very small section of the potential of the spring. Excavation parallel to the contour of the land, at or below the spring outlet may substantially increase the flow of the spring. Perforated pipes can be installed in a parallel ditch and backfilled with drain rock. These are then connected to a “spring box” (where water can be gravity fed or pumped to troughs, or a storage facility).

Care must be taken when accessing a spring to ensure that water is not lost in any of the following ways:

- Ensure the spring is free-flowing and fully captured;
- Ensure the water collection is on an impervious surface that will resist seepage; and,
- Ensure the water cannot seep around the outlet pipe by using a cut-off collar.

It is also important to fence off the spring area to prevent trampling and contamination by livestock and to create a ditch around the site to protect it from surface water run-off. Once a suitable spring has been developed, a number of storage options could be considered as described in the sections below.

### 4.0 STORAGE

Water can be captured and stored for use when needed using the methods described above. Storage tanks are used to contain the water. Tanks should generally be sized to hold a three to seven-day supply of water for cattle. Water storage tanks can be made from a variety of materials as long as they safely store water at a reasonable cost. The most common materials are:

- Plastic;
• Fibreglass;
• Concrete;
• Metal tanks;
• Earthen reservoirs;
• Grain bin rings;
• Large rubber tires; or,
• Large stock watering tanks.

Various systems are used to access stored water. Examples of these systems are described below.

Gravity-fed Systems
Ideal systems for sloping pasture land where it is possible to locate a reservoir or dugout upslope from a watering site. A pipeline is then installed from the reservoir into a stock tank. As a general rule, the water level in the reservoir should be a minimum of 1.5 m (5 ft) higher than the stock tank, plus an additional 0.3 m (1 ft) of additional height for every 30 m (100 ft) of pipe.

Animal Operated Pasture Pumps
These pumps are usually referred to as nose pumps because cattle operate them by pushing on them with their noses.

Pipelines
Shallow buried pipelines are ideal for ranches with an intensive rotational grazing systems within 3 km of existing water and mainline power. These systems allow livestock producers to better utilize their water source rather than construction of many small dugouts/reservoirs around the pastures.

Gas-powered Pumping Systems
A low-cost alternative for pumping water to large herds of livestock. The pumps are typically portable and can be moved from one water source to the next.

Solar-powered Pumping System
A reliable, low maintenance system that can be used to pump water from reservoirs. Solar systems often incorporate a battery into their design. A sunny spot is required for these systems, but a location that is not in plain view (theft prevention) and sheltered from high winds is also important. The initial costs of these systems are higher but they are long lasting and save cost over the long term.

Wind-powered Pumping Systems
Windmills perform best in areas that have higher than average wind speeds. Windmills should be sited on high ground (and away from trees) where they have good exposure to the wind.

5.0 HAULING WATER

Water hauling can be a viable alternative, particularly for intensive livestock grazing management as cattle are moved daily from pasture to pasture. By utilizing an old truck with a main storage tank and a mobile stock tank, the watering source can be continuously relocated throughout the pasture along with the cattle. This method can be costly and is often not economically feasible in remote areas.
APPENDIX B

ClimateBC Seasonal Climate Variables
Title: ClimateBC Seasonal Climate Variables
File: 1214.0007.01

Seasons:

Winter (_wt): Dec. (prev. yr) - Feb for annual, Jan, Feb, Dec for normals
Spring (_sp): March, April and May
Summer (_sm): June, July and August
Autumn (_at): September, October and November

Directly calculated seasonal variables:

Tave_wt  winter mean temperature (°C)
Tave_sp  spring mean temperature (°C)
Tave_sm  summer mean temperature (°C)
Tave_at  autumn mean temperature (°C)

Tmax_wt  winter mean maximum temperature (°C)
Tmax_sp  spring mean maximum temperature (°C)
Tmax_sm  summer mean maximum temperature (°C)
Tmax_at  autumn mean maximum temperature (°C)

Tmin_wt  winter mean minimum temperature (°C)
Tmin_sp  spring mean minimum temperature (°C)
Tmin_sm  summer mean minimum temperature (°C)
Tmin_at  autumn mean minimum temperature (°C)
PPT_wt  winter precipitation (mm)
PPT_sp  spring precipitation (mm)
PPT_sm  summer precipitation (mm)
PPT_at  autumn precipitation (mm)

