



## **Legionnaires' GIS**

# **Legionnaires' GIS User Guide**

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## Introduction

During a Legionnaires' disease outbreak investigation, descriptive epidemiology and microbiological investigation are often sufficient to identify the outbreak source.

However, there are instances where the source of an outbreak remains unclear. In these situations preparing a model in a *Geographic Information System (GIS)* can potentially help identify an outbreak source or a location for additional investigation.

The Legionnaires' GIS allows you to:

- Map **cases** and **(potential) sources** as dots on a map. In this manual we use the term 'cases' to represent cases of Legionnaires' disease, as defined by the EU surveillance case definition or as defined by a specific outbreak case definition. The term 'sources' is used to represent potential sources (or vehicles) of an outbreak, e.g. cooling towers.
- Map **case density** on a map using a colour code. The density - or *probability density function* - expresses the probability that cases are observed at a certain location. It is calculated based on the observed case locations and a smoothing parameter (called search radius (bandwidth)) in a *kernel density estimator* formula.
  - The varying density expresses that the probability of finding the next case nearby previous cases is expected to be higher than of finding the next case far away. Drawing a density map has been compared with throwing a hand full of sand on the location of a case, whereby that point location gets smoothened out over the surrounding space. Doing this for all cases, results in varying height of sand levels, similar to the density of cases on the map.
- Map **case risk** on a map using colour codes. The risk is calculated by dividing the case density by the population density.
  - The varying risk expresses that the probability for an individual among hundred others to fall ill, is expected to be higher in a low populated area with a number of observed cases than in a highly populated area with the same number of observed cases.

Below is the overall process to build a Legionnaires' GIS model:

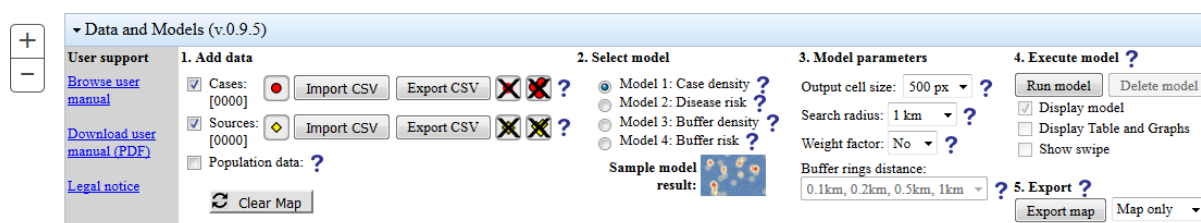
- *Add the case and source data.*
- *Select the model to be applied.*
- *Configure the model parameters.*
- *Run the model.*
- *Export the results.*


## Introducing the Legionnaires' GIS interface

**NOTE: Legionnaires' GIS is compatible with Google Chrome and Mozilla Firefox only.**



In the Legionnaires' GIS, you construct a map by placing *layers* containing representations of your data onto a geographic map (the *Basemaps*). Map layers are configured using the GIS - Data and Models Toolbar

Figure 1: Legionnaires' GIS Data and Models Toolbar



The  buttons allow you to zoom in and out of the map. To pan around the map, left mouse click and drag.

In the GIS interface:

- Case data are represented by a red circle .
- Source data are represented by a yellow rectangle .
- The total number of cases and sources is shown in brackets (e.g. [0008]) in the **Add data** group on the toolbar.

To clear (delete) all data uploaded into the geographical map and to revert back to default *basemap*, click the **Clear Map** button.

Description and use of the Legionnaires GIS Toolbar controls are detailed within the relevant sections below:

- *Add data (on cases, potential sources and population).*
- *Select the model to be applied.*
- *Configure the model parameters.*
- *Run the model.*
- *Export the results.*

To hide/unhide the control panel and to display/undisplay the Search, Switch BaseMap, Legend and Measurement controls, click on the Data and Models Bar located left side of the screen.

These controls provides the following functions:

- *Search* – search for geographical locations (addresses or coordinates).
- *Switch basemap* – presents a choice of basemaps and select from the displayed maps such as Street (default), topographic, National Geographic, Oceans basemaps etc.
- *Legend* – displays layer symbols and names. NOTE: These are empty until layers are created.
- *Measurement* - measure the distance between points on the map, measure the area of a drawn polygon, get the latitudinal and longitudinal coordinates for a point.

To minimise any of the above controls, click on the button to do so.

Figure 2: Toolbar hidden

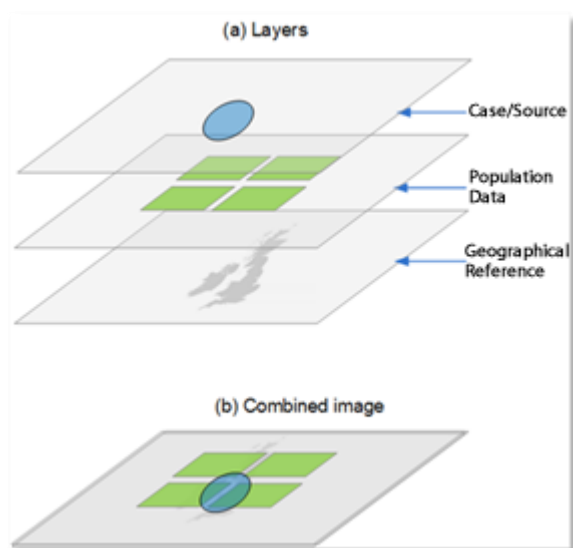


## Layers

The Legionnaires' GIS builds maps using layers. The bottom layer is the *basemap*, which provides the spatial references for the layers that the user adds.

