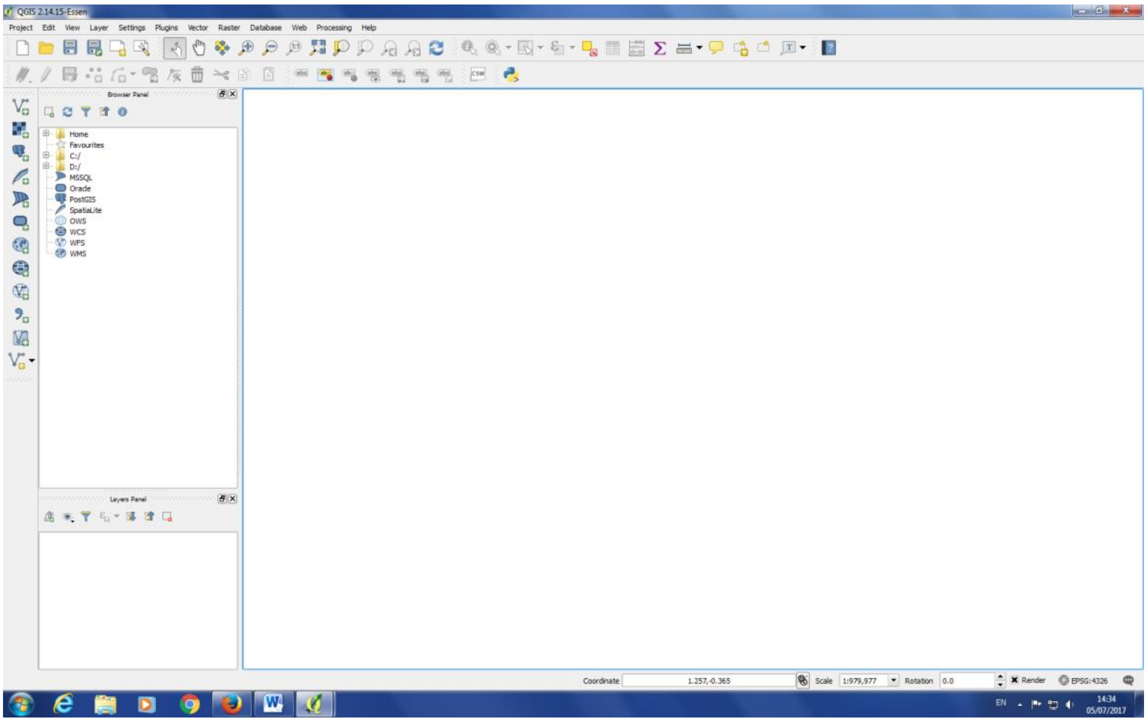
GIS and Computational Archaeology Practical Handout

by Arnau García (ag2023@cam.ac.uk), Andreas Angourakis (aa2112@cam.ac.uk),
Enrico R. Crema (erc62@cam.ac.uk)

Welcome to your first GIS (geographic information system) tutorial! This session will give you a little taste of what computational archaeology is and how it can help answer questions about the human past. This handout will give you detailed instructions on how to carry out the analysis in this practical, so that you can follow each step during the session in case you get lost. We will be using QGIS (version 3.8.1), a widely used free and open source platform for geographic information system. If you are interested, you can download and install a copy on your own computer from the following website:
http://www.qgis.org/en/site/

1. Let's start by double-clicking on the QGIS folder icon on your desktop. This will open a window with several files. To start your QGIS session, double-click on the one named "QGIS Desktop 2.14.15". After few seconds a window might appear (prompting you about some tips), click on the *OK* button if that happens.

2. Now click on *Project* on the top left of your screen and then on *New.* You should now see on your screen something very similar to the figure below (you might want to click on the square shaped icon on the top right of your window to have your program visualised in full screen):

