A tool to estimate and reduce GHGs from farms

The purpose of this document is to provide an introduction on how to use the Holos model (version 4) and the required vs. optional inputs.

For the purpose of this training, we are going to create a farm that has an annual beef production system, and a feed crop production system. The farm is located in Manitoba near Portage La Prairie.

Launch Holos

Please note that Holos 4 can be installed on a Microsoft Windows PC only. Mac OS will be supported in the next version.

Launch Holos by double-clicking on the Holos desktop icon. If there are no saved farms in the system, Holos will create a new farm and ask the user for a farm name and an optional comment (Figure 1). If there is already a saved farm in the system, Holos will ask the user to open the existing farm or to create a new farm (Figure 2).

Enter "**Holos 2022**" as a farm name and "**training version**" as the "**comment**". Ensure to click the "**Advanced Mode**" button so that additional features and functionality will be available. Click "**Ok**" to proceed to the next screen

Ensure "**Metric**" is selected as the unit of measurement type and then click the "**Next**" button at the bottom of the screen (Figure 3).

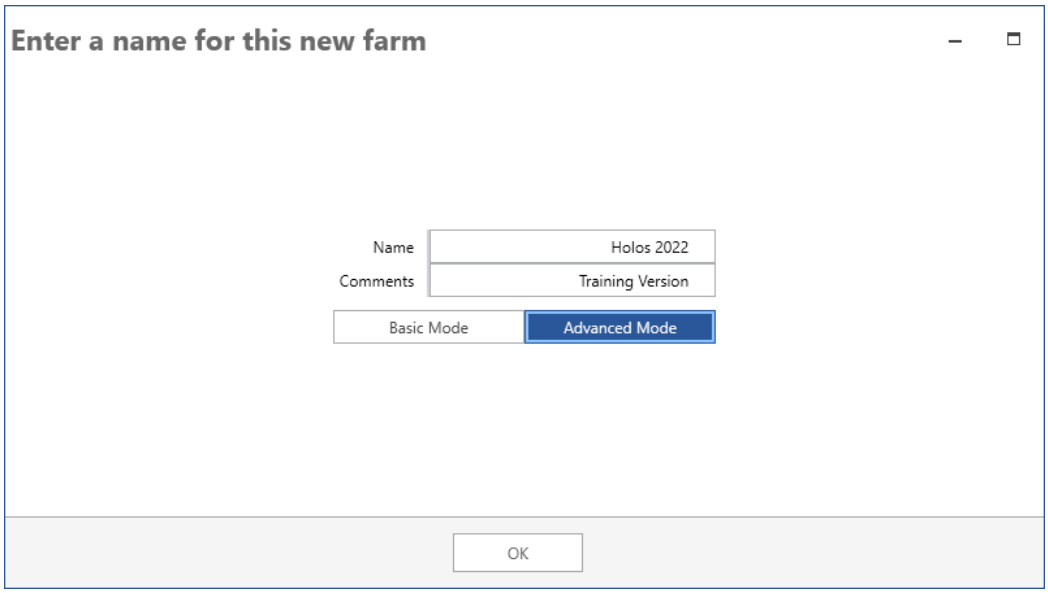

Figure 1: Entering a name for the new farm.

Figure 2: If a farm has been previously saved, Holos will prompt to re-open that farm.

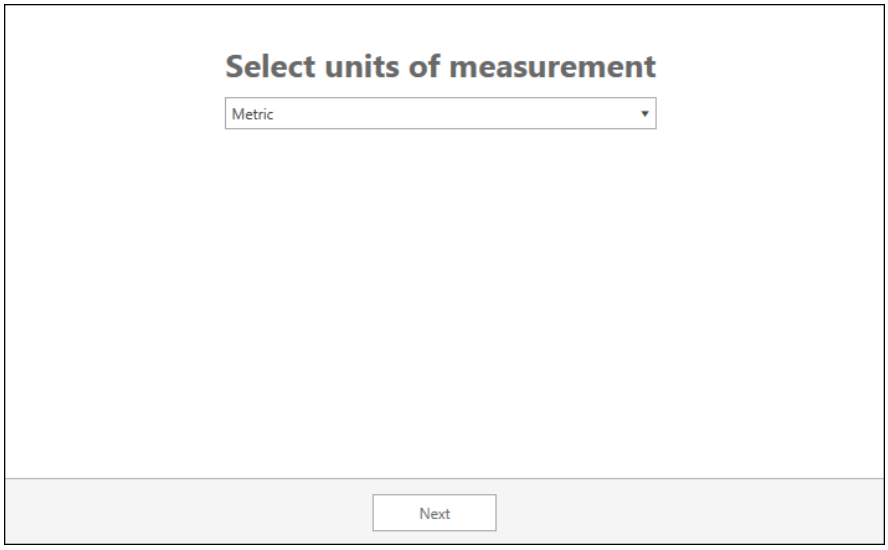

Figure 3: Select metric as the unit of measurement.

Creating and locating the new beef farm

The beef farm that we will create for this exercise is located in the province of Manitoba. Select "**Manitoba**" on the "**Select a province**" screen, and then click the "**Next**" button.

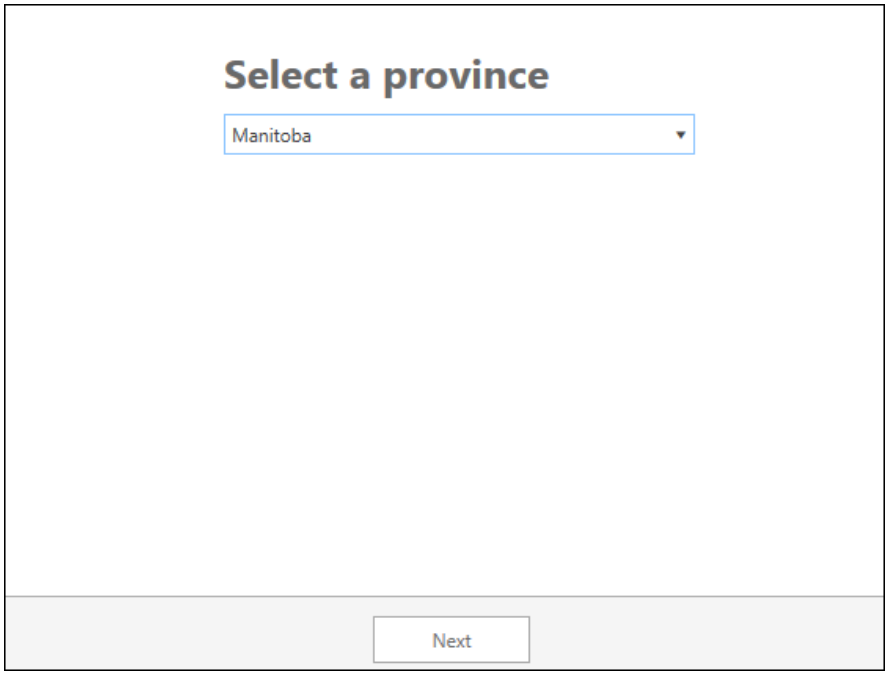

Figure 4: Select manitoba as the province.

Holos uses **Soil Landscapes of Canada** (SLC), which are a series of GIS coverages that show the major characteristics of soils and land for all of Canada (compiled at a scale of 1:1 million). SLC polygons may contains one or more distinct soil landscape components.

The "Farm Location" screen brings up a map of Canada with the province of Manitoba centered on the screen (Figure 5).

The map contains red colored polygons that can be selected by moving the cursor over the region that contains the location of your farm. You can zoom in or out of the map by using the mouse wheel or by hovering the cursor over the zoom icon at the bottom of the screen.

The beef farm for this example is located between Winnipeg and Portage la Prairie (Portage) with SLC polygon number **851003**.

1. Find and right-click on this polygon to select it on the map. Note that at this point daily climate data will be downloaded from NASA. You can also select a specific polygon by clicking the "Enter a Polygon" button (Figure 6).

Note: Climate data is central to most calculations performed by Holos. For the most accurate estimation of farm emissions, measured climate data should be provided by the user which will override the default data obtained from the NASA weather API.

Holos will use daily precipitation, temperature, and potential evapotranspiration values to model soil carbon

change (climate parameter), nitrous oxide emissions, as well as ammonia volatilization.

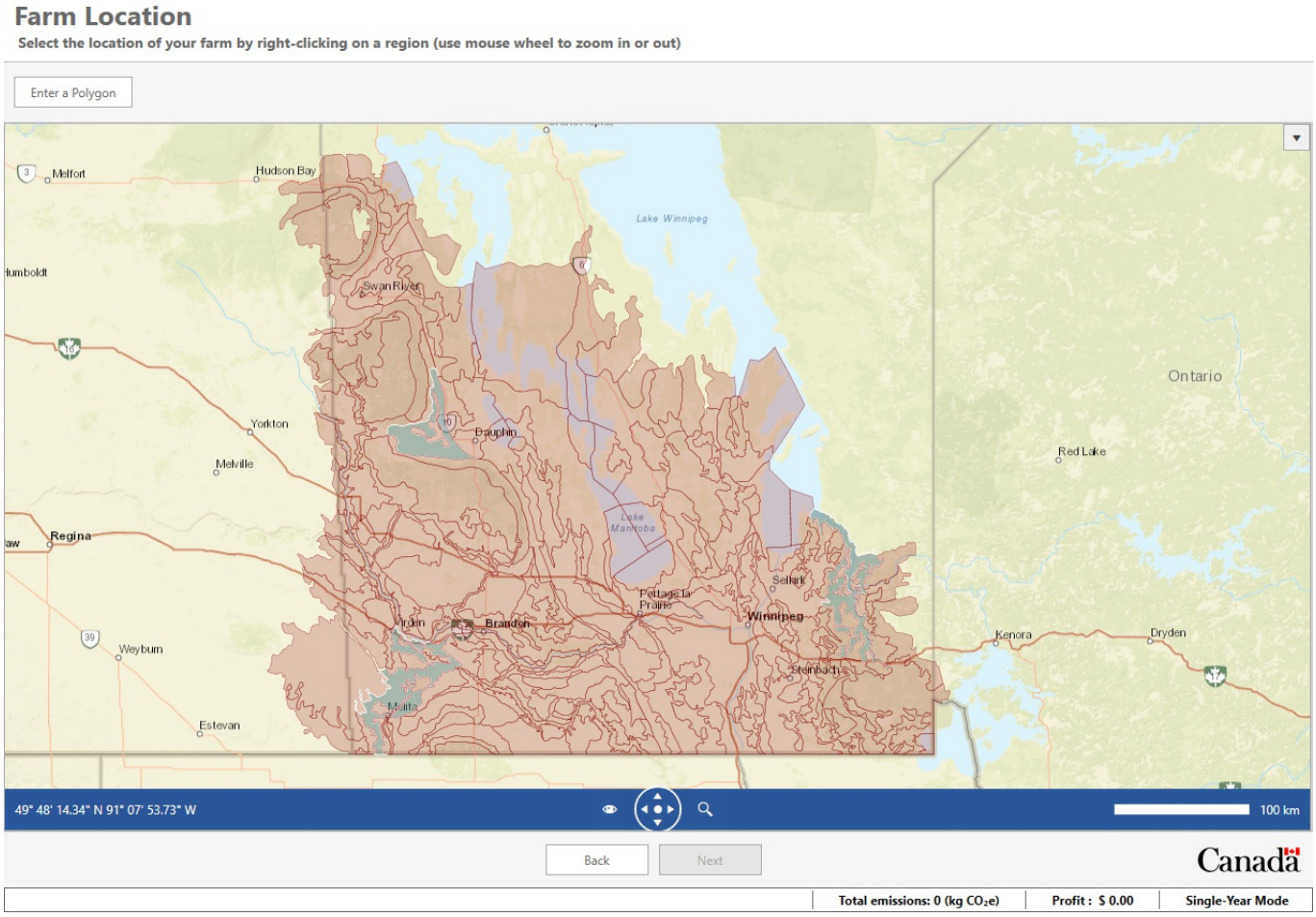

Figure 5: Map of the Manitoba province showing the different selectable polygons.

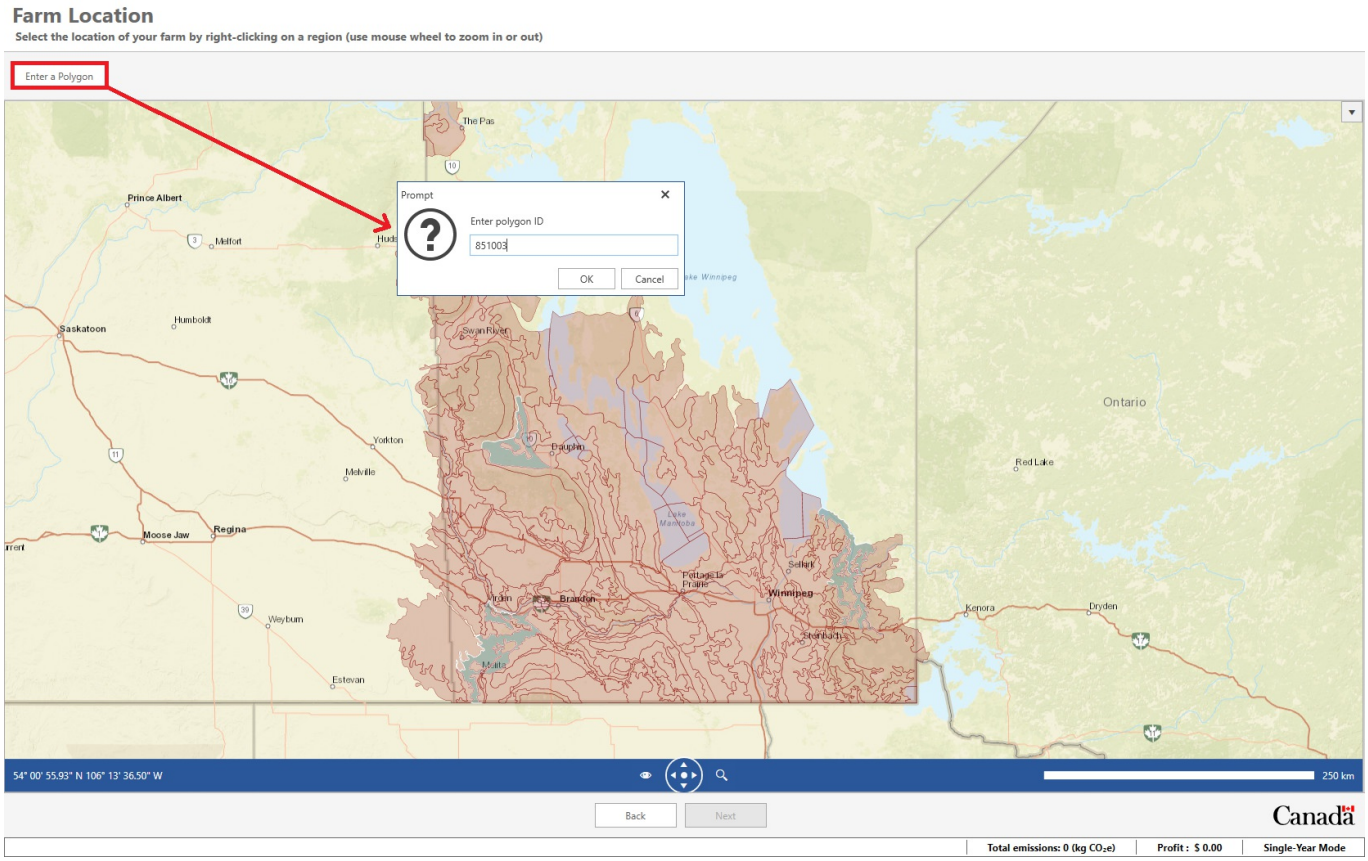

Figure 6: Specifying a polygon ID using the option button.