In *Figure 3*, layers A and B are added to a basemap.

Figure 3: Constructing a map from layers



Each layer is created from a separate dataset comprising of records which must contain both the data (e.g. cases or potential sources) that the user wants to plot onto the map, and a geocode (latitude and longitude) for each record which relates the record to its spatial location.

The Legionnaires' GIS assigns symbols to created layers automatically.

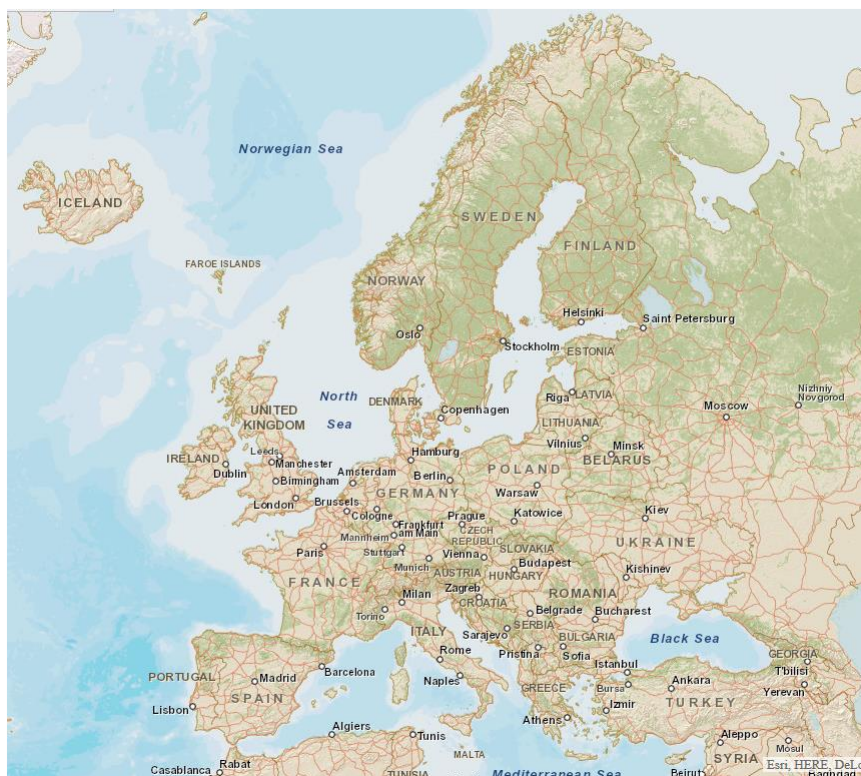
The layer for population contains the Eurostat *GEOSTAT* 2011 dataset by default. However, the user can request ECDC ELDSNet team to *upload an alternative population dataset* should more accurate data be available.

An uploaded dataset must be in a Comma Separated Variable (*CSV*) file.

## Basemaps

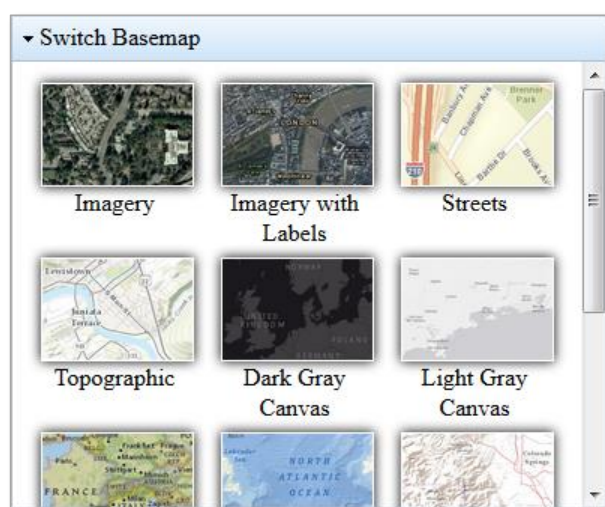
A basemap depicts background geographical reference information such as national and regional borders, roads and topography. The GIS uses the basemap to visualise the data in a layer spatially, and to rescale data layers.

Figure 4: Legionnaires' GIS default basemap



To change basemap, click on the **Switch Basemap** button and click on a map of choice. NOTE: Changing basemaps will not result in the deletion of any previously uploaded data, as data uploads are stored in their own layer.