RAD_wt  winter solar radiation (MJ m\(^{-2}\) d\(^{-1}\) )
RAD_sp  spring solar radiation (MJ m\(^{-2}\) d\(^{-1}\) )
RAD_sm  summer solar radiation (MJ m\(^{-2}\) d\(^{-1}\) )
RAD_at  autumn solar radiation (MJ m\(^{-2}\) d\(^{-1}\) )

**Derived seasonal variables:**

DD_0_wt  winter degree-days below 0°C
DD_0_sp  spring degree-days below 0°C
DD_0_sm  summer degree-days below 0°C
DD_0_at  autumn degree-days below 0°C

DD5_wt  winter degree-days below 5°C
DD5_sp  spring degree-days above 5°C
DD5_sm  summer degree-days above 5°C
DD5_at  autumn degree-days above 5°C
DD_18_wt  winter degree-days below 18°C
DD_18_sp  spring degree-days below 18°C
DD_18_sm  summer degree-days below 18°C
DD_18_at  autumn degree-days below 18°C

DD18_wt  winter degree-days below 18°C
DD18_sp  spring degree-days above 18°C
DD18_sm  summer degree-days above 18°C
DD18_at  autumn degree-days above 18°C

NFFD_wt    winter number of frost-free days
NFFD_sp    spring number of frost-free days
NFFD_sm    summer number of frost-free days
NFFD_at    autumn number of frost-free days

PAS_wt    winter precipitation as snow (mm)
PAS_sp    spring precipitation as snow (mm)
PAS_sm    summer precipitation as snow (mm)
PAS_at    autumn precipitation as snow (mm)

Eref_wt    winter Hargreaves reference evaporation (mm)
Eref_sp    spring Hargreaves reference evaporation (mm)
Eref_sm    summer Hargreaves reference evaporation (mm)
Eref_at    autumn Hargreaves reference evaporation (mm)
CMD_wt    winter Hargreaves climatic moisture deficit (mm)
CMD_sp    spring Hargreaves climatic moisture deficit (mm)
CMD_sm    summer Hargreaves climatic moisture deficit (mm)
CMD_at    autumn Hargreaves climatic moisture deficit (mm)

RH_wt    winter relative humidity (%)
RH_sp    winter relative humidity (%)
RH_sm    winter relative humidity (%)
RH_at    winter relative humidity (%)
APPENDIX C

Presentation and Engagement Materials
Climate Change Risk Assessment Tool for Ponds Used as Livestock Water Sources

For BC’s ranching community, it is important to maintain the use of BC grasslands to ensure optimum rangeland productivity. In order to access the available forage, livestock require a sustainable water source. However, over the last century, climate change has contributed to the loss of a large percentage of the world’s wetlands. In British Columbia’s (BC) semi-arid grassland ecosystems, a reduction in size and number of livestock watering ponds has been identified. These ponds are at further risk of reduction due to predicted continuing changes in climate.

The intent of this project is to develop a prototype online tool for identifying the risk to currently stable livestock watering ponds based on future climate projections. The tool will be accessed through the internet and will be preloaded with a BC rangeland climate model. Ranchers will provide the other information needed to assess individual ponds, such as the pond location, depth, seasonal fluctuations, surface runoff and surrounding vegetation. The tool will then combine the climate information with the rancher’s answers to several questions and provide an assessment of the risk of decline for the individual pond.

The tool is intended for use by producers and industry advisors in the southern interior of BC to identify the risk level associated with ponds that are important to grazing management. The pond risk assessments can be used in planning proactive adaptation strategies to maintain livestock water sources. The tool will also provide data that can be used to leverage and support funding for capital projects needed to sustain and/or increase livestock water supply.

How You Can Help

To ensure the model is relevant and meets the needs of the producers and industry advisors who will use it, we need your input. Below are a series of questions that refer to a natural grassland pond used as a livestock watering source. Please answer these questions, basing your answers on a pond on your range. We will input your answers into our model and look at climate projections for your area to develop a risk assessment that is specific to your pond. We are also interested in your thoughts on how we can make this tool better. Please provide feedback on the attached form.