Once the farm location is selected, soil information (texture, sand, and clay proportions) for the types of soils found in this region are displayed on the right side of the screen. It's possible that more than one soil type per region will be found and the user is expected to select their soil type from this list or use the default selection. (Figure 7)

For this tutorial, keep the default first selected soil type, and keep the default "Hardiness zone".

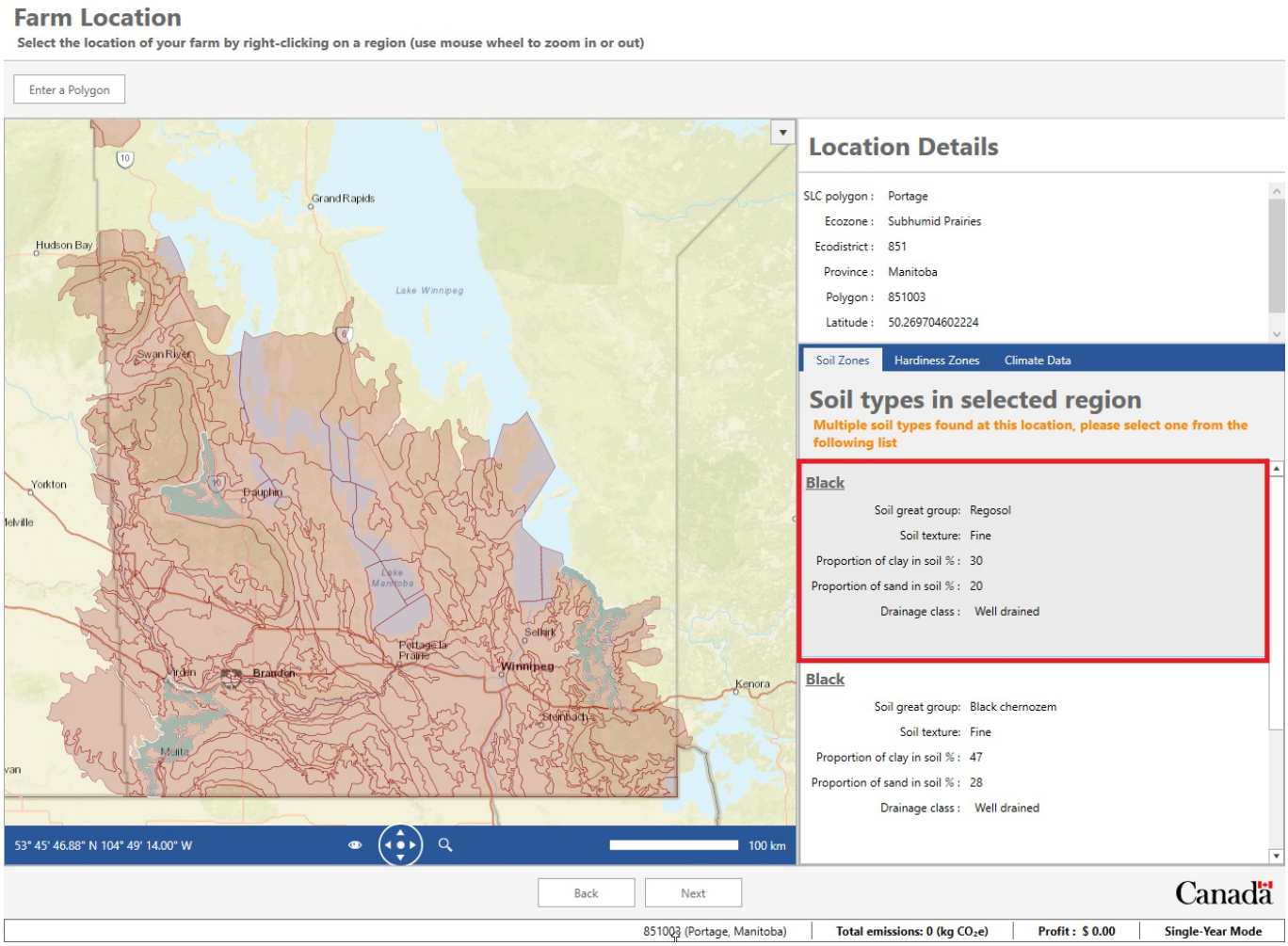

Figure 7: Multiple soil types might be available for a given region.

Note: Soil data obtained from the user's selected location will be used in the calculation of location-specific N2O emission factors. Properties such as soil texture, top layer thickness, and soil pH are required for these calculations, and can be overwritten.

Click the "Next" button to proceed to the next step.

Selecting farm Components

Now that the farm location has been selected, we can move on to the "Component Selection" screen. This is where the user can select different components for their farm. Holos will display all available components on the left side of the screen under the "All Available Components" column (Figure 8). These components are grouped into various categories including Land Management, Beef Production and Dairy Cattle.

If we click on the drop downdrop-down button next to a categories' name, we can then see the available components in that category. For this portion of the training section, we will be are working with the "Land management" and "Beef production" categories.

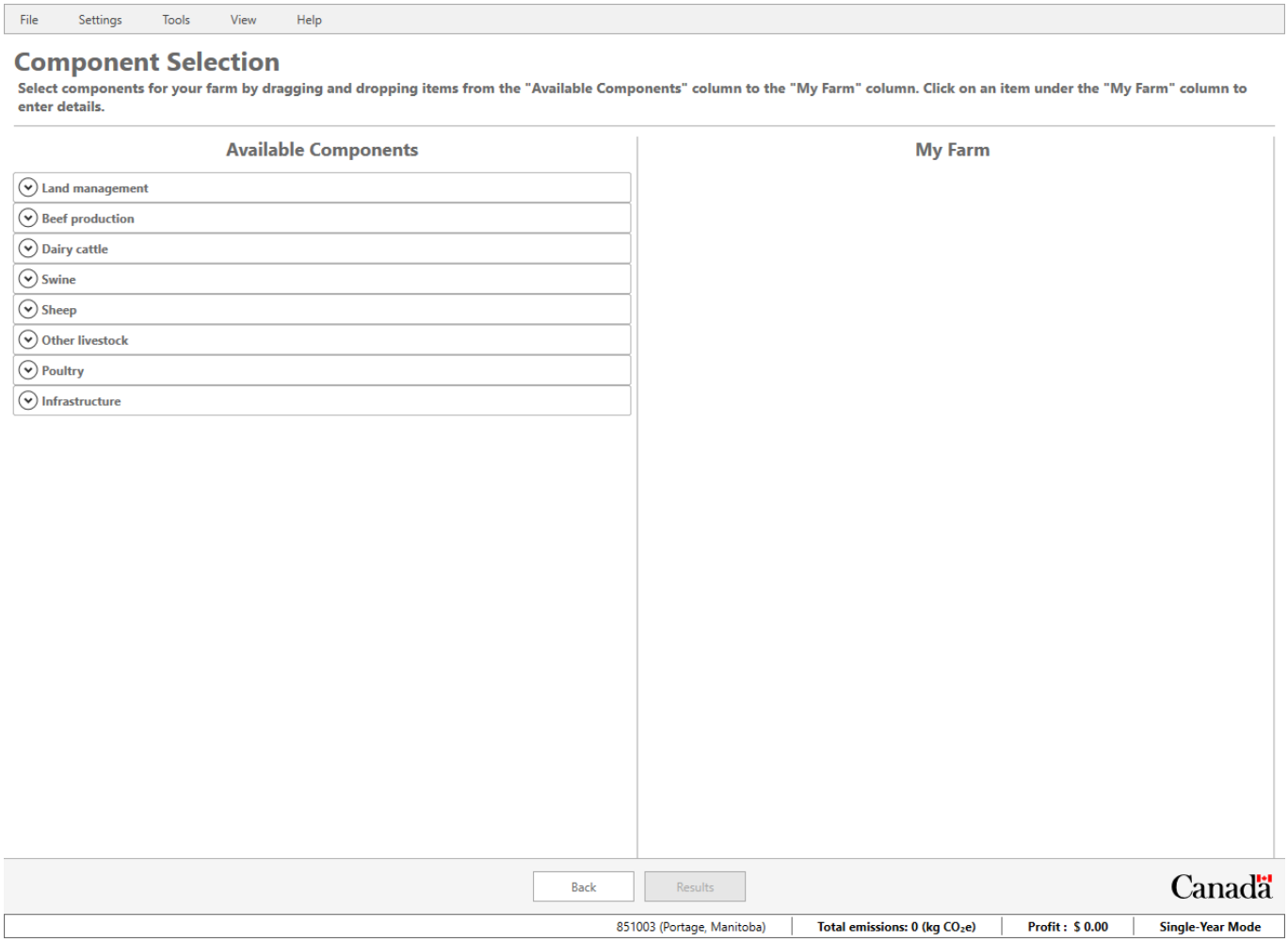

Figure 8: The available components screen. Specific components can be chosen here to include in the farm.

The Holos model is designed to define the land management before livestock. This is because we are allowing livestock to be placed onto a specific pasture (field) for grazing, and that is easier done when a pasture field has been defined already (otherwise the user would have to interrupt the livestock setup to setup a field).

Crop and Hay Production

Note: In order to calculate soil carbon change for fields and crop rotations, click on the “Settings” menu and select the “Multi-year” option (default is Single-Year).

Now we can add our first component to the farm. Drag a “Field” component from the left side of the screen and drop it on the “My Farm” on the right side (Figure 6). The screen will now update to reflect this new component that you have added to your farm. Holos will label the field as “Field #1”. At this point, we can now enter production information related to the crop being grown on this field.

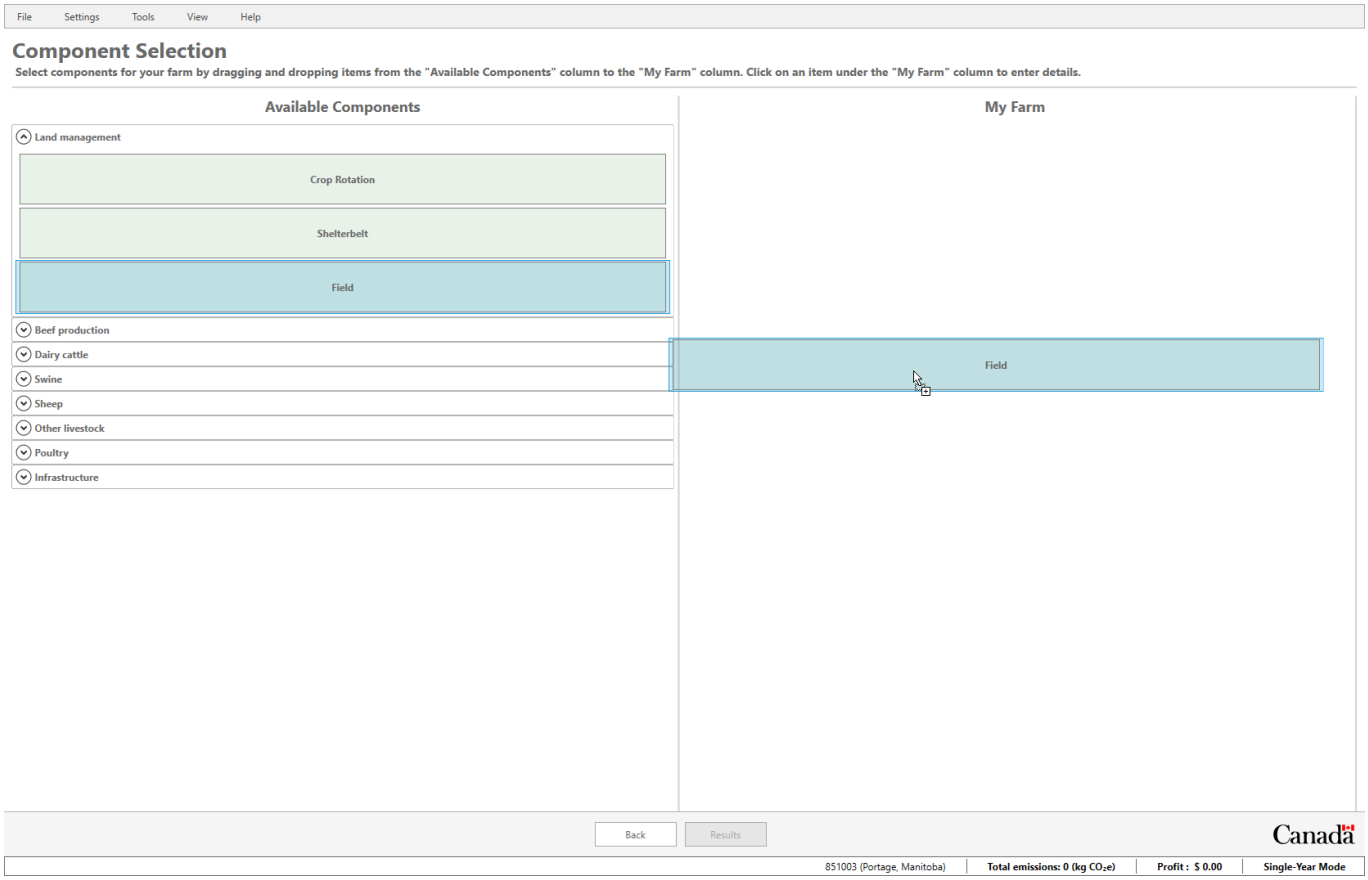

Figure 9: Adding a component to the farm.