Figure 5: Basemap gallery

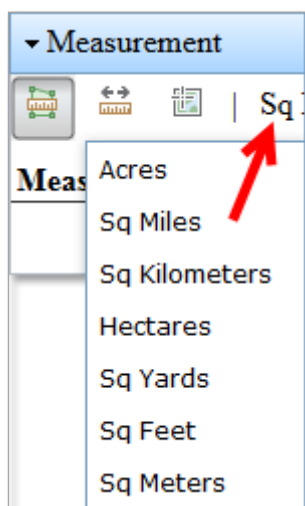



## Measurements


The **Measurement** button opens a toolbar that enables you to:


- Measure the area of a polygon.
- Measure the distance between points.
- Identify the latitude and longitude of a point.
- See measurement results

Right-click in the upper right hand corner of the toolbar to select a system of measurement for the control you want to use.



 **Area:** Click on three or more locations to create a polygon. *Double-click on the final location to finalize the polygon to be measured.*

 **Distance:** Click on the location from which the measurement is to be taken and click on one or more further locations to continue the measurement. *Double-click on the final location to end the lines to be measured.*

 **Latitude and longitude:** Click on a location to display its latitude and longitude, which you can then select and copy from the display.

*Click on any of the icons in the toolbar to clear your measurements.*

## Searching for a location

The **Search** button opens a text field in which you can type a geographic location. A location refers to an address (e.g. Tomtebodavägen 11a, 171 65 Solna, Sweden) or a pair of coordinates of latitude and longitude in decimal notation (e.g. 18.019369, 59.348564).

For addresses, possible matches found in the ArcGIS database are then listed beneath the field. Click on the correct link to find and pinpoint the searched location.



## Legend

By default, the map legend is collapsed. Once you add a layer to the map viewer (i.e. upload a dataset) or create a model, the legend automatically expands to display the layer's legend details.



## 1. Add data

Cases and sources are each saved in a separate *layer* in the GIS. They are added to their own layers using the **Add data** controls described in [Table 1](#) using the following methods:

- Uploading files in the formats described in [Case data](#) and [Source data](#).
- Adding and removing instances directly in the GIS interface.

When you upload a case dataset, any case data already entered in the map will be deleted. Likewise, when you upload a source dataset, any source data already entered in the map will be deleted.

However, you can add and/or remove cases or sources to an uploaded dataset in the GIS interface. These changes will only be saved if you export all the data as a new CSV file.

As well as case and source data, you can display a population density layer derived from the Eurostat [GEOSTAT](#) 2011 dataset. If necessary, you can also upload population data from another source, e.g. more recent or local data, see [Uploading an alternative population dataset](#).

Apart from case and source data, you are able to display a population density layer derived from the Eurostat [GEOSTAT](#) 2011 dataset. It is possible to have own up to date or local data population data uploaded into GIS. This needs to be requested to ECDC. NOTE: once your submitted data has been uploaded into GIS, it will then be available to all GIS users. See [Uploading an alternative population dataset](#).

The **Add data** controls shown in [Figure 6](#) are described in [Table 1](#).

Figure 6: Add data controls

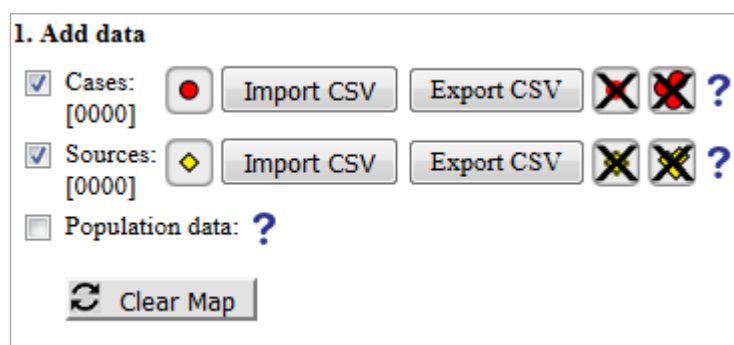

















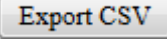





Table 1: Add data controls

Control	Description
Cases	Click the <input checked="" type="checkbox"/> <b>Cases:</b> checkbox to display or hide cases on the map.
	Click the <b>Cases</b> button  to start adding cases. The button's background colour changes to red  . To add an individual case, point the cursor to the location on the map and then click. A case is added to your map as a red circle  at the selected location.
	The add-cases functionality is activated when you import a case CSV file.
	Click the red button  to deactivate the functionality.