1. Location of your pond (name of range or nearby town): _______________________________________

2. Is there consistently surface water in your pond year round?
   a. Yes   b. No   c. Unknown

3. How would you describe the seasonal fluctuations in water level?
   a. Large fluctuations   b. Moderate fluctuations   c. Small fluctuations

4. Have you ever noticed surface runoff flowing into the pond?
   a. Yes   b. No

5. What is the approximate maximum depth of the pond?
   a. Greater than 2 meters   b. Between 1 and 2 meters   c. Less than 1 meter

6. How would you describe the vegetation growing in the pond?
   a. Growing at the perimeter   b. No vegetation growing in the pond   c. Unknown

7. Are any of these species present in or around the pond (see images on back)?
   a. Bulrush, cattails, sedges, water lily, willow (or other trees in close proximity)
   b. Silverweed, foxtail barley, nuttals alkali grass
   c. Red glass wort (or evidence of a salt ring around the pond)
Climate Change Impact Risk Assessment Tool for Ponds Used as Livestock Water Sources
Background

- A recent study funded by the Ranching Task Force of British Columbia revealed considerable declines in BC’s grassland ponds.

- Individual ponds differ in their sensitivity to changes in climate.
Pond Risk Assessment Tool

• Predicts a level of risk for individual ponds.
• Benefits for you of the risk assessment include:
  - Anticipate how your pond may react to projected changes in climate.
  - Allow you time to prepare strategies to deal with potential water shortages.
  - Give you evidence you may need to support funding for increasing water supply on your range.
How it Works

Are any of these species present in or around the pond?

- Bulrush, cattails, water lily, willow (other trees in close proximity)
- Silver-weed, fox-tail barley, nuttals, alkali grass
- Red Glass Wort (or evidence of salt ring around the pond)
Live Demonstration

• Climate Grid
  - https://urbansystems.truvian.com/#/map/ggOHC696RhqLXsd5Z89-Ng

• Pond Assessment Questionnaire
  - https://surveys.qualtrics.com/SE/?SID=SV_cDdKwjUYv67e7ml
Rangeland Ponds in BC

A Risk Assessment Tool for Ponds Used as Livestock Water Sources

BC's rangelands represent 1% of the provincial land base, 96% of which are working rangelands.

Evaluating future impacts to livestock watering ponds

Land Mass

BCs rangelands represent 1% of the provincial land base, 96% of which are working rangelands.

Are your ponds at risk?

Significant decline in number and surface area of ponds over 20 years

Changes in pond number

63% decrease

1990s to 2010s

Changes in pond surface area

54% reduced

1990s to 2010s

Resources

Changes in climate may be responsible for these declines

Snow Pack

Increases in winter temperatures impact snowpack accumulation and contribution to early spring melt.

Evaporation

Increases in summer temperature result in higher evaporation rates.

Grasslands provide economic and cultural benefits. They are valuable as a source of carbon sequestration, clean water and air, and high quality low-cost forage for the ranching community. Grasslands are classified as semi-arid and have limited sources of fresh water to support cattle. Freshwater ponds provide a source of drinking water for cattle during grazing.

A recent study reported a decline in the number of ponds and surface area of water over the last 20 years, citing climate change as a major contributing factor. The loss of natural livestock watering sources can lead to declines in productivity and ultimately, economic uncertainty.
FOR BC’S RANCHING COMMUNITY, IT IS IMPORTANT TO MAINTAIN THE USE OF BC GRASSLANDS TO ENSURE OPTIMUM PRODUCTIVITY. IN ORDER TO ACCESS THE AVAILABLE FORAGE, LIVESTOCK REQUIRE A SUSTAINABLE WATER SOURCE.
RECENT STUDIES SUPPORT WHAT BC RANCHERS HAVE NOTICED, THAT BC’S GRASSLAND PONDS HAVE DECREASED IN NUMBER AND SIZE OVER THE LAST 15 TO 20 YEARS. CHANGES IN BC’S CLIMATE MAY BE LINKED TO THESE DECLINES.
BC ranchers have been concerned for some time about the decline of livestock watering ponds in BC’s rangelands, which are critical to the ability of their livestock to access forage resources.
THIS TOOL WILL PROVIDE A WAY FOR RANCHERS TO DETERMINE THE RISK OF DECLINE TO CURRENT PONDS ON THEIR RANGELANDS. OUR TEAM IS DEVELOPING A CLIMATE CHANGE IMPACT RISK ASSESSMENT TOOL FOR PONDS USED AS LIVESTOCK WATER SOURCES.
Feedback – We are interested in your thoughts on this tool. Please provide feedback below.