Wheat with Cover Crop

Our first field on the farm will grow continuous wheat with a cover crop of hairy vetch. Change the following elements in the "**Field #1**" component.

1. Rename the field to "**Wheat & Hairy Vetch**" in the "**Step 1**" section of the screen. Change the area of the field to **18 ha**.
2. Select "**Wheat**" as the main crop and "**Hairy Vetch**" as the cover crop in "**Step 2**".
3. Under the "**General**" tab:
    - Select "**Reduced Tillage**" as the tillage type.
    - Enter a yield of **3000 kg/ha** (wet weight). The dry weight value will automatically be calculated based on the moisture content of crop value.
    - Enter "**200**" as the amount of irrigation.
    - Select '**0**' as the pesticide passes.

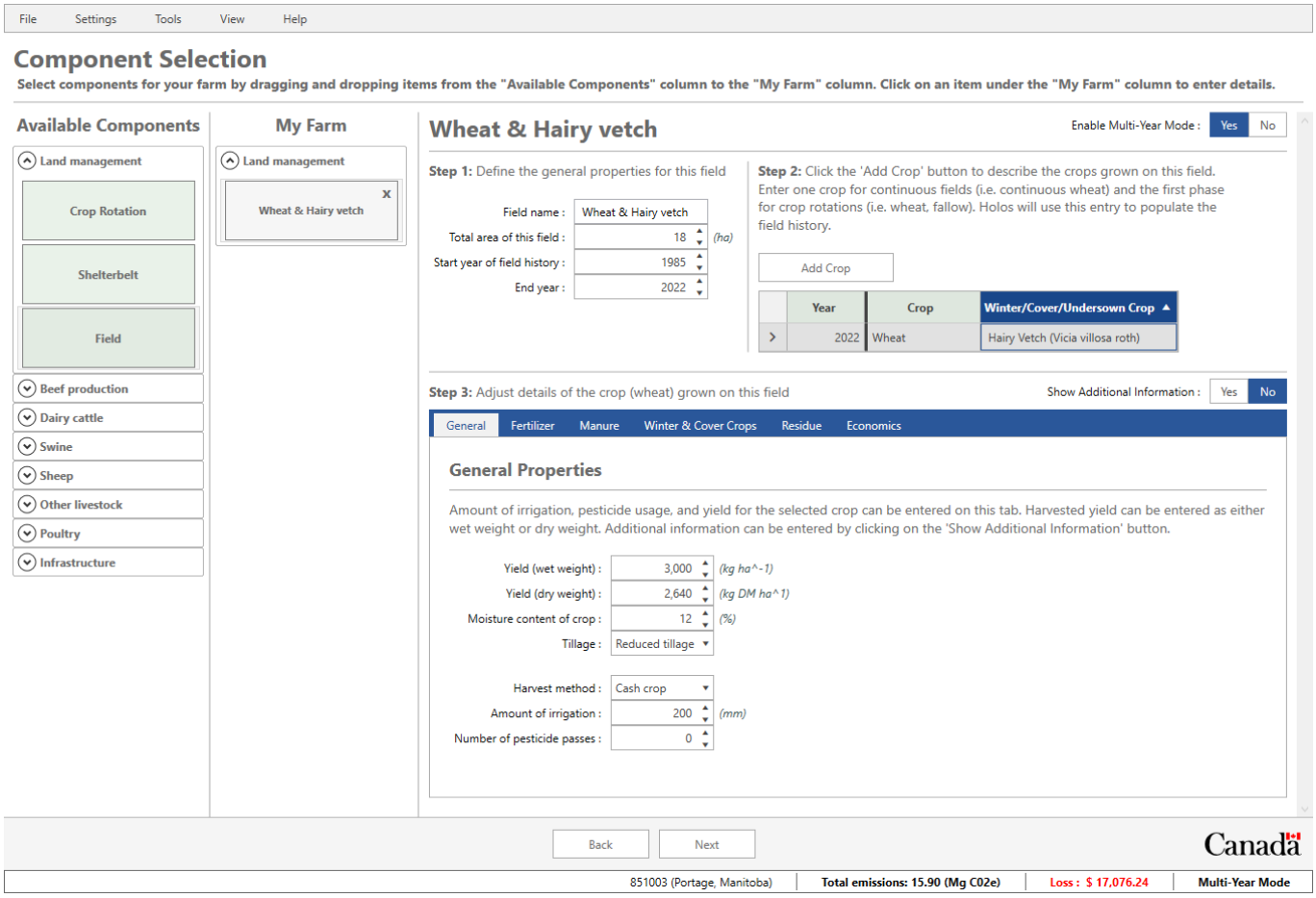

Figure 10: Field Component of the farm.

4. Select the '**Fertilizer**' tab and click the "**Add Fertilizer Application**" button. Holos has now added a new fertilizer application for this field and will suggest Urea as the fertilizer blend. A default application rate is calculated based on the yield value entered for this field. Details of this fertilizer application can be changed by clicking the "Show Additional Information" button (e.g., season of application, different fertilizer blend, etc.).

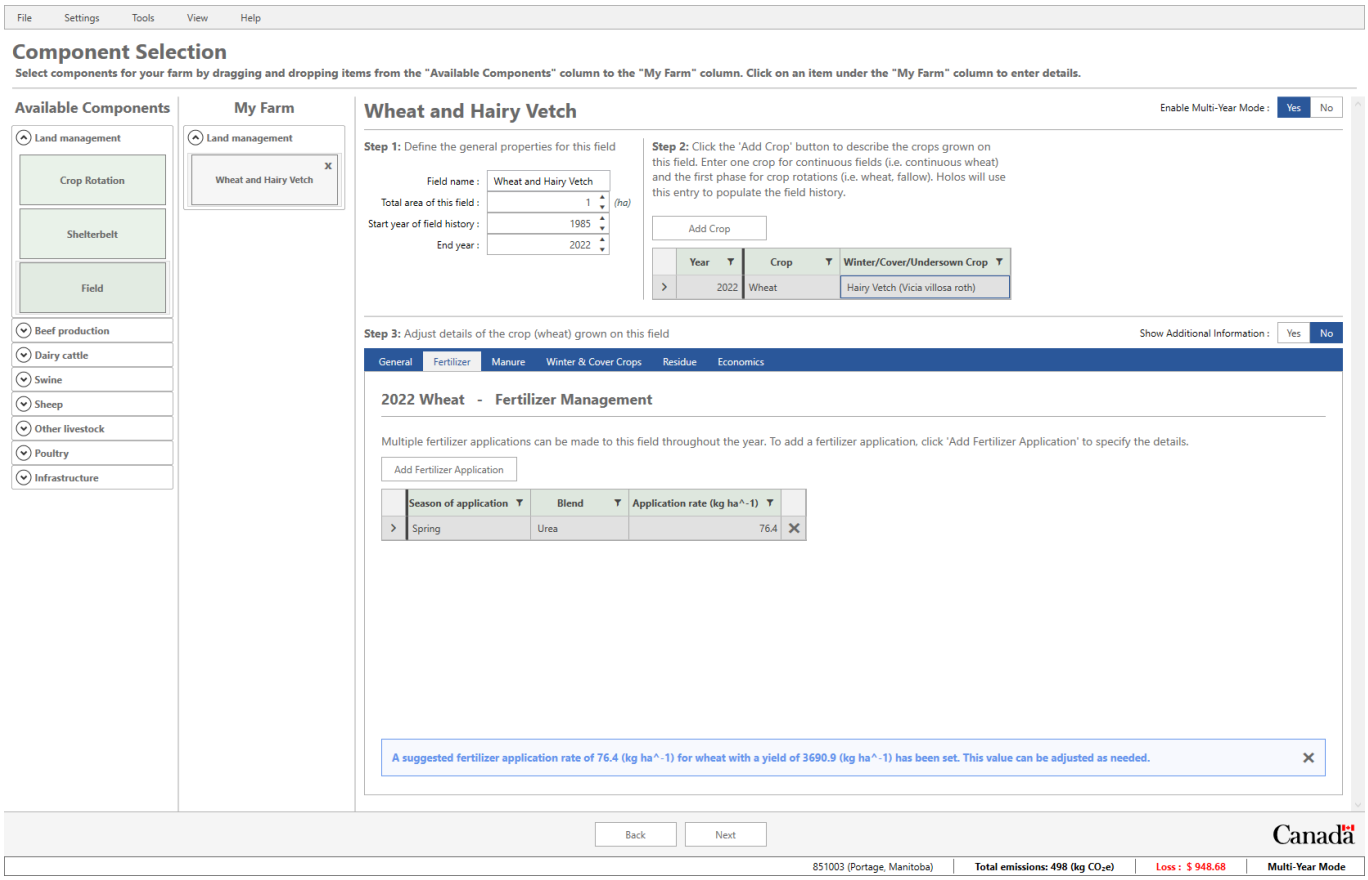

Figure 11: Adding fertilizer to a field.

Note: At a minimum, Holos requires the area of the field, type of crop grown, and a field-specific fertilizer application rate to calculate direct and indirect nitrous oxide emissions.

Residue management of each crop (and cover crop) can be adjusted in Holos (see 'Residue' tab). Holos provides default values depending on the type of crop being grown and will set a value for percentage of product returned to soil, percentage of straw returned to soil, etc. These residue input settings will have an impact on the final soil carbon change estimates.

Furthermore, biomass fractions and N concentrations can be overwritten by the user, and in this way 'custom' crops can be added that are currently not available.

Pasture (native) / Grasslands Information

The cow-calf operation (defined later on) relies on native pasture for the summer months (May through October).

1. Drag a new "**Field**" tab component to your list of components. Enter the name "**Native grassland**" in the 'Field name' input box.
2. Enter "**100**" as the total area of the field.
3. Select "**Pasture**" from the crop list under '**Crop**' column **(step 2)**. Please note that Holos auto populates the 'Winter/Cover/Undersown Crop' area when a perennial crop is selected.
4. Keep '**0**' as the amount of irrigation and pesticide passes.

5. No fertilizer is used for this crop.

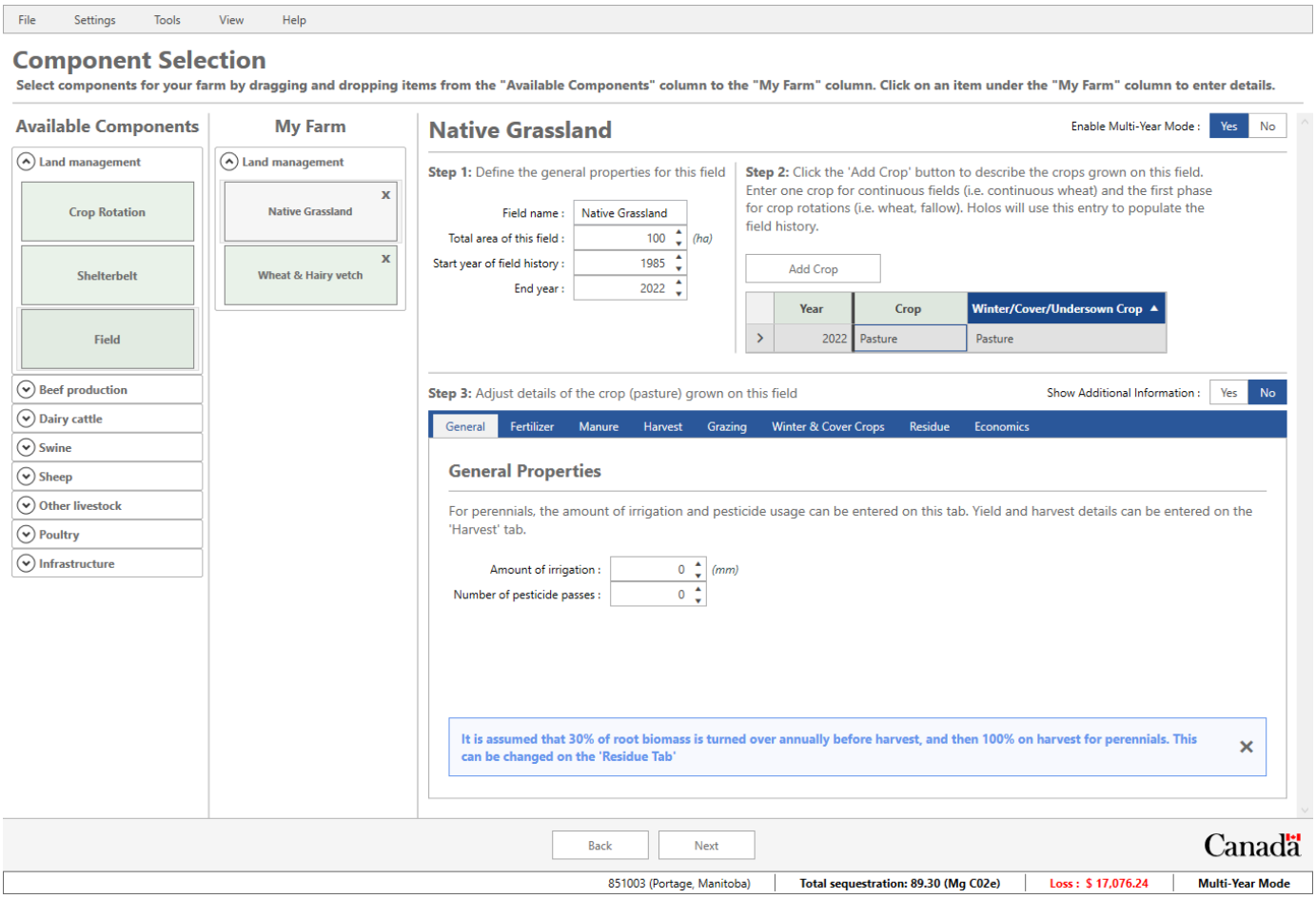

Figure 12: Pastures/Grasslands information.