Control	Description
	<p>Click the <b>Delete Case</b> button  to start deleting individual cases. The button's background colour changes to red . To delete an individual case, point the cursor to the case on the map and then click.</p> <p>Click the red button  to deactivate the functionality.</p>
	<p>Click the <b>Delete All Cases</b> button  to delete all cases – you are prompted to confirm or cancel the deletion.</p>
	[0000] Counter of the number of cases added.
Sources	<p>Click the <input checked="" type="checkbox"/> <b>Sources:</b> checkbox to display or hide sources on the map.</p> <p>Click the <b>Sources</b> button  to start adding sources. The button's background colour changes to red . To add an individual source, point the cursor to the location on the map and then click. A source is added to your map as a yellow rectangle  at the selected location. The add-sources functionality is activated when you import a source CSV file.</p> <p>Click the red button  to deactivate the functionality.</p> <p>Click the <b>Delete Source</b> button  to start deleting sources. The button's background colour changes to red . To delete an individual source, point the cursor to the source on the map and then click.</p> <p>Click the red button  to deactivate the functionality.</p> <p>Click the <b>Delete All Sources</b> button  to delete all sources – you are prompted to confirm or cancel the deletion.</p>
	[0000] Counter of the number of sources added.
Import CSV	Click the <b>Import CSV</b> button  to import respectively a case or source dataset from a CSV file.
Export CSV	<p>Click the <b>Export CSV</b> button  to export respectively the cases or sources displayed in the GIS as a dataset in a CSV file.</p> <p>NOTE: In Internet Explorer or Firefox, to save the exported CSV file copy the contents displayed in the popup window and paste into a new MS Excel file then save the file.</p> <p>In Google Chrome, the exported CSV file will be downloaded to your local drive.</p>
Population data	Check the <b>Population data</b> checkbox <input checked="" type="checkbox"/> <b>Population data</b> to display the default GEOSTAT population data layer.
Clear map	Click the <b>Clear Map</b> button  <b>Clear Map</b> to delete all the data you have uploaded and entered in the map and to revert to the default <a href="#">basemap</a> .
Help	Click on  to open the online Help.

## Case data

Case data are represented in the GIS by a red circle .

The total number of cases is shown in brackets (e.g. **[0008]**) in the **Add data** group on the toolbar.

For a CSV upload, the mandatory variables in a case data CSV file are listed in [Table 2](#).

*Table 2: Mandatory case data variables*

ID	Name	Latitude	Longitude	Weight factor
1	text	decimal	decimal	decimal
2	text	decimal	decimal	decimal

The mandatory/required variables must meet the following requirements:

- ID: a sequential number to identify the case. Numeric field.
- Name: text identification of the case and/or location. Text field.
- Latitude and longitude: coordinates specified in centesimal degrees, e.g. 47.866, -1.632. Decimal field.
- *Weight factor*. Decimal or integer field.

The GIS can deal with a few additional attribute variable columns (that constitute the basis for the weighting factor), such as the type of location (home/work/leisure – text field) and the duration in hours spent at a location (integer field). The GIS can produce outputs taking into account different locations per individual (i.e. more than one row per individual).

*Table 3: Case data CSV example*

id	name	lat	lon	weight_factor
1	Case A Residential	59.33166	18.05521	1
2	Case B Residential	59.33159	18.05499	0.5
3	Case B Work	59.33153	18.05474	0.25
4	Case B Leisure	59.33159	18.05499	0.25
5	Case C Work	59.33153	18.05474	1

## The weight factor


The weight factor is set on by default, but can be turned off, in which case all rows are considered to have weight one.

The weight factor is used to account for the proportion of time a case spent at a given location. The data contains one row per location visited with a weight (number between 0 and 1) proportional to the time spent at that location. The size of the case symbol in the map is proportionate to the weight factor.

For example, case B might have spent, in the exposure period between 2 and 10 (or 14) days before falling ill, half of the time at location X, a fourth of the time at location Y, and a fourth of the time at location Z. The weighted factors would thus be 0.5, 0.25 and 0.25 respectively. It is not required that the sum of weight factors equals 1 (e.g. it could be less if a case was for a certain number of days outside the area considered), but the accumulated weight factors for a single case should not be greater than 1.

When interpreting the map, one needs to consider that exposure periods are not the same for different cases, but that this factor is not considered by the model.

## Source data

Source data are represented in the GIS by a yellow rectangle .

The total number of sources is shown in brackets (e.g. <sup>[0008]</sup>) in the **Add data** group on the toolbar.

For a CSV upload, the mandatory variables in a source data CSV file are listed in [Table 4](#).

*Table 4: Mandatory source data variables*

ID	Name	Latitude	Longitude
1	text	decimal	decimal
2	text	decimal	decimal

The following variables must meet the following requirements:


- ID: a sequential number to identify the case. Numeric field.
- Name: text identification of the location. Text field.
- Latitude and longitude: coordinates specified in centesimal degrees, e.g. 47.866, -1.632. Decimal field.

*Table 5: Source data CSV example*

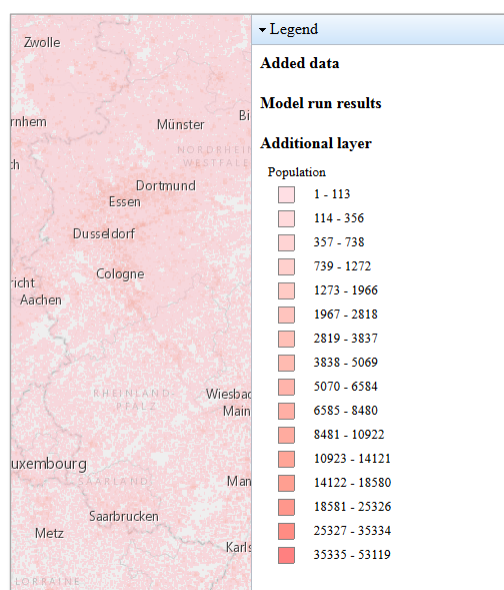
id	name	lat	lon
1	Source # Alabama 1	48.14044	-1.527
2	Source # Colorado 2	48.142	-1.5258

## Population data

The Eurostat [GEOSTAT](#) 2011 dataset is used in the Legionnaires' GIS as the default population [layer](#). However, you can [upload an alternative population dataset](#) should you have more accurate data.