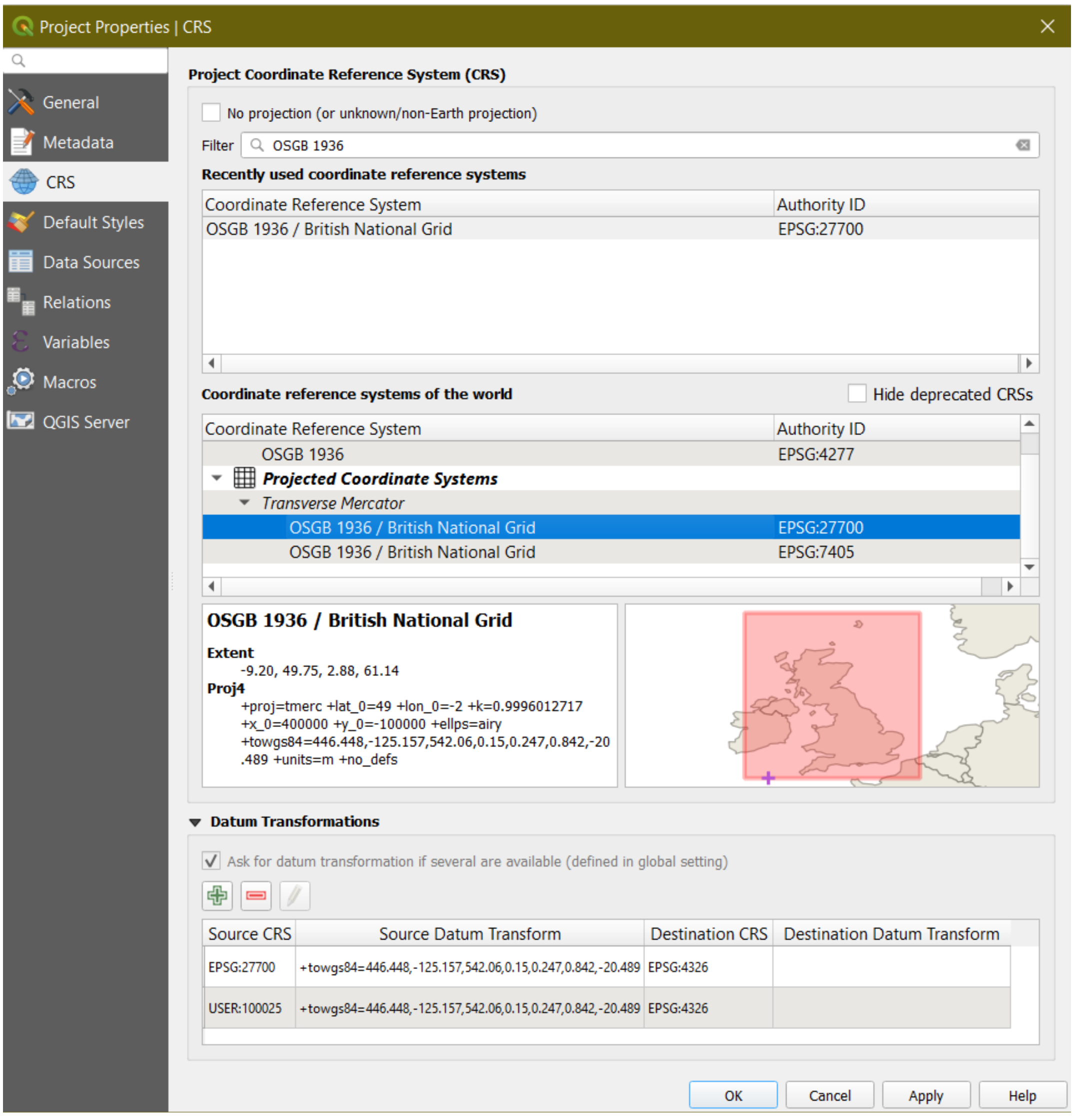


3. The large empty white window is your canvas and it is where we will be mapping our spatial data. Most GIS handle two kinds of data: **vector** and **raster**. The former is used to represent various kinds of shapes such as **points**, **lines**, and **polygons**. At a regional scale we often use **point** data to represent the location of sites while at the scale of an

individual site this might be the spot where a specific find/object was recovered. **Lines** and **polygons** can represent a variety of things, from rivers to the shape of individual buildings. **Rasters** are instead grids which are used to represent things that are continuous over space, such as elevation or temperature.