Barley Grain and Mixed Hay Rotation

To demonstrate the crop rotation component (as opposed to using individual field components), we will assume that barley grain and mixed hay are grown in rotation, with the mixed hay under seeded to the barley so that it can be harvested in both main years (example derived from University of Alberta's Breton plots, Figure).

When using the "Crop Rotation" component, any sequence of crops that are input into this components will be applied to each individual field that is part of the rotation setup. This means one field is added for each rotation phase, and the rotation shifts so that each rotation phase is present on one field. Since each field can have a different historical management, soil carbon algorithms will run for each field.

For this example, we assume that the farm requires **70 ha** of barley grain and mixed hay, which are grown in rotation. We will need to setup three fields where barley grain is rotated in each field every two years (Figure 7). When using the crop rotation component, the crop management input of a specific crop is repeated on each field in the rotation where the crop is grown.

To setup the rotation:

1. Add one "**Crop Rotation**" component from the available components.

2. To expand the horizontal space available in Holos, click on "**View**" from the top menu bar and select "**Hide List of Available Components**".
3. The rotation of this field **begins in 1985 and ends in 2022**. Under step 1, please ensure that these two values are set as the start and end year respectively.
4. Enter "**70**" ha as the total area of this field.
5. Under **Step 2** change the crop to **Barley**. The year for this crop should be 2022.
    - Under the **General Tab** change the tillage type to **Reduced Tillage**.
    - Enter **3000** kg/ha (wet weight) as the yield for this crop.
    - Keep **0** as the amount of irrigation and number of pesticide passes.
6. Now add another crop to this rotation. Click on "**Add Crop**" under "**Step 2**" to add a second crop to the rotation. Note that Holos sets the year for this new crop to 2021 or one before the previous crop's year. This means that Holos is expecting the user to enter crops that have been grown in reverse order back to 1985.

***Note**: It is not necessary to enter a crop for each individual year going back to 1985, only enough crops to describe a single phase of the rotation will need to be entered by the user. Holos will then copy the phase information and back-populate the field history (e.g., Holos will copy the rotation back to 1985 on behalf of the user).*

7. For this newly added crop select "**Mixed Hay/Hay Mixed**" as the crop type.
8. Click on the "**Add crop****" button a final time. For this third crop, select "Hay Mixed**" once again as the crop type.

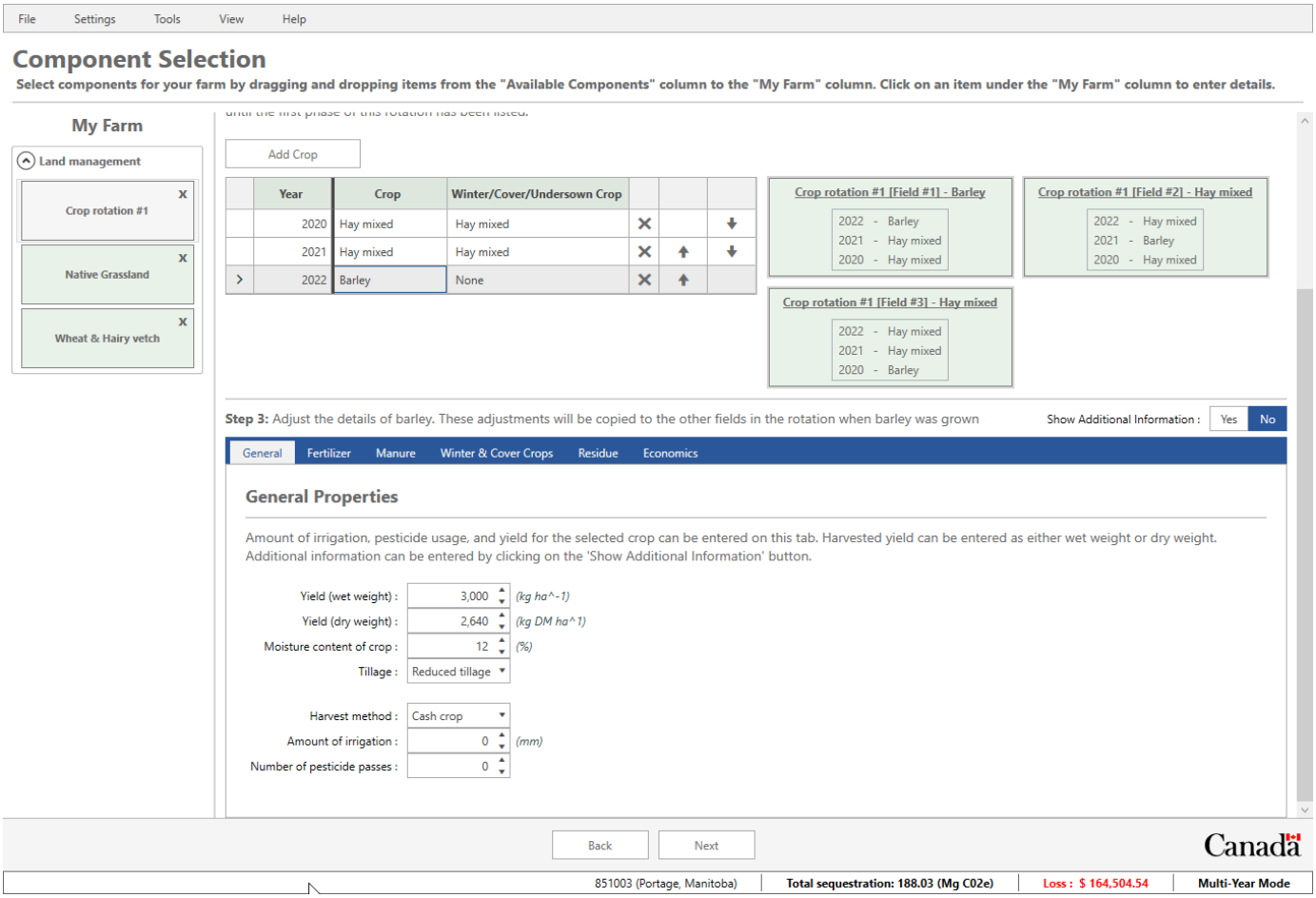

Figure 13: An example of a crop rotation of three crops.

9. Now add harvest data to each of the mixed hay crops. You will need to select each **mixed hay** crop and add the harvest data to that specific crop. So select the first mixed hay crop (2021) and then:
    - Go under the **Harvest Tab** and click **Add Harvest Data** button to create a new harvest.
    - Select a Harvest date of "August 31, 2021", assuming the harvest is done on the same day every year.
    - Select **Mid** for **Forage growth stage**.
    - Enter **5** as the total number of bales.
    - Enter **500** as the **Wet bale weight**.
10. Repeat the above steps (step 9) for the second mixed hay crop.

If the hay field is harvested more than once, the "Add Harvest/Grazing Date" button can be used to add subsequent harvests.

Cow-Calf Operation

Click the view menu item again and uncheck **Hide List of Available Components** option so that we can see all of the available components again.

Adding animal components follows the exact same approach that was used for land management components. Under the **Beef Production** category in the available components, drag and drop one **Beef Cow-Calf** component to the **My farm** section on the right. Replacement heifers will not be used in this example, so we will remove this group by clicking the **X** icon right next to its entry under **Step 1**.

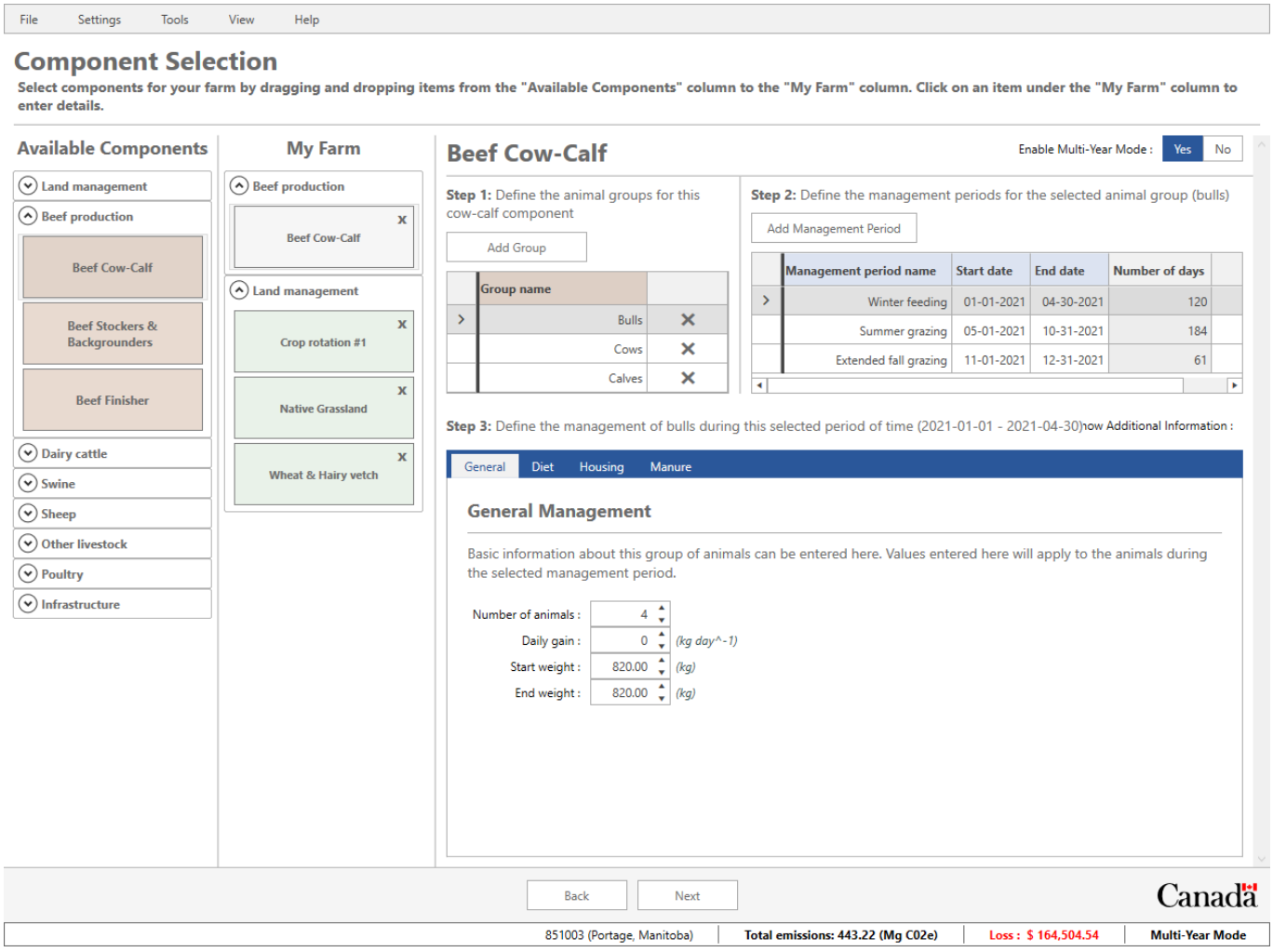

Figure 14: The Beef Cow-Calf Component.

Entering Beef Cows, Calves and Bulls Information.

Beef Cows - Winter Feeding

Following the annual feeding cycle, the beef farm we are working with is **divided into three management (production) periods**. We can now enter production and management data corresponding to these three management periods.

1. Under the animal groups section in '**Step 1**', make sure that the "**Cows**" row is selected in order to enter the associated management information for that group.

2. Click the management period named "**Winter Feeding**" in '**Step 2**' to activate that management period.

3. Ensure "January 1, 2021" is set as the 'Start date' and that "April 30, 2021" is set as the 'End date' (120 days). Note that the 'Number of days' being shown will be inclusive of the start and end dates.

Next, we can enter data related to the number of animals, diet, manure system, and housing type.

- **General Tab:**
    - Enter **150** as the number of animals.
    - Keep the remaining entries at their default values.

***Note**: The number of animals, average daily gain, and feed quality are the minimum required inputs for calculating methane and nitrous oxide emissions. Length of management periods (i.e., duration of grazing) also will be needed. Housing and manure management information are also important inputs but are relatively more impactful on the emissions of monogastrics.*

- **Diet Tab:**

We are going to create a custom diet for our group of cows during the "**Winter feeding**" management period. (Holos incorporates feed ingredient information from the recently published Nutrient Requirements of Beef Cattle book (2016).

Click on the '**Diet**' tab. Since we are going to create our own custom diet, we will click on the '**Custom Diet Creator**' button. Note that Holos provides a default set of animal diets that can be used.

- Custom-Diet Creator:
    - Click the "**Add Custom Diet**" button in the "**Step 1**" section of the screen to create a new custom diet.
    - Rename this diet to "**My Custom Cow Diet**" then press the Enter key to save the name.
    - Under step 1, ensure that you have the **Animal Type** set to **Beef Cow**.
    - To add ingredients to our new diet, select "**Alfalfa hay**" from the ingredient list, and then click the "**Add Selected Ingredient to Diet**" button.
    - We will add one more ingredient to our diet. Select '**Barley Hay**' from the ingredient list, and then click the "**Add Selected Ingredient to Diet**" button.
    - Enter **50%** for '**Barley Hay**' and **50%** for '**Alfalfa Hay**' in "**Step 3**". Note that Holos now reports the diet being complete since all ingredients total up to 100%.
- Click the "**OK**" button to save the new custom diet
- Select the "**My Custom Cow Diet**" diet from the diet drop down-down menu.