Check the **Population data** checkbox  **Population data** in the Add data group on the toolbar to display the GEOSTAT population data layer.

Click the **Legend** button to display the scaling of the population data. The population density symbols uses a pink to red scale and 40 % transparency.



## Upload an alternative population dataset

The Eurostat [GEOSTAT](#) 2011 dataset is populated as a layer in the Legionnaires' GIS by default. However, you can request the ECDC ELDSNet team to upload replacement population density data should you have more accurate data.

To request an upload of a new replacement dataset:

1. Prepare a raster according the requirements in [Table 6](#) and [Table 7](#).
2. Send a zip file containing the raster to ECDC: [eldsnet@ecdc.europa.eu](mailto:eldsnet@ecdc.europa.eu). NOTE: add a descriptive subject and detailed explanations in the email body!

Submitted population density data will be checked by ECDC and GIS will be configured with the submitted data. You will be informed by email when the data has been uploaded. NOTE: The data will then be available for use by all GIS Users.

**Table 6: Raster requirements**

Cell size: 500 meters
Spatial_Reference: WGS_1984_Web_Mercator_Auxiliary_Sphere
Raster value should represent population
Data format: ESRI File geodatabase version 10.1+
File geodatabase should contain only one raster layer

File geodatabase should be zipped

*Table 7: Other requirements (detailed)*

Number_of_Bands	1
Cell_Size	500, 500
Format	FGDBR
Source_Type	Generic
Pixel_Type	signed integer
Pixel_Depth	32 Bit
NoData_Value	absent
Colormap	absent
Pyramids	absent
Compression	LZ77
Spatial_Reference	WGS_1984_Web_Mercator_Auxiliary_Sphere
Linear_Unit	Meter (1.000000)
Angular_Unit	Degree (0.0174532925199433)
False_Easting	0
False_Northing	0
Central_Meridian	0
Standard_Parallel_1	0
Auxiliary_Sphere_Type	0
Datum	D_WGS_1984

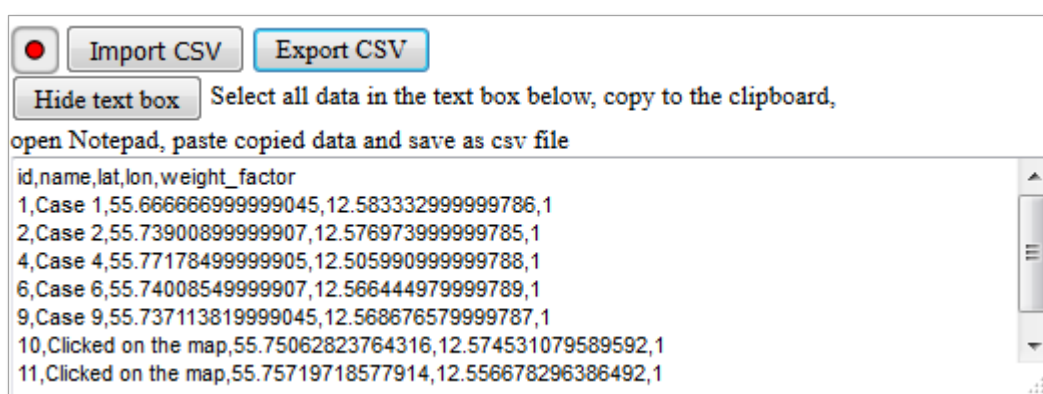
## Export data

To export cases or sources:

If using Internet Explorer or Firefox, click the **Export CSV** button to display the case or source records in a pop-up window.

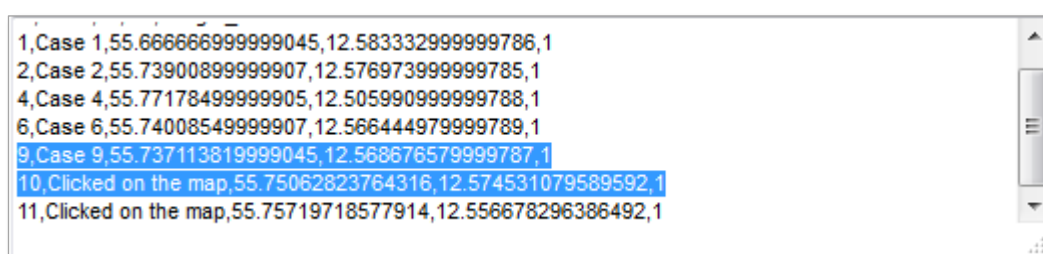
In [Figure 7](#) the records include both imported cases (from a CSV file) and cases added through clicking on the map. Cases deleted through the map are not included in the data, e.g. Case 3 in [Figure 7](#).