Will the information provided by the tool be useful to you for long-term range management and planning? (Please circle one)

a) Yes  b) No

Why or why not?

How can we make this tool better?

Any other comments?
APPENDIX D

Press Release and News Articles
Online Tool to Help Ranchers Plan for Drying Ponds in B.C.’s Rangelands

Kamloops, December XX, 2016 – A team of researchers from Urban Systems and Thompson Rivers University (TRU), are developing an on-line tool to help ranchers predict the risk of decline to ponds on their rangelands.

A previous study, funded by the Ranching Task Force of B.C., supports what B.C.’s ranchers have known for years – that B.C.’s grasslands closed-basin ponds are drying up due to changes in climate. That’s particularly bad news for local ranchers who graze livestock on grasslands, and rely on ponds to provide a much-needed sustainable water source for their animals.

The Climate Change Impact Risk Assessment Tool will be accessed through the internet and will be preloaded with a B.C. rangeland Global Information System (GIS) climate model. Ranchers will provide the other information needed to assess individual ponds, such as the pond location, depth, seasonal fluctuations, surface runoff and surrounding vegetation. The tool will then combine the GIS information with the rancher’s answers to several questions and provide an assessment of either high risk, moderate risk or low risk of decline for the individual pond.

“Once finalized, the tool will help ranchers anticipate how their ponds may react to projected changes in climate,” says Dr. Tom Pypker, Assistant Professor from TRU. “Our main goal in providing this information is to help equip ranchers to proactively plan for how to deal with future water shortages on their rangelands.”

To help refine the tool and make sure it is easy for ranchers to use, the research team is asking ranchers to test a prototype and get involved in focus groups.

“We plan to work closely with ranchers and other end users of the tool to identify whether the tool is asking the right questions of ranchers and if the information provided by the tool is in a format that they can easily use,” says Aaron Coelho, Water Resources Consultant with Urban Systems.

Ranchers at a recent meeting of the Kamloops Stockmen’s Association had an opportunity to try the tool and provide feedback. The ranchers indicated that it would be valuable to have region-wide evidence of water shortages to back up their observations. They also indicated that the tool will need to focus on more predictive capacity to be useful for water management.
This first phase in the project will result in a tool prototype. The team will be seeking alternate funding in 2017 to bring the tool to general use and make it accessible to all B.C. ranchers.

The Climate Change Impact Risk Assessment Tool project is part of the work being delivered by the BC Agriculture & Food Climate Action Initiative (CAI). CAI develops tools and resources to assist B.C. farmers and ranchers with adapting to impacts of climate change. CAI's Farm Adaptation Innovator Program engages directly with producers and local partners, providing funding for piloting, demonstration and knowledge transfer around farm level adaptation.

Funding for this project has been provided by the Governments of Canada and British Columbia through the Investment Agriculture Foundation of BC under Growing Forward 2, a federal-provincial-territorial initiative. The project is also receiving in-kind support from Thompson Rivers University, the BC Ministry of Agriculture and the BC Ministry of Forest, Lands, and Natural Resource Operations.

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For More Information Contact:

Aaron Coelho, M.Sc., A.Ag.
Urban Systems Ltd
250-374-8311
acoelho@urbansystems.ca

Dr. Tom Pypker
Thompson Rivers University
250-374-5414
typker@tru.ca
Researchers from Urban Systems and Thompson Rivers University (TRU) are developing an online tool to help ranchers predict the risk of decline to ponds on their rangelands.

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The team will be seeking alternate funding in 2017 to bring the tool to general use and make it accessible to all B.C. ranchers.
Ranching water management? There will be an app for that

By Cam Fortems - December 20, 2016

Water availability is essential to ranching operations in the Kamloops region. Tim Ennis photo

Those behind a project intended to give ranchers warning before key cattle-irrigation ponds dry up hope to move into a new phase of adding data and refining the tool.