***Note:** Diet quality information such as crude protein, total digestible nutrient, and fat are required inputs so that Holos can estimate enteric methane emissions from an animal group.*

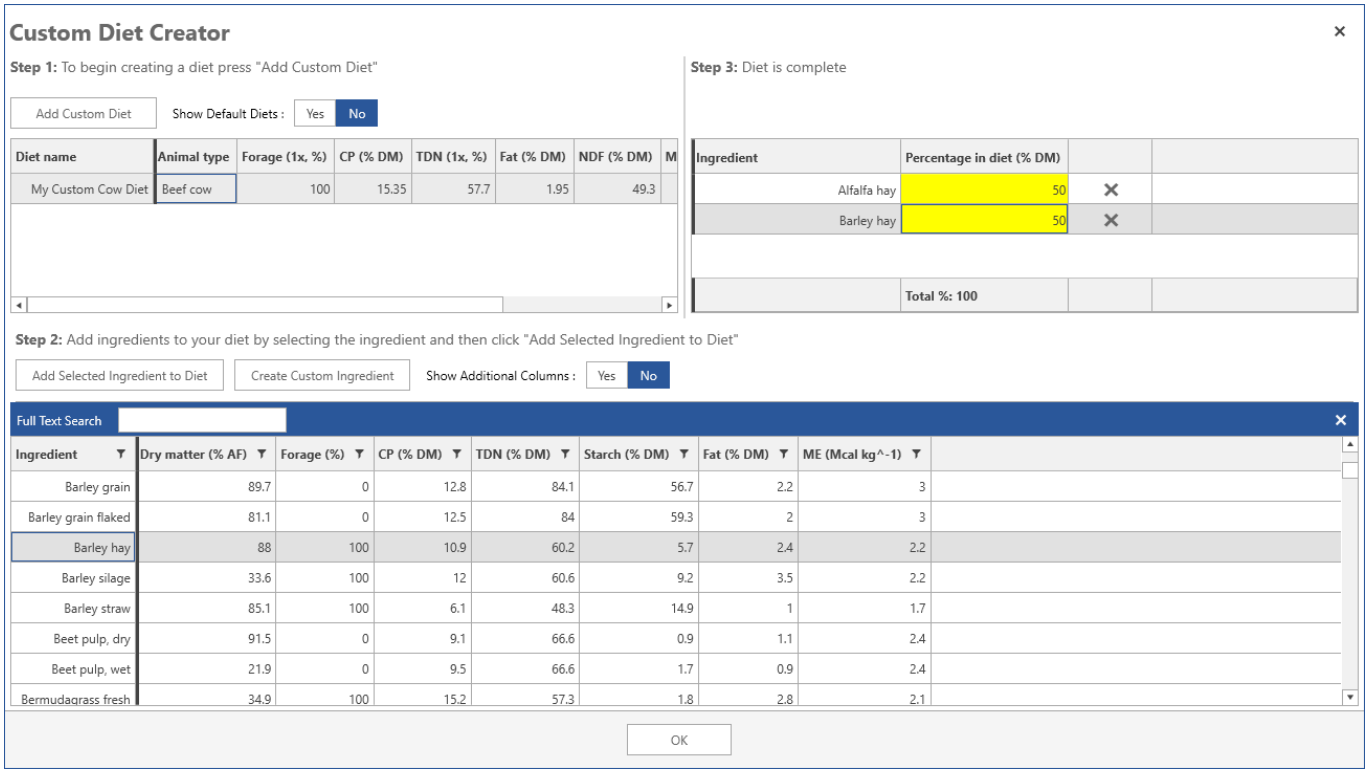

Figure 15: Custom diet creator for Cows animal group.

- Housing Tab:
  - Select **Confined no barn** as the housing type.
- Manure Tab:
  - Select **Deep Bedding** as the manure handling system.

Beef Cows - Summer Grazing

Click on the management period named **Summer Grazing**. Ensure that the start date is set to April 1st, 2021 and the end date is set to October 31st, 2021.

- General Tab:
  - Enter **150** as the number of animals.
- Diet Tab:
  - Select **High energy & protein diet** as the diet type.
- Housing Tab:
  - Select **Pasture** as the housing type.
  - Select **Native Grassland** as the pasture location.
  - Select **Continuous/Mob Grazing** as the type of grazing.
- Manure Tab:

- Select **Pasture** as the manure handling system.

Beef Cows - Extended Fall Grazing

Click on the management period named **Extended Fall Grazing**. Ensure that the start date is set to November 1st, 2021 and the end date is set to December 31st, 2021.

- **General Tab:**
  - Enter **150** as the number of animals.
- **Diet Tab:**
  - Select **Medium energy & protein diet** as the diet type.
- **Housing Tab:**
  - Select **Pasture** as the housing type.
  - Select **Native Grassland** as the pasture location.
  - Select **Switchback Grazing** as the type of grazing.
- Manure Tab:
  - Select **Pasture** as the manure handling system.

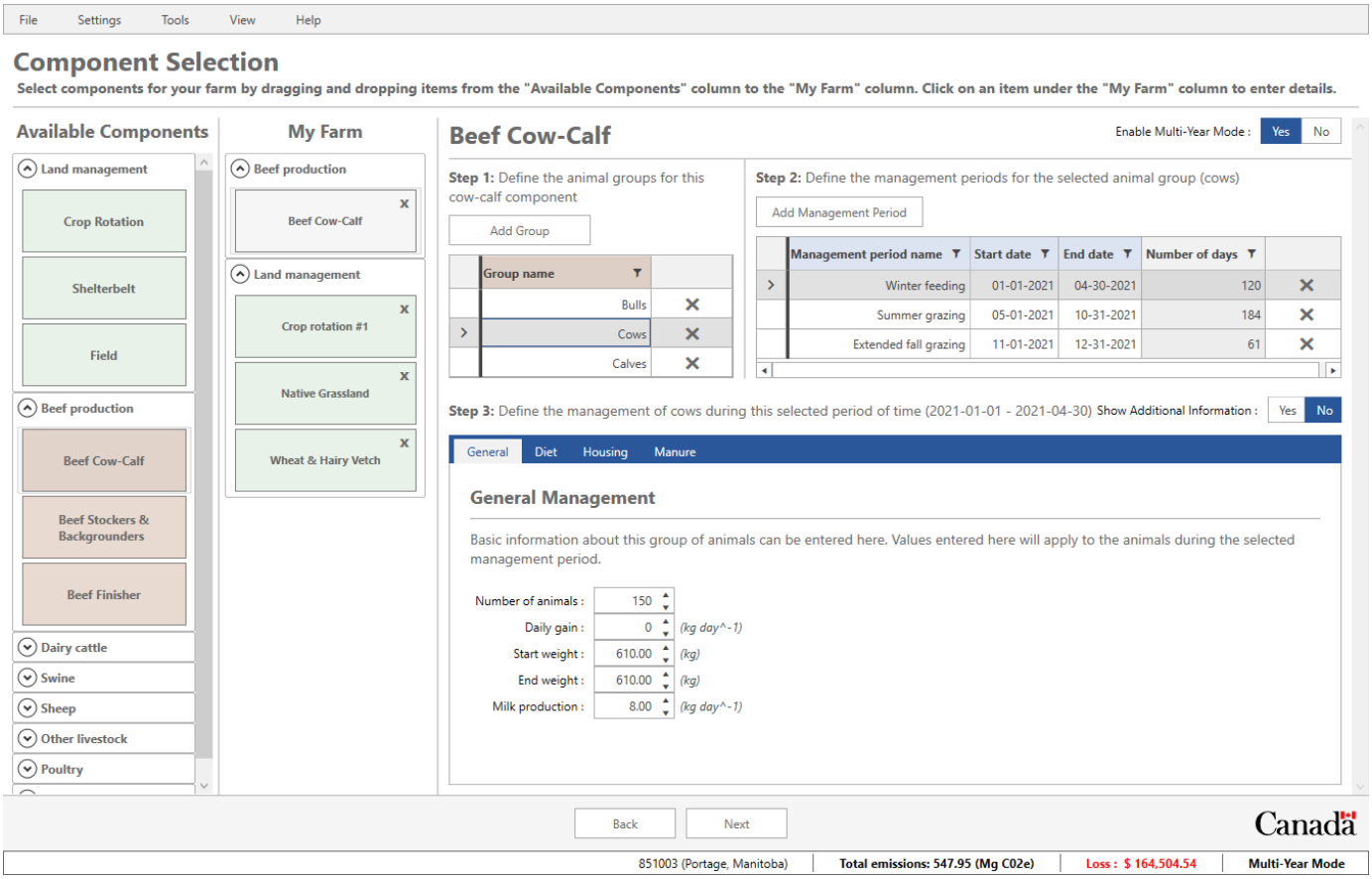

Figure 16: Beef Cow-Calf, Cow group

Bulls

Click on the **Bulls** row in the animal group section **Step 1**. Information related to diet, housing and manure management is identical to the cows group.

- Right click on the **Bulls** animal group. A menu will appear allowing you to select the option to copy management periods from another animal group. Since the management for the bulls is similar to the management for the cows, click the **Copy Management From → Cows** sub-menu item.
- Adjust the **number of bulls** for each of the three management periods to **4**.

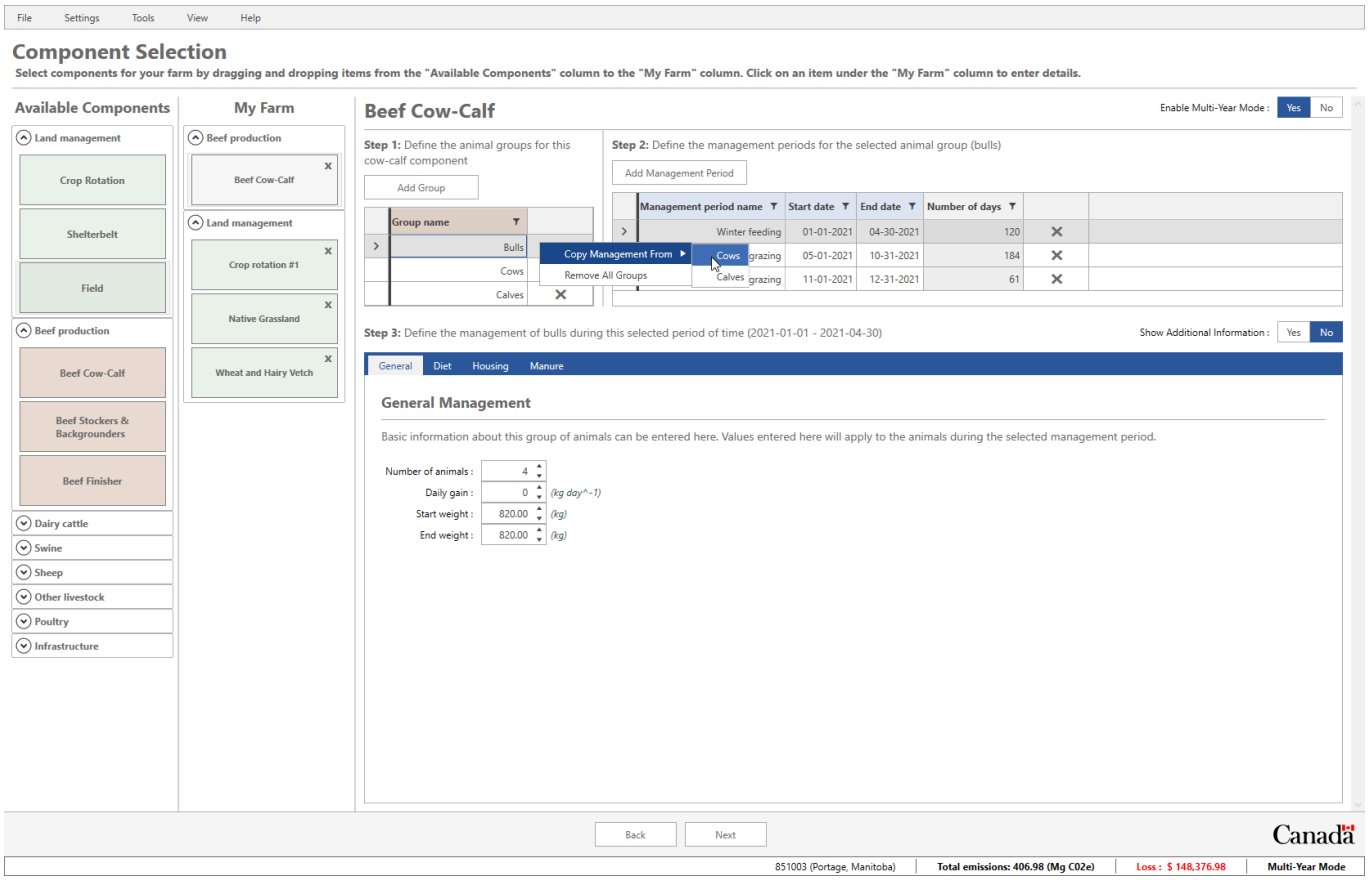

Figure 17: Copying data from another animal group

Beef Calves

Calves on our farm are born on March 1 and weaned on September 30 at the age of seven months. Using a final weaning rate of 85%, we will have 110 calves from March to September. Following the cows, calves will be in confinement for the months of March and April and will be grazing on pasture from May to September. This will result in two separate management periods.

Click on the **Calves** row in the animal group section **Step 1** to activate the calf group. The first management period will span from **March 1, 2021 to April 31, 2020** and the second management period will span from **May 1, 2020 to September 30, 2020**.

Management Period # 1:

Rename this period from Management Period # 1 to **Confinement**.

- **General Tab:**
    - Enter **110** as the number of animals.
    - All other options as default.
- **Diet Tab:**
    - Select **Medium energy & protein diet** as the diet type.
- **Housing Tab:**
    - Select **Confined no barn** as the housing type.
- Manure Tab:
    - Select **Deep bedding** as the manure handling system.

Management Period # 2:

Rename this period from Management Period # 2 to **Grazing**.

- **General Tab:**
    - Enter **110** as the number of animals.
- **Diet Tab:**
    - Select **High energy & protein diet** as the diet type.
- **Housing Tab:**
    - Select **Pasture** as the housing type.
    - Select **Native Grassland** as the pasture location.
    - Select **Continuous/mob grazing** as the type of grazing.
- Manure Tab:
    - Select **Pasture** as the manure handling system.

Beef stocker & backgrounder operation

To enter information on backgrounder and stocker animals, we will add a new "**Beef Stockers & Backgrounders**" component to our farm.