Figure 7: Exporting case records



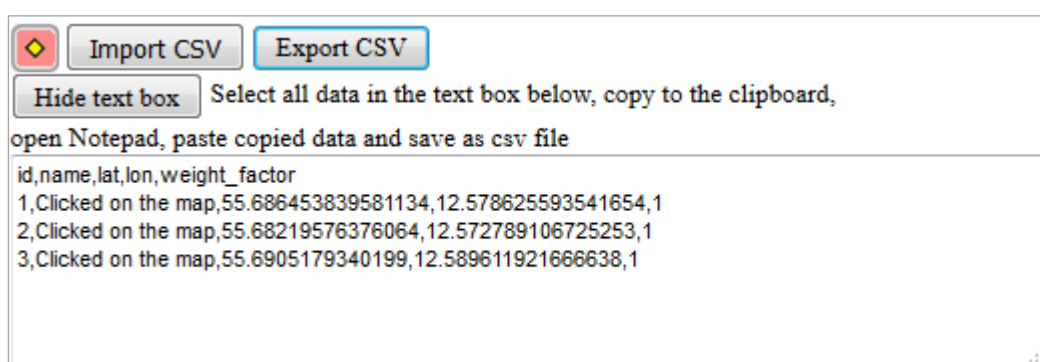
1. You can select some (**Ctrl + click**) or all (**Ctrl + A**) records.

Figure 8: Selecting case records to be exported



2. Right-click the selected records and select **Copy**, or enter **Ctrl + C**.
3. Paste the copied records into a text editor or spreadsheet such as Excel and save the file with the CSV extension, e.g. *<name>.csv*
4. Click the **Hide text box** button to return to your map.

Figure 9: Exporting source records



If using Google Chrome, the exported CSV file will be downloaded to your local drive.



## 2. Select a model

The methodology of the four models in the Legionnaires' GIS is described in the [Introduction](#).

(The methodology of the four models which Legionnaires' GIS provides is described at the beginning within the [Introduction Section of this HelpFile](#).

Below are the two scenarios when you utilise the tool:

- A. When you only have case locations but have no potential outbreak source locations such as cooling towers
  - Model 1: Case density map.
  - Model 2: Case risk map.
- B. When you have case locations and some potential source locations that you want to compare in terms of probability of indeed being the source:
  - Model 3: Case density within buffer rings around potential sources.
  - Model 4: Case risk within buffer rings around potential sources.

Models 2 and 4 (the risk maps) take the population density into account and are therefore usually preferable to models 1 and 3 (the density maps).

The population density is based on residential locations of case subjects. Instances where data on cases is also available on time spent in different locations besides residential location such as workplaces, leisure locations etc. it will not be meaningful to calculate risks based on residential locations data. In such a situation, a density map might be more appropriate than a risk map.

The outputs of each model are shown in [Table 8](#). Note: only the models containing source data (models 3 and 4) have the option to display the results in a table.

The processes performed when you execute each model are described in [Table 11](#).

Check the radio buttons illustrated in [Figure 10](#) to select your model.

Figure 10: Model selection controls

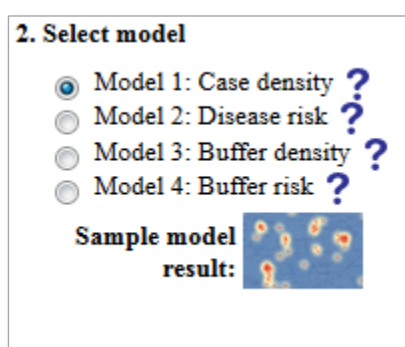


Table 8: Model outputs

Output	Description	Model			
		1	2	3	4
ID	ID of the source as in the source layer – either the ID from the CSV file for an imported source, or a sequentially added number for a source added in the interface. See <a href="#">Figure 11</a> .	N	N	Y	Y
Name	Name of the source as in the source data layer – either the name from the CSV file for an imported source, or <i>Clicked on the map</i> for a source added in the interface. See <a href="#">Figure 11</a> .	N	N	Y	Y
Buffer	Distance in metres of the buffer from the source.	N	N	Y	Y
km <sup>2</sup>	The calculated area of each buffer.	N	N	Y	Y
Total cases	Total number of cases in each buffer area from the case layer.	N	N	Y	Y
Cases per km <sup>2</sup>	Case density per km <sup>2</sup> .	Y	N	Y	N
Cases per km <sup>2</sup> per 10000	Cases per km <sup>2</sup> per 10000 in each buffer area calculated using the population layer data.	N	Y	N	N
Total population	Total population in each buffer area calculated using the population layer data.	N	N	N	Y
Cases per 10000	Cases per 10000 in each buffer area calculated using the population layer data.	N	N	N	Y
Table	The tables allow you to compare potential sources. The Model 3 table is illustrated in <a href="#">Figure 12</a> and the Model 4 table in <a href="#">Figure 13</a> .	N	N	Y	Y
Graph	<p>The graphs allow to compare potential sources.</p> <p>Model 3: graph displays, for each potential source, the cases per km<sup>2</sup>, versus the buffer distance from source for each buffer group. See <a href="#">Figure 12</a>.</p> <p>Model 4: graph displays, for each potential source, the cases per 10000 population versus the buffer distance from source for each buffer group. . See <a href="#">Figure 13</a>.</p> <p>The graph is either a smoothed polyline with a grey area under the curve or, if the graph depicts a monotonic descending curve, the area under the curve is red.</p> <p>A descending density or risk with distance from an aerosol producing potential source, may indicate a plausible epidemiological association. However, this depends on the height, extent of the aerosol plume, and the distances. The tables and graphs are only complementary geographical evidence.</p>	N	N	Y	Y