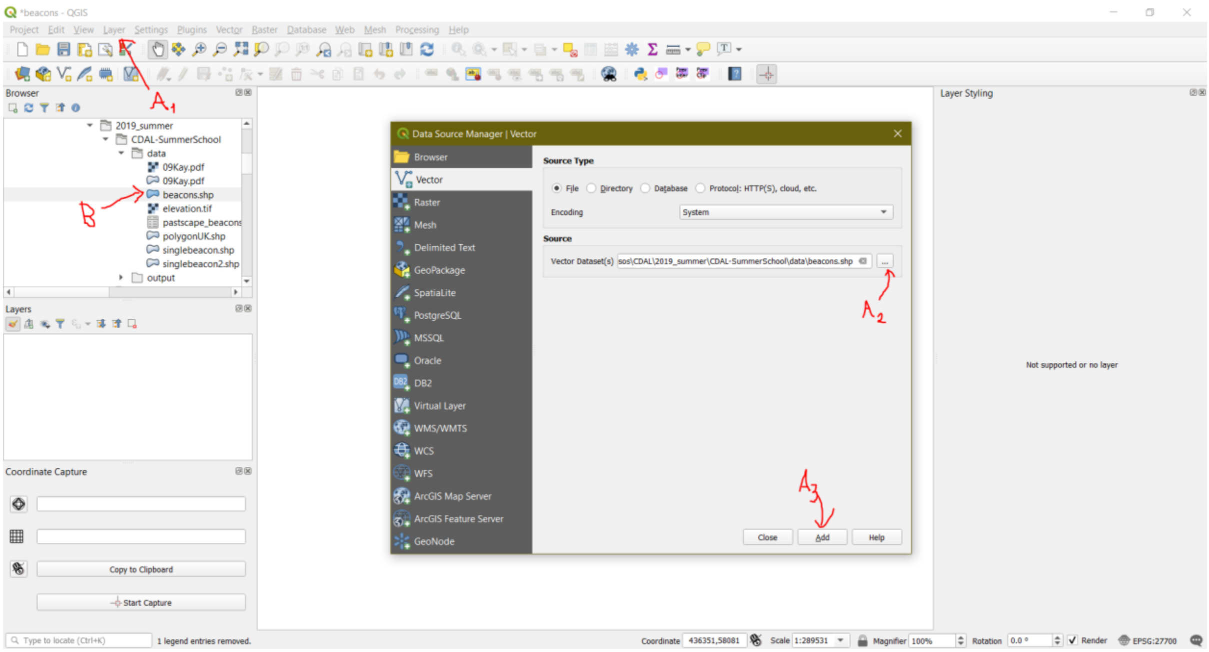
4. Now let's try making a distribution map of our beacons. Before reading our spatial data into QGIS we need to specify our *coordinate system*. Different countries use different systems for making their maps and we need to specify what system we want to use. In this case we will use the ***OSGB1936/British National Grid*** **system**.

5. Click on *Project* on the top bar, then on *Project Properties*. On the left panel click on the icon named CRS. Type "OSGB 1936" (without the quotation marks) in the box that says "Filter". In the window named "Coordinate reference Systems" you should see, under the section *Projected Coordinate Systems* an item called "OSGB 1936 / British National Grid EPSG:27700". Click on this, and then click on the button that says "Apply" and then on the button that says "Ok". The window should automatically close.