- Drag and drop a new **Beef Stockers & Backgrounders** component. The beef farm manages 200 backgrounders (100 steers and 100 heifers).
- Click on the **Heifers** group to activate it and to enter management data for this group.
    - For "Management period #1", enter "**October 1, 2021**" as the '**Start date**' and "**January 18, 2022**" as the '**End date**' (110 days).

- **General Tab:**
    - Enter **100** as the number of animals.
    - Enter **1.1** kg/day as the daily gain.
    - Enter **240** kg as the start weight.
- **Diet Tab:**
    - Select **Medium Growth** as the diet type.
    - Select **None** as the diet additive.
- **Housing Tab:**
    - Select **Confined no barn** as the housing type.
- Manure Tab:
    - Select **Deep bedding** as the manure handling system.

- The management data for the **Steers** group is the same as **Heifers**. Right click on the Steers group to activate the right-click menu and select **Copy Management From → Heifers**

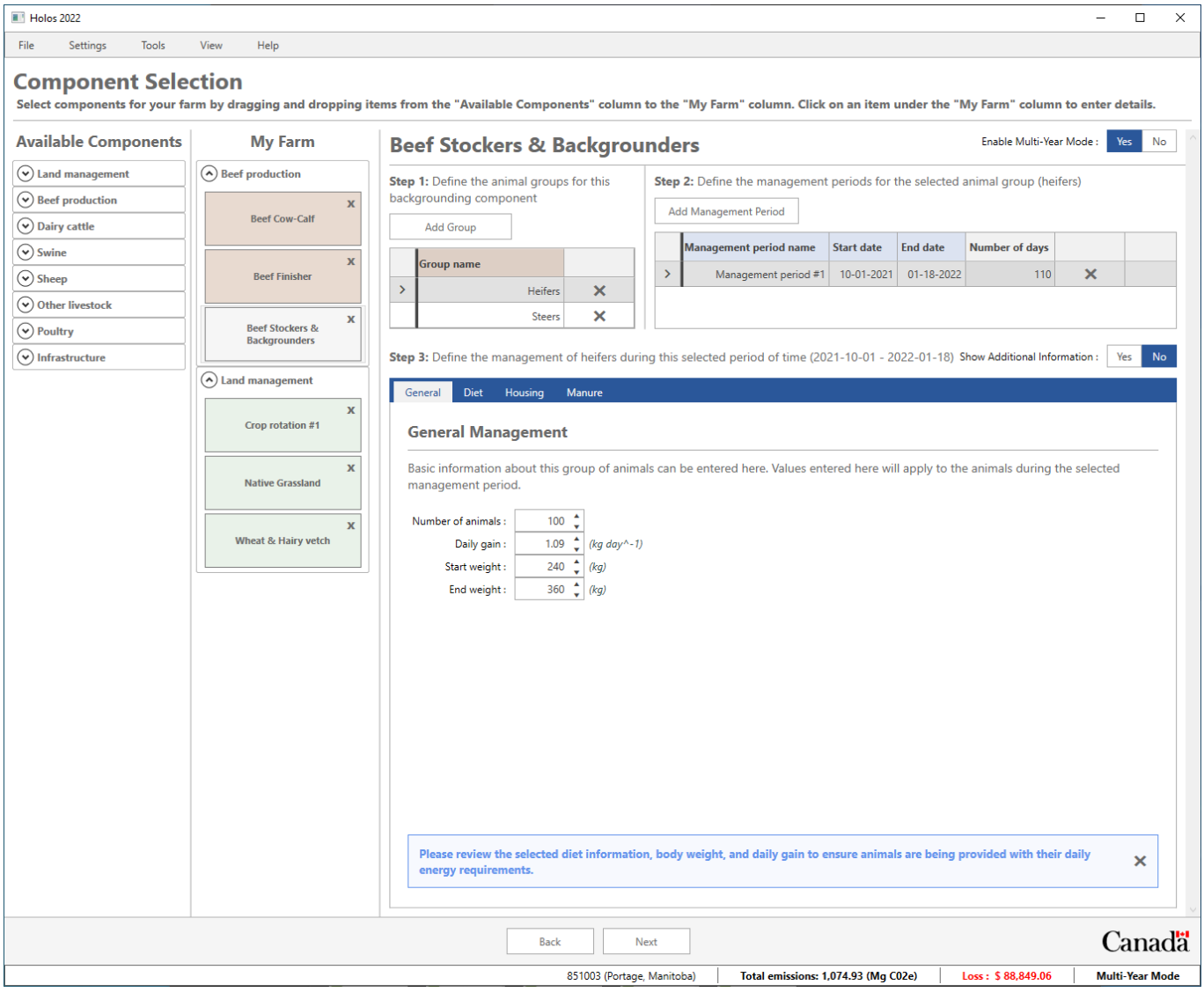

Figure 18: Beef stocker & backgrounder operation

Finishing Feedalot Operation

We will now **repeat the steps used for Beef Stockers & Backgrounders** to enter the beef feedlot management data. Drag a new **Beef Finisher** component from **All components** to your list of components.

- The beef farm manages 200 backgrounders (100 steers and 100 heifers) in a feedlot operation for **170 days**.
- Click on the **Heifers** group to activate it and to enter management data for this group.
  - For "Management period #1", enter "January 19, 2022" as the **Start date** and "July 7th, 2022" as the **End date**.
  - **General Tab:**
    - Enter **100** as the number of animals.
    - Enter **1.2** kg/day as the daily gain.
    - Enter **350** kg as the start weight.

- **Diet Tab:**
    - Select **Barley grain based diet** as the diet type.
    - Select **None** as the diet additive.
- **Housing Tab:**
    - Select **Confined no barn** as the housing type.
- Manure Tab:
    - Select **Deep bedding** as the manure handling system.

- The management data for the **Steers** group is the same as **Heifers**. Right click on the Steers group to activate the right-click menu and select **Copy Management From → Heifers**

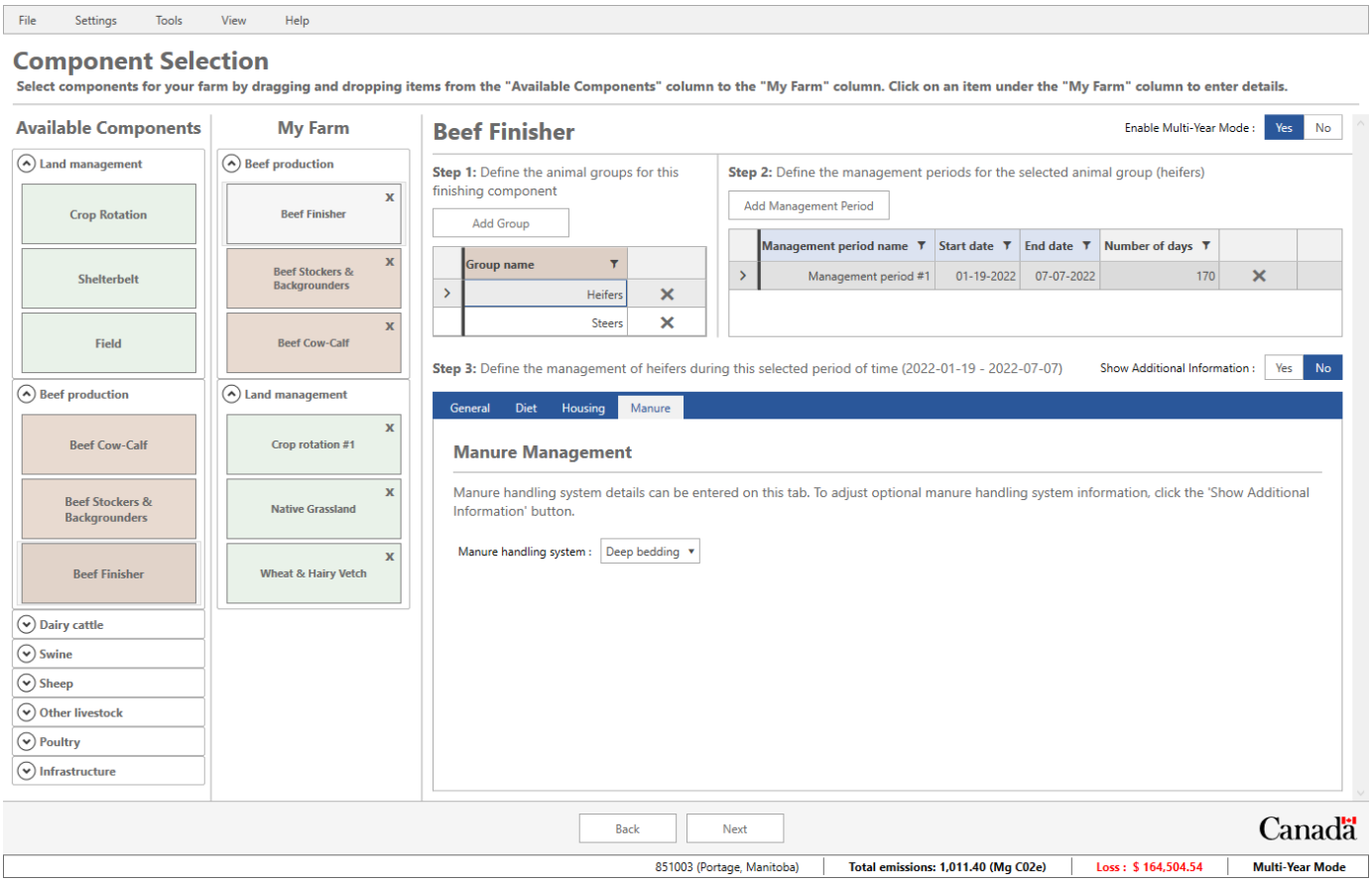

Figure 19: Beef Finisher component

Adding a Manure Application to the Wheat Field

Holos has the ability to add manure applications from manure that is sourced from livestock on the current farm or from imported manure (off-site). Since we have now defined our animal components, we can apply manure to any field on our farm.

1. Select the **Wheat & hairy vetch** field from the list of components added to our farm.

2. Click on the **Manure tab** and then click the **Add Manure Application** button.
    - Select **Beef cattle** as the **Manure type**.
    - Select **Livestock** as the **Origin of manure**.
    - Select **Solid storage** as the **Manure handling system**.
    - Enter **1,000 kg/ha** as the amount of manure applied to this field.
3. Note that both chemical fertilizers and manure applications can be made on the same field

Adding supplemental hay/forage for grazing animals

We can also add additional hay/forage for animals that are grazing on a particular field. Since we have now placed a group of animals on the "Native Grassland" field component, and we have also provided harvest information for our mixed hay crops on the crop rotation component, we can then add an additional forage supplement for these grazing animals.

1. Select the **Native Grassland** field component we created earlier.
2. Click on the **Grazing tab.**
    - Click the **Add Supplemental Hay** button to add additional forage for the animals on this field.
    - Change the **Number of bales** to 1
    - Enter **500** as the wet bale weight.
    - Keep the moisture content as the default value.

Pullet Farm Operation:

We will add one last animal component to our farm. In addition to the beef cattle operations of this farm, we will also be adding a "Chicken Meat Production" component to our farm. If you hover your mouse cursor over the "Chicken Meat Production" component under the "Poultry" category, Holos will display a tooltip that gives a brief description of a chicken meat production operation:

"Chicks arriving in the operation from a multiplier hatchery are raised to market weight (1-4 kg)"

1. Drag one "Chicken Meat Production" component to the farm. For each group (Pullets and Cockerels), each management period for that group will consist of 400 animals. This means numbers of animals will be consistent throughout the management periods / year.
2. Select the **Pullets** group. The start and end dates for each management period will be:
    - **Brooding Stage:** Start January 1st, 2022 - End January 22nd, 2022.
    - **Rearing Stage:** Start January 23rd, 2022 - End June 26th, 2022.
    - **Rearing Stage:** Start June 27th, 2022 - End November 28th, 2022.
3. For each management period, set number of animals to 400.
4. Leave the entries in Housing and Manure as default.

- The management data for the **Cockerels** group is the same as **Pullets**. Right click on the Cockerels

group to activate the right click menu and select **Copy Management From → Pullets**

Timeline Screen

We are now finishing the process of defining our farm. Click the **Next** button to go forward to the timeline screen. The timeline screen provides a visual layout of all the fields from 1985 to the specified end year for each field. This screen also allows the user to add historical and projected production systems.

The **Add Historical Production System** button enables the user to add a different cropping history to individual fields whereas the **Add Projected Production System** button enables the user to add a future (projected) cropping system to individual fields.

Adding a historical production system

We will assume that the barley grain and mixed hay rotation fields were previously in a continuous wheat cropping system between **1985 and 2000.**

1. To add a new historical cropping system, select one of the fields that are in the barley grain and mixed hay rotation. To select an item, click on the timeline bar to activate that field. We will select the first field in this rotation (i.e., the field with the name of "**Crop rotation #1 [Field #1]**")
2. Click on the **Add Historical Production System** button which will add a new row to the table under the "**Step 1**" section in the upper left section of the screen. Notice that this new entry has the words "**Historical management practice**" added.
3. We will set the end year of this historical management practice to the year **2000**. To adjust this we use the numeric up/down buttons within the cell.
4. We then click the "**Edit Selected**" button. This will open a new screen that allows us to adjust the crops grown and the management during this period.
5. Click on the "**Barley**" crop under the "**Step 2**" section. Change the crop type to '**Wheat**' and on the '**General**' tab change the yield to **3,500** kg/ha. We will keep the other settings unchanged.
6. We also need to remove the "Hay mixed" crops from this historical period. Click the '**x**' icon beside each of the "**Hay mixed**" crops under the "**Step 2**" section. Clicking the '**x**' icon will remove these crops from the rotation for this period of time.
7. Click "**Ok**" to save adjustments we just made to this field.
8. Repeat these same steps so that the other fields in this rotation also have continuous wheat from **1985 to 2000** using the same steps we used for the first field.