## Output tables and graphs to compare potential sources

The output tables and graphs for the source-data models (model 3 and 4) are illustrated in [Figure 12](#) and [Figure 13](#). The outputs in the tables and the graphs are described in [Table 8](#).

[Figure 11](#) illustrates the difference between a source imported from a CSV file and a source added through the interface by clicking on the map.

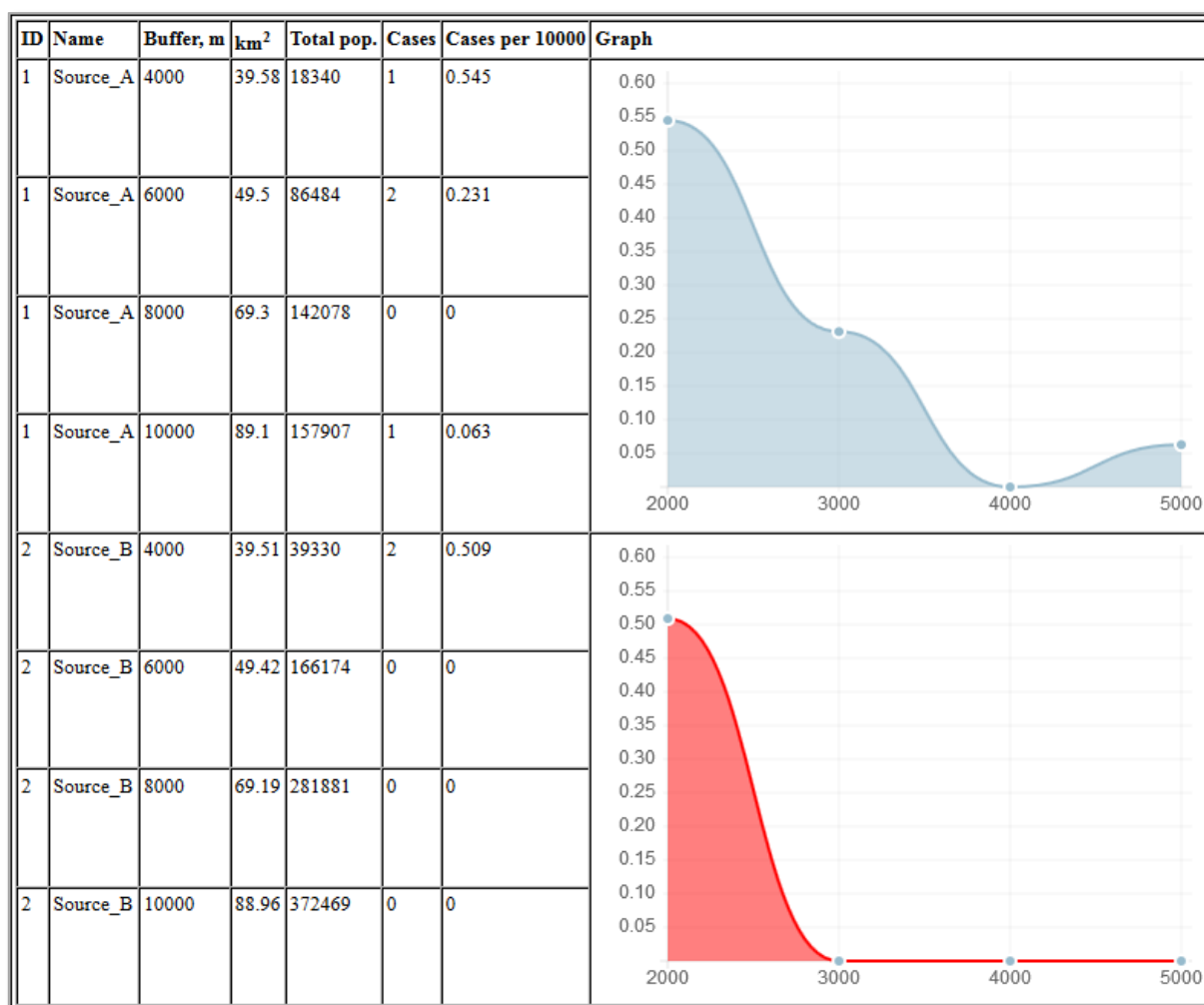
*Figure 11: Source identifications in model tables*

3	Source_C	10000
4	Clicked on the map	4000

Figure 12: Model 3 output table and graph



Figure 13: Model 4 output table and graph



## 3. Configure model parameters

Setup the Model Parameters accordingly to the options as defined in [Table 9](#) to configure the *selected model*.

Figure 14: Model parameter controls

**3. Model parameters**


Output cell size: 500 px ?

Search radius: 1 km ?

Weight factor: No ?

Buffer rings distance: 0.1km, 0.2km, 0.5km, 1km ?

Table 9: Model selection parameters

Parameter	Description
Output cell size	Select the cell size in pixels to be used in the output raster: 20, 50, 100, 200, or 500 pixels. The default selection is 20 pixels. NOTE: This is disabled for Model 3 and Model 4.
Search radius	Select the search radius in kilometres to be used by the kernel function: 0.2, 0.5, 1, 2, 5, 10 kilometres. NOTE: This is disabled for Model 3 and Model 4.
Weight factor	Specify whether to apply a <i>weight factor</i> field to each case location. <ul style="list-style-type: none"> <li><b>No.</b> Default. The system applies the same weight factor (1) to all case locations.</li> <li><b>Yes.</b> The system applies the value in the weight_factor field in the uploaded CSV case data file as the weight factor for each case location.</li> </ul>
Buffer rings distance	Select the radius of the buffer rings to be applied in the model. There are four sets of buffer rings, ranging from 0.2 to 1 kilometre, to 5 to 20 kilometres. Disabled for Model 1 and Model 2.
Clear map	Click the <b>Clear Map</b> button  <b>Clear Map</b> to delete all the data you have uploaded and entered in the map and to revert to the default <i>basemap</i> .
Help	Click on ? to open the online Help.

## 4. Execute a model

Use the controls as defined in [Table 10](#) to execute the *configured model*. When the model has been generated, it is displayed as a new layer in the GIS interface and a *legend* for the layer is created.

The processes performed when you execute a model are described in [Table 11](#).

Figure 15: Model execution controls

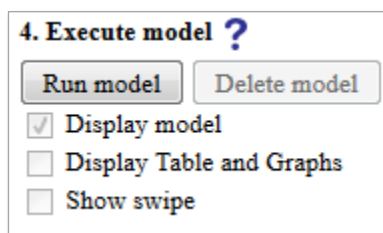


Table 10: Model execution controls

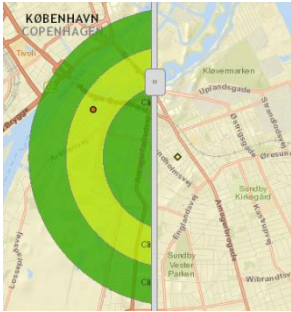

Control	Description
Run model	Click <b>Run model</b> to execute the selected model.
Delete model	Click <b>Delete model</b> to delete the model, the table and the graphs. The cases and sources are not deleted.
Display model	Click the <input checked="" type="checkbox"/> <b>Display model</b> checkbox to display or hide the model in the GIS interface.
Display table and graphs	Click <input checked="" type="checkbox"/> <b>Display Table and Graphs</b> checkbox to display or hide the model's <i>tabular and graphic results</i> in the <b>Results</b> frame <b>Results</b> at the bottom of the GIS interface. Only for model 3 and 4 (source-data models) tables and graphs are produced (to compare sources).
Show swipe	Click the <input checked="" type="checkbox"/> <b>Show swipe</b> checkbox to activate the swipe tool, which you can use to slide over the displayed model and expose the underlying data (cases and sources) to the right of the swipe tool. NOTE: The Display Model checkbox need to be activated for this function to work. 
Clear map	Click the <b>Clear Map</b> button  <b>Clear Map</b> to delete all the data you have uploaded and entered in the map and to revert to the default <i>basemap</i> .
Help	Click on <b>?</b> to open the online Help.

Table 11: Model processes

Process	Action
<b>Model 1 - Case density map</b>	
1.	Estimate the <i>probability density function</i> based on the number of cases by location.
<b>Model 2 - Case risk map</b>	
1.	Estimate the <i>probability density function</i> based on the number of cases by location.
2.	Calculate the risk by dividing the case density by the population density.
<b>Model 3 - Case density within buffer rings around potential sources</b>	
1.	Create four concentric buffers around each potential source.
2.	Calculate the number of cases falling within each buffer.
3.	Calculate the density of cases for each buffer.
4.	Create a graph for each source displaying the density (y-axis) against the distance of the buffer from the source (x-axis).
<b>Model 4 - Case risk within buffer rings around potential sources</b>	
1.	Create four concentric buffers around each potential source.
2.	Calculate the risk in each buffer by dividing the case density by the population density.
3.	Create a graph for each source displaying the risk (y-axis) against the distance of the buffer from the source (x-axis).



## 5. Export a map or portrait

This functionality allows you to print the map you create in a pdf format. The current export functionality is to be considered a beta version with some known bugs and will be improved soon.