The project comes out of a master’s thesis project done by one of the partners in the project, Aaron Coelho, who originally sought to quantify drying of ponds used in the high country as part of the background study for B.C.’s ranching task force in 2009.
Two of the locations he looked at include Lac Du Bois and the Hamilton Commonage in Nicola Valley.

His thesis found that, from the early 1990s, there was upwards of a 50 per cent decrease in available water overall from the six locations under study.

“At Lac Du Bois, there’s one pond I studied where it’s the lowest I’ve ever seen it,” Coelho said.

The decrease has a relationship to depletion of groundwater and lack of recharge.

Coelho, through employer Urban Systems, is partnering with Thompson Rivers University professor Tom Pypker on the online tool for water management.

They have shown it to ranchers, including at a recent Kamloops Stockmen’s Association meeting, to get feedback.

However, before it can be placed in their hands, Coelho said they need funding in 2017 to add more data that will include more grassland areas.

It has been funded through the federal-provincial Growing Forward 2 program.

Thus far, the project remains in the demonstration phase, but Coelho said it shows promise as a working tool.

Once it is further developed, ranchers will be able to answer a series of questions about a particular pond.

The online tool will combine that information with its overall dataset to make predictions about the future.

Once it is fully developed, Coelho said a smartphone-based app would be able to instruct a rancher “in three to 10 years, your pond is either high-risk, medium-risk or low-risk” to disappear.

That would give ranchers a heads-up so they can look at alternatives, including, for example, trucking in water or developing deep groundwater wells.
Online tool could help B.C. ranchers prepare for drought

Ranchers in the Kamloops area now have tool to help them predict impacts of climate change on ponds

By Jenifer Norwell, CBC News  Posted: Dec 21, 2016 7:00 AM PT Last Updated: Dec 21, 2016 7:00 AM PT

Aaron Coelho has found ponds in the Kamloops area have seen a 50 percent reduction in size and number. (Tom Pypker)

Thompson Rivers University has teamed up with a company in Kamloops to develop an online tool to help ranchers manage climate change.
For the past few years, Aaron Coelho has been looking into the decline of ponds in the area's ranchlands. He started out with a study to confirm anecdotal evidence from ranchers that ponds were becoming less common and shrinking in size as part of his masters in environmental science.

Aaron Coelho with Urban Systems is working with a team of researchers to develop an online tool to model drying ponds in B.C. (Tara Copeland/CBC)

"What I did see was a lot of dry ponds," said Coelho who is now a water resources consultant with Urban Systems.

**Ponds shrinking in B.C.**

His findings backed up what he saw on the ground. In a region-wide study of B.C., Coelho found a decline of more than 50 percent of surface water since the early 1990s. This drop in access to water causes major challenges to ranchers because cattle won't choose to graze in areas that don't have accessible water.
"It shows a shift in this ecosystem and it's driven by climate and there's nothing saying this trend isn't going to continue," he said.

"It could even get worse."

- **B.C. snowpack reaches record low for May**
- **B.C. has seen worse droughts than previously thought, tree rings reveal**
- **B.C. drought: Vancouver water restrictions a wake-up call for residents and politicians**

When he took this information to ranchers in the area, Coelho found people wanted to know how to use this information to manage their water sources. That lead to his current project.

He's currently working with Tom Pypker, an assistant professor in the department of natural resource sciences at Thompson Rivers University. They are developing the Climate Change Impact Risk Assessment Tool.

Aaron Coelho is developing a climate modelling tool to identify where the risk areas are for drought. (Aaron Coelho)

The first part of the tool allows ranchers to zoom into an area using a program like Google Earth.

Ranchers can find their farm and then click on it to see what the risk factor is for future drought for each part of the property.
They also have to fill out a short questionnaire to figure out where the water in the pond comes from and how that might affect how resilient it is to climate change.

The climate modelling tool shows what the risk of climate change is over time. (Aaron Coelho)

"They can then project, 'OK, 30 years from now the climate doesn't look favourable. This pond may be at risk. I may need to think about other ways to bring water to my range,'" said Pypker.