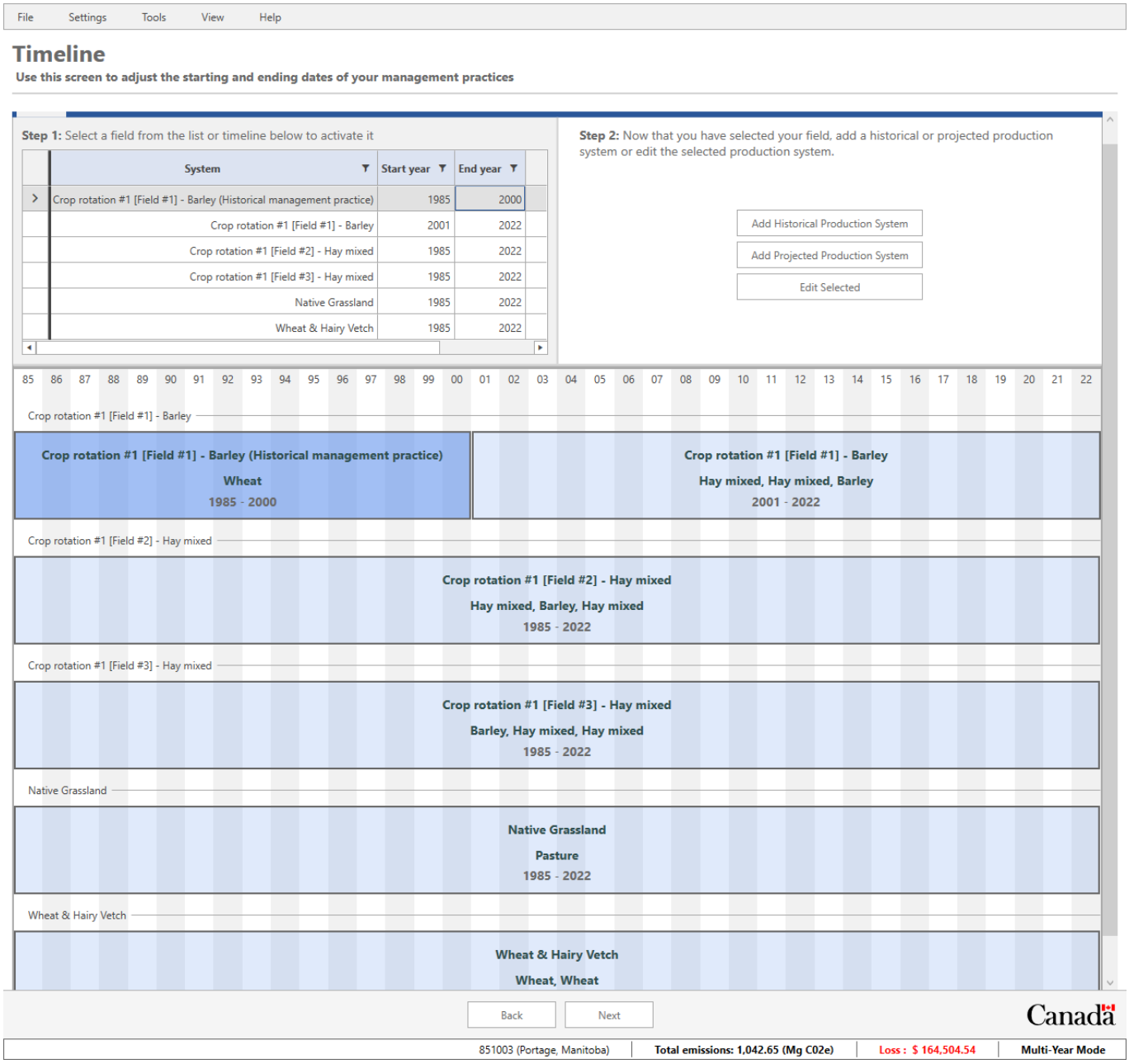

Figure 20: Customized Timeline Screen

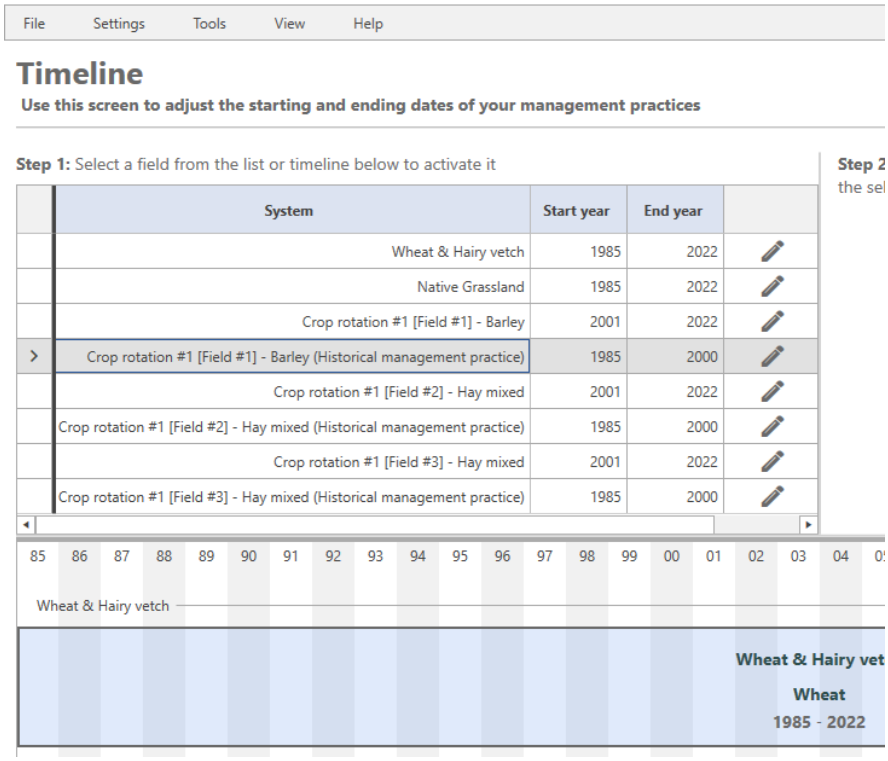

Figure 21: Adjusted start and end year for productions systems on the timeline screen.

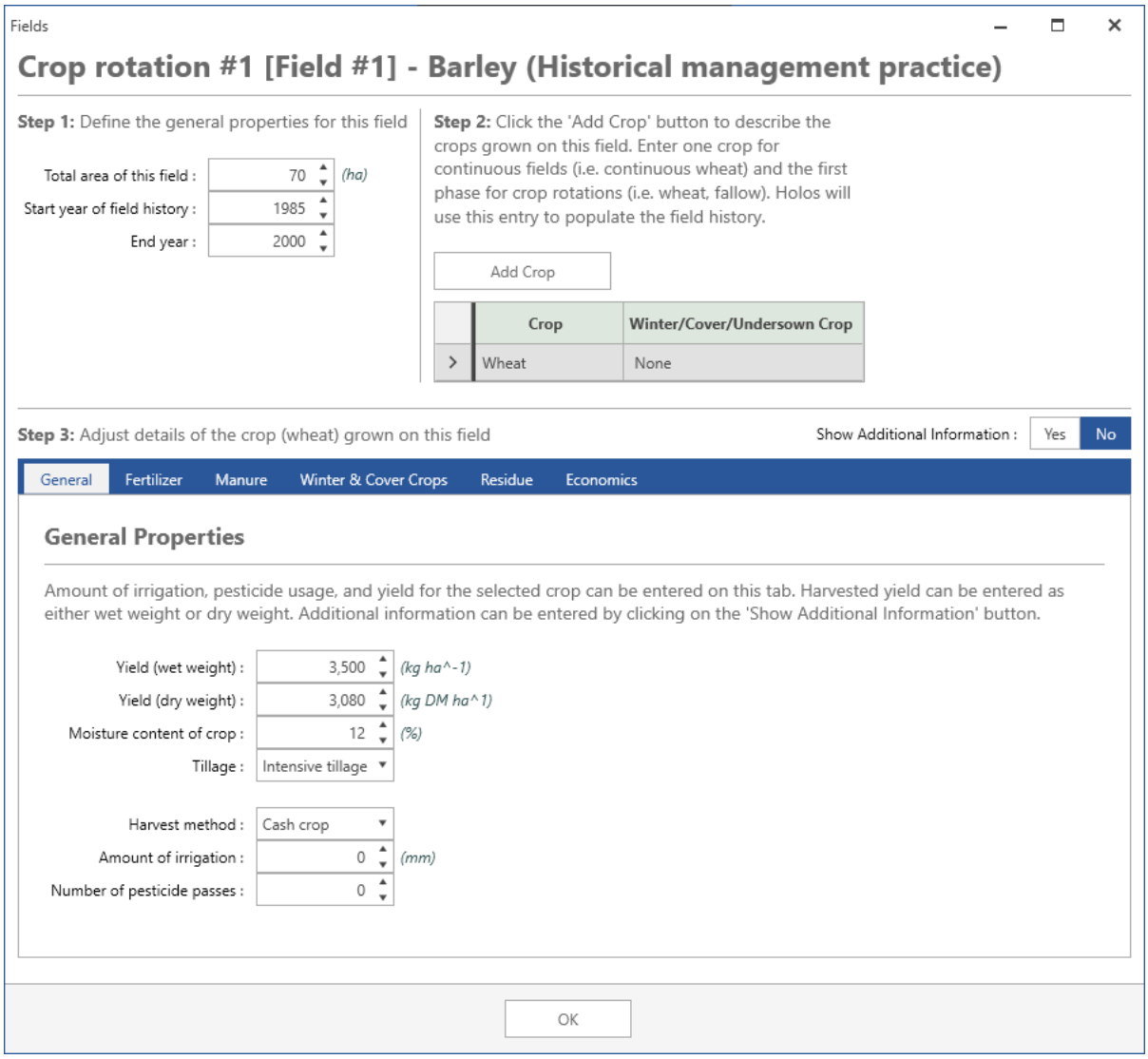

Figure 22:

Details Screen

Click the "**Next**" button to go forward to the details screen.

To avoid the requirement that a user needs to provide crop yields going back to 1985 for each field on the farm, the model will use Stats Canada reported crop yields as defaults (where available). The model allows the user to calculate how changes in crop type, yield, tillage, residue management, manure, irrigation or fallow will result in changes to soil carbon.

We will adjust this grid so that we can view the above ground and below ground carbon inputs for our wheat field and then we will adjust the crop yield for one specific year.

1. We will set a filter on the first column named '**Field name**' so that we only display information for our wheat and hairy vetch field. Beside the column heading, click the '**funnel**' icon to set a filter. Check the box beside **Wheat & hairy vetch**.

2. On the far left of this screen, click the "**Enable Columns**" sidebar (located near the "Field name"

column).

3. Place a check beside **Above ground carbon input** to show the column and remove the check beside the **Notes** column to hide it.
4. Click the **Enable Columns** sidebar again to collapse it.
5. We can now (optionally) adjust the yields for our wheat field for any given year if actual measured yields are available.
6. Adjust the yield for **1987** to be **4,100** kg/ha.
7. Note that Holos has updated the above ground carbon inputs for this.

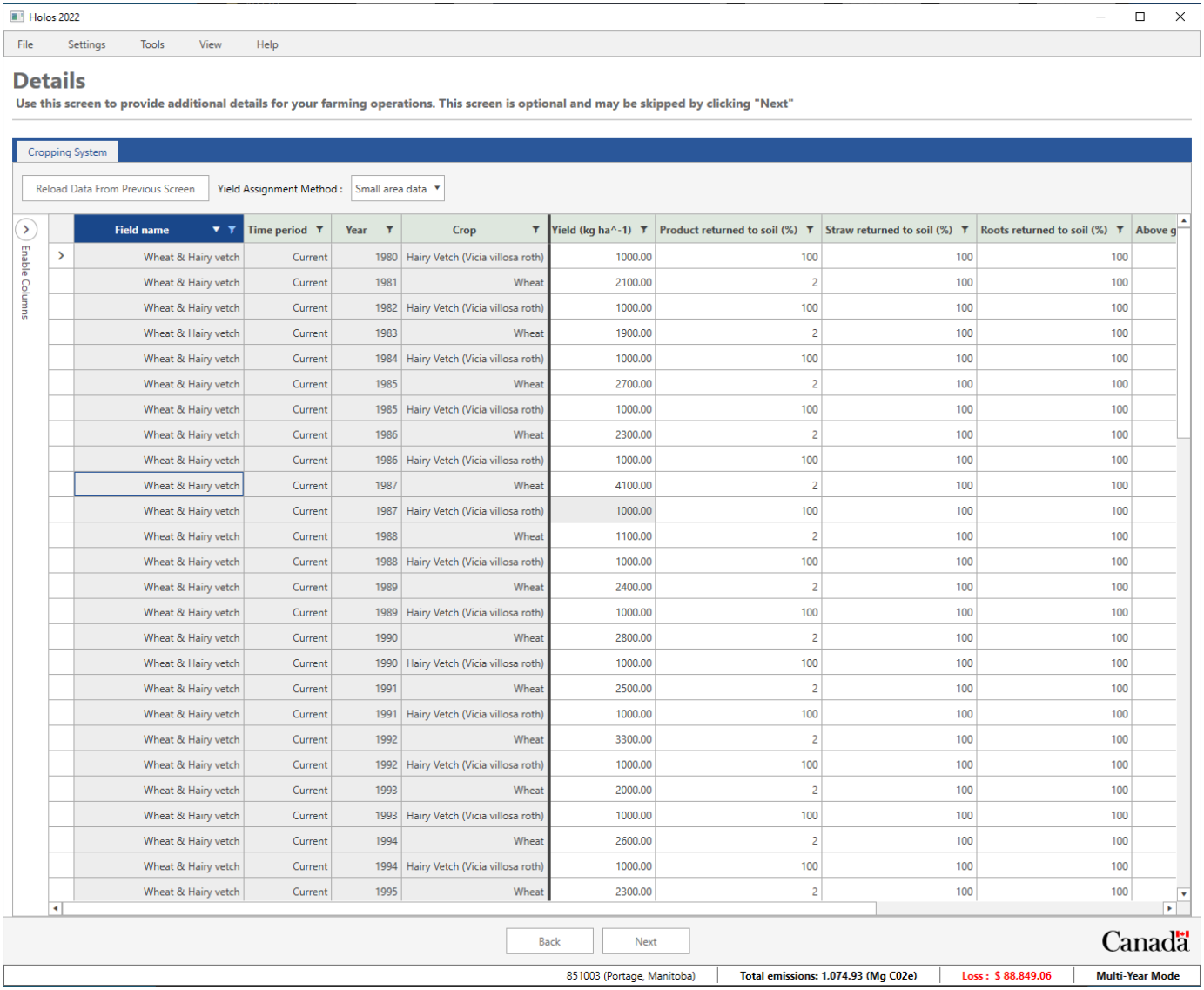

Figure 23: Details screen

Discover results

Click the "**Next**" button to move to the final results report. Results will now be displayed in a variety of reports and charts.