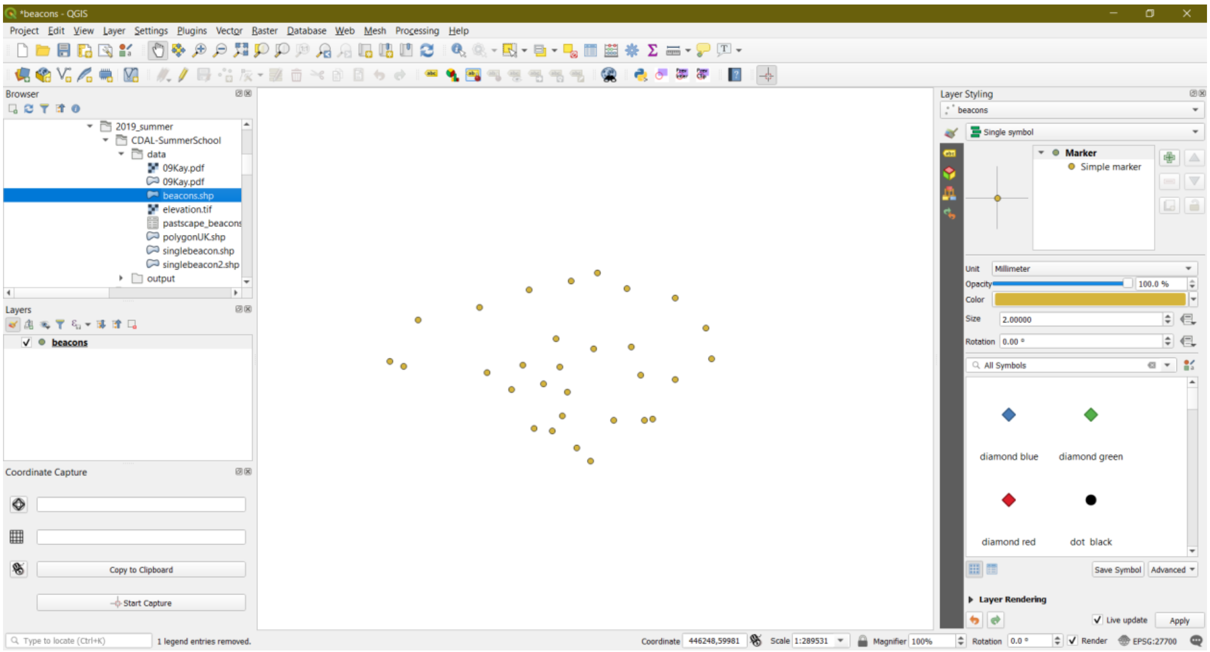


6. We are now ready to read our spatial data. Go to *Layer* then select *Add Layer* and then click on *Add Vector Layer* (option A, step 1). In the pop-up window, click on "…" (step 2), then navigate in the file explorer to "CDAL-SummerSchool" and then to "data". Select the file named "**beacons.shp**" and click *Open*. This will bring you back to the first window. Click on *Add* (step 3). You may also use the *Browser* panel (top left, option B), where you can double-click on the file name to add the layer.

7. The beacon positions were obtained at Historic England's PastScape engine (http://www.pastscape.org.uk). The sample in raw format is available as a csv file in the folder named "raw data".



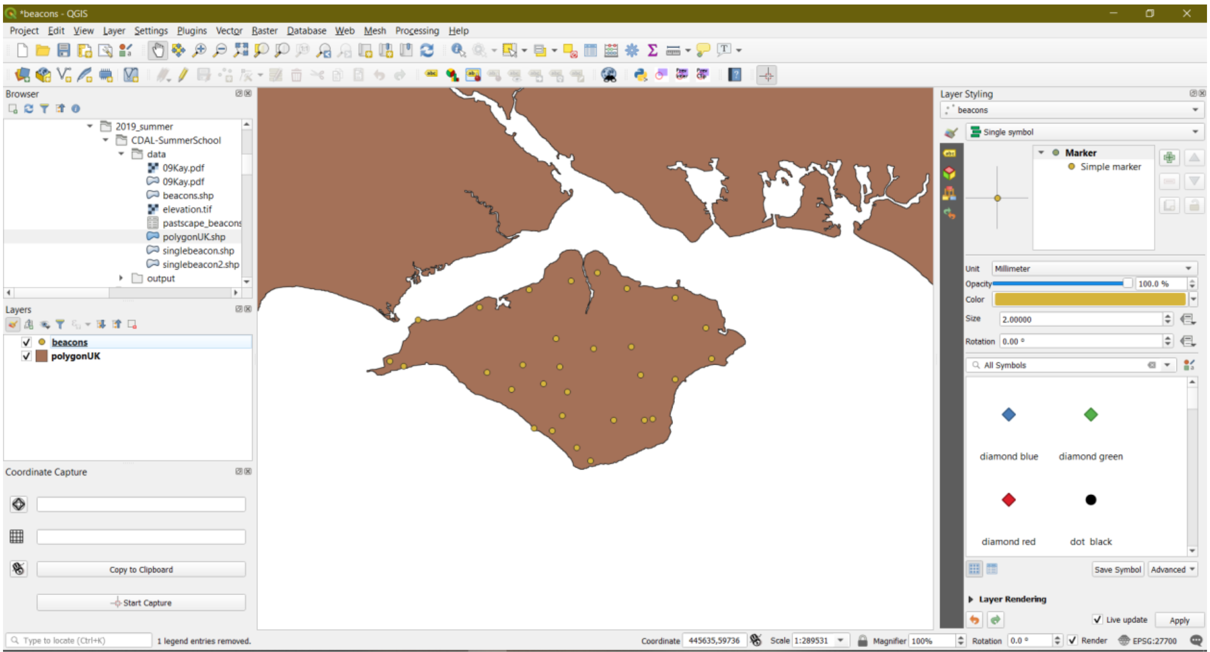
8. You should have now a series of vector points representing each of our beacons. We know they are located somewhere on the Isle of Wight, but the map does not tell much… isolated points on a blank space don't certain mean much without a context! We can make the map more readable by visualising a polygon representing the UK on the background.



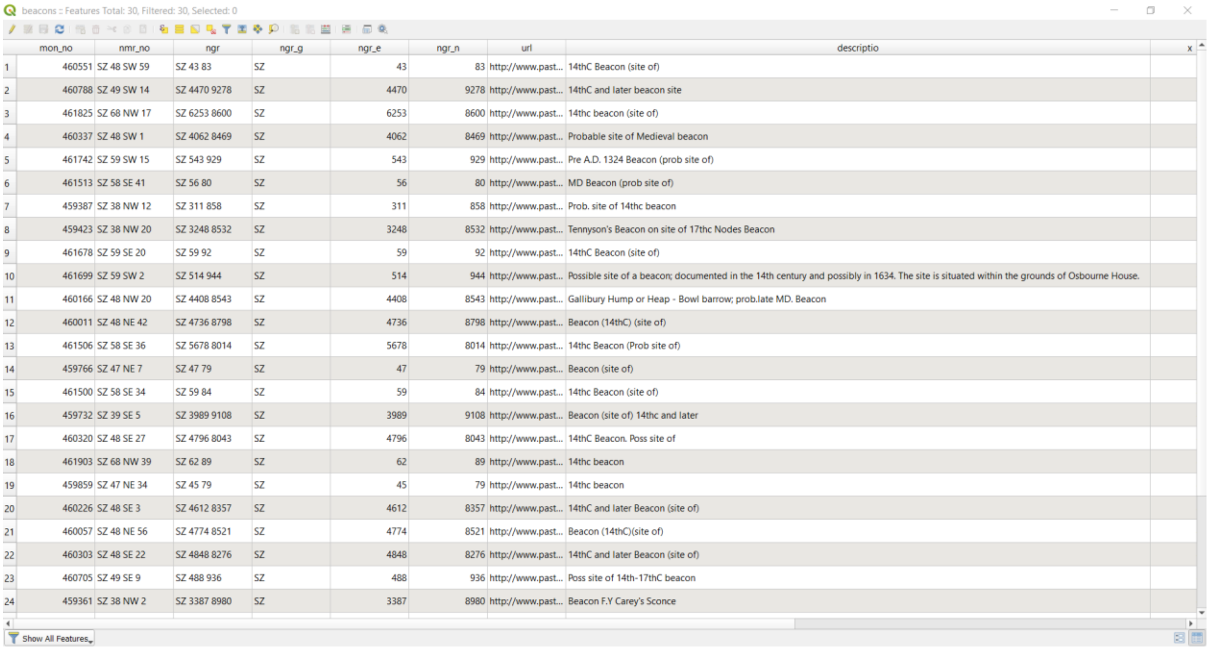
9. Repeat the steps you used to open "**beacons.shp**", but this time select the file named "**polygonUK.shp**".

10. You should now have a nice view of the Isle of Wight, but we no longer see our beacons! This is because they are hidden under our polygon. In order to see them again move your cursor inside the *Layers* panel on your bottom left, then click and drag the item called "polygonUK" below "beacons". You should now be able to see your vector points on top of your polygon data.

11. You can "navigate" your map by using the mouse scroll wheel to zoom in and zoom out, and by click and dragging to move around.



12. Now select "beacons" on the *Layers Panel*, right-click to open a menu and choose "Open Attribute Table". You should see a new window containing a large table. These are attributes associated with each of our beacons. Maximise the window and expand the field called "description" (move the mouse near the right edge of the column; when an icon with two arrows pointing at opposite directions appear, click and drag to your right to expand the field). You can now see short individual descriptions for each beacon.