**Lakes and ponds drying up**

This is the kind of tool that Bob Haywood-Farmer could have used over a decade ago. He has been ranching in the Savona area just west of Kamloops his whole life.

In his lifetime, he's seen dramatic changes to how much water cattle on his farm can access.

"We've got lakes that used to have water in them that we haven't seen water in now for 15 years," said Haywood-Farmer.
Cattle won't graze in areas that don't have good access to water. (Aaron Coelho)

Despite that he's not sure how he would end up using the predictive tool.

"It might be useful on ones where the ponds still have water," he said. "So many of our ponds have already dried up that we pretty much know where we're at with those."

**Online tool to help with planning**

Coelho is hoping this new online tool will help ranchers develop a plan for water management.

"The advantage that the tool gives is it gives them a sense of what might happen in the future which of course none of us can really predict unless we have some good model and good data to base the model on," said Coelho.

Coelho and his team are hoping they will be able to release the tool more broadly in 2017 so ranchers across the province can use it.
Each year, as average temperatures rise and snowfall levels slowly decline, concerns over water security are building throughout British Columbia, as well as elsewhere in Canada. Of the numerous communities effected by drought conditions, ranchers in BC, whose closed-basin ponds are drying up due to changes in the climate, tend to feel the impact particularly hard. Access to sustainable and reliable water sources like these ponds is integral to providing nourishment for their animals, not simply as a drinking source, but also in maintaining the grasslands that feed the livestock.

Aaron Coelho, Water Resources Consultant, became aware of this challenge through his Masters Thesis research at Thompson Rivers University.

“I evaluated the extent of water loss in BC’s semi-arid rangelands and found that there was an over 50% decline in surface water from the early 1990s to the early 2010s. When presenting this information to the...
ranching community, they often asked, ‘What can we do about it?’” Coelho explained. “This is a tough question because the problem is climate driven and there are no easy solutions. When it comes to changes in climate the best thing we can do is adapt.”

Dr. Tom Pypker – Thompson Rivers University

Coelho’s innovative research earned him the Governor General’s Academic Gold Medal, one of the highest awards offered to Canadian graduate students. Determined to turn his findings into something that could have an impact, in May of 2016, together with Dr. Tom Pypker, Associate Professor at TRU and Coelho’s thesis supervisor, he began developing a tool to help assess the given risks of individual ranchers.

The result of their work is the Climate Change Impact Risk Assessment Tool, a web-based tool that the team is using to predict the risk of decline of ponds on rangelands throughout the province. It combines BC’s rangeland Geographic Information System (GIS) climate model with information provided by individual ranchers such as pond location, depth, seasonal fluctuations, surface run-off and surrounding vegetation, to provide an assessment of the potential for decline of the identified pond, at either a high, moderate or low risk.

Recently, Coelho and Pypker met with the Kamloops Stockmen’s Association, where members had the opportunity to test out the first phase of the tool and provide feedback on its functionality. Overall, the response was positive, with ranchers emphasizing the value of having the evidence of the water shortages to back up what they have been observing for some time now.

“We plan to work closely with ranchers and other end-users of the tool to identify whether it is asking the right questions of ranchers and if the information provided by the tool is in a format that they can easily use.” stated Coelho.

After reviewing the feedback they have received, Coelho and Pypker will develop a tool prototype, which they aim to complete by the end of March, 2017. They are also currently seeking alternative funding to work on making the tool available to general use, including ranchers throughout BC.

Coelho stated that he hopes this tool will integral in gathering regionwide data that helps to support the individual observations ranchers have been making for years. This could be the key to providing scientific evidence to support ranchers with at-risk grasslands as they apply for funding to implement water management tools and strategies to better prepare for drought-like conditions.

He is optimistic about how the project will assist ranchers throughout the province. “When the tool is completed, the intent will be to provide ranchers with information about their water sources that will help them plan and adapt to future conditions.”

End Note: Funding for this project to date has been provided by the Governments of Canada and British Columbia through the Investment Agriculture Foundation of BC under Growing Forward 2, a federal-provincial-territorial initiative. It has also received in-kind support from Thompson Rivers University, the BC Ministry of Agriculture and the BC Ministry of Forests, Lands, and Natural Resource Operations.