1. Click on the tab named **Emissions Pie Chart**

   Starting with the **Emissions pie chart** we can see an overall breakdown of the enteric CH4, manure CH4, direct and indirect N2O. We are also able to see a detailed breakdown of the sources of these emissions.

2. Click the "Yes" button beside **Show details**

   We can see that the biggest source of emissions from our farm is the cow-calf component. If you hover your mouse pointer over any slice of this chart you can get an isolated look at the different emission sources.

3. Click on the tab named **Detailed Emission Report**

   The **Detailed Emission Report** will display a monthly or annual GHG emission report. The detailed emission report will report on enteric methane, manure methane, direct & indirect N2O, and CO2 emissions from the farm.

Click the **Report Format (Monthly)** button to switch to a monthly report. Now we can see a monthly breakdown of all emissions from the farm and the emission source.

In the **Unit of measurements** drop-down menu, you can choose to have the results displayed as CO2 equivalents (CO2e) or as unconverted greenhouse gas (GHG), and you can also choose the unit of measurement as either tonnes or kilograms.

The **Estimate of Production** report provides total harvest yields, amount of land applied manure, and estimates of milk production for dairy components.

The **Feed Estimate** report provides an estimate of dry matter intake based on energy requirements of the animal and the energy in the feed.

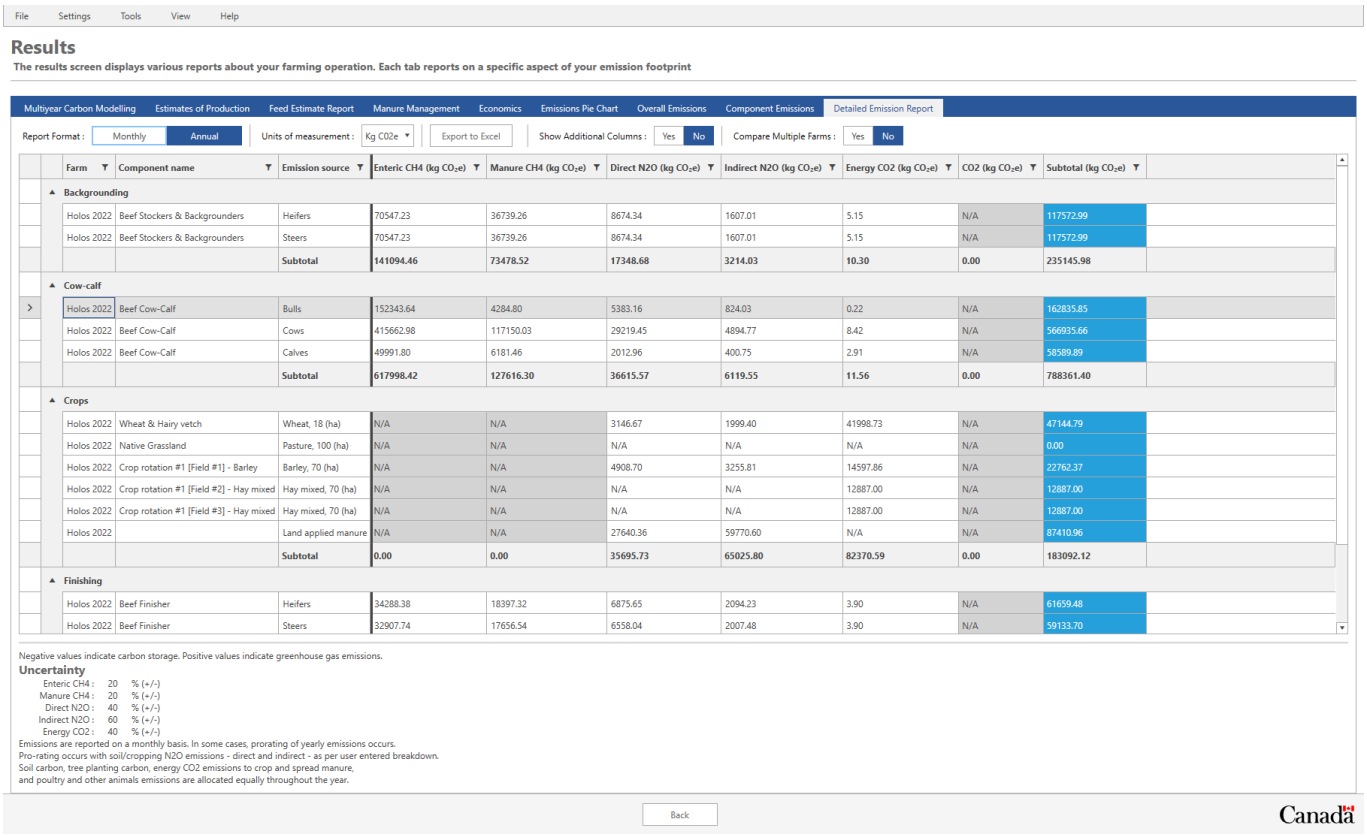

Figure 24: Detailed Emissions Report section of results.

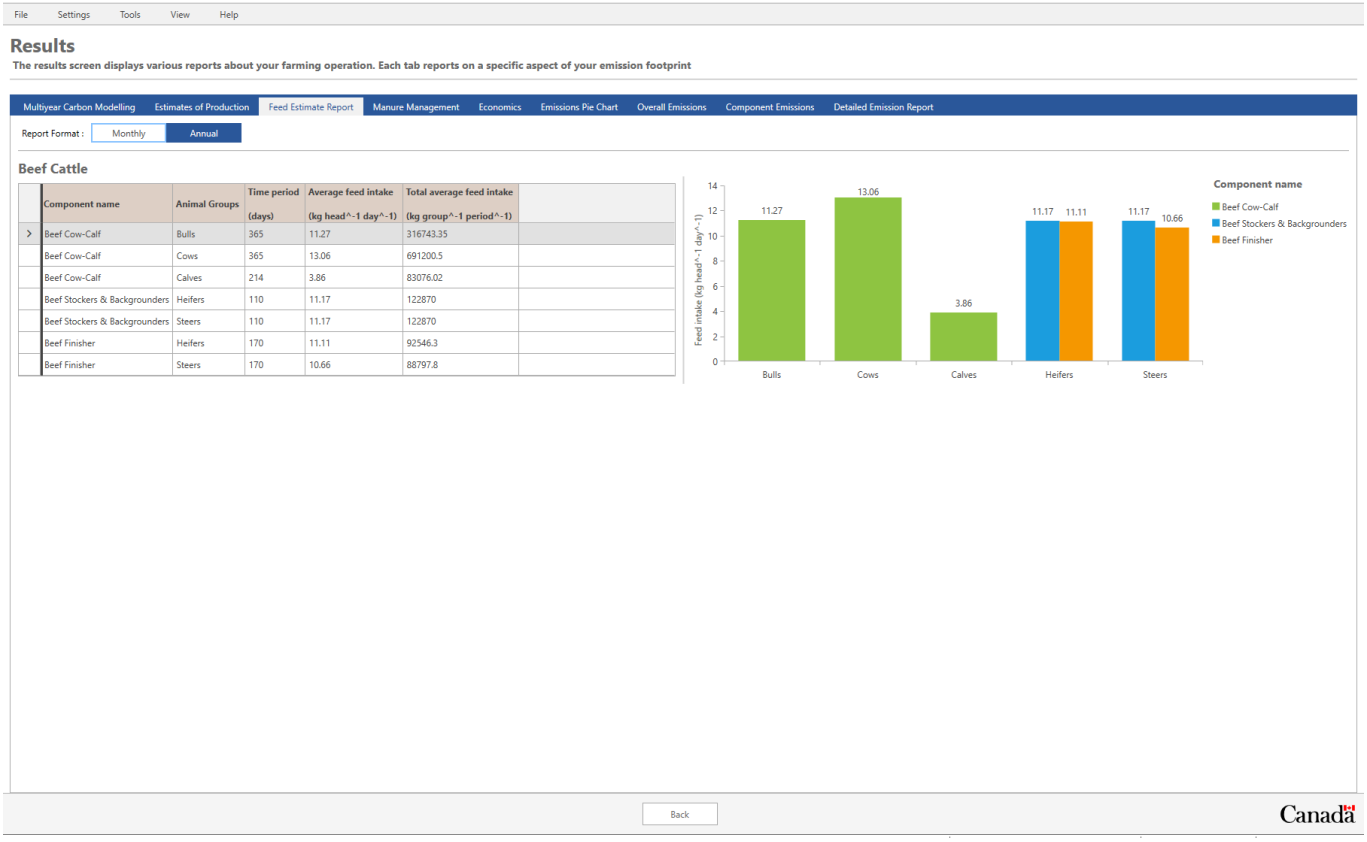

Figure 25: Field Estimates Report section of results.

Soil carbon modelling results

On the results screen we can see the change in soil carbon over time by clicking the “Multiyear Carbon Modelling” tab. This tab displays a graph showing the change in soil carbon over time for each one of our fields.

For each field on the graph, you can hover your mouse over the series to get more information for each historical year of the field.

If we click on one of these points, we can then view a more detailed breakdown of these results. We can also export this data by clicking the “Export to Excel” button.

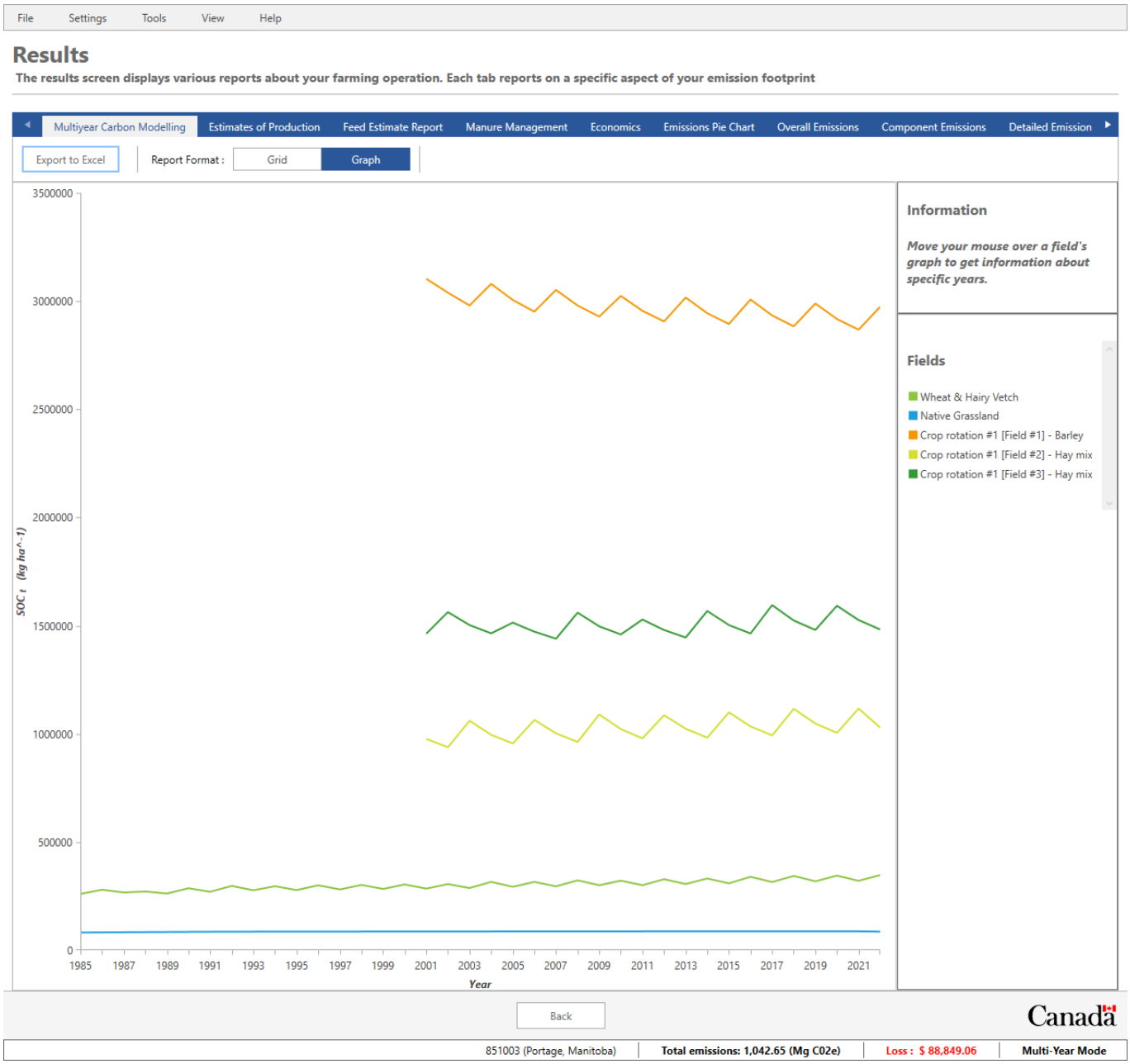

Figure 26: Carbon report section. Allows switching between graph and table format.

Finally...

Whole-systems approach

An ecosystem consists of not only the organisms and the environment they live in but also the interactions within and between. A whole systems approach seeks to describe and understand the entire system as an integrated whole, rather than as individual components. This holistic approach can be very complex and describing the process can be difficult. One method to conceptualize a whole system is with a mathematical model.

The whole-systems approach ensures the effects of management changes are transferred throughout the entire system to the resulting net farm emissions. In some cases, reducing one GHG will actually increase the emissions of another. The whole-systems approach avoids potentially ill-advised practices based on preoccupation with one individual GHG.

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To contact us, email: aafc.holos.acc@canada.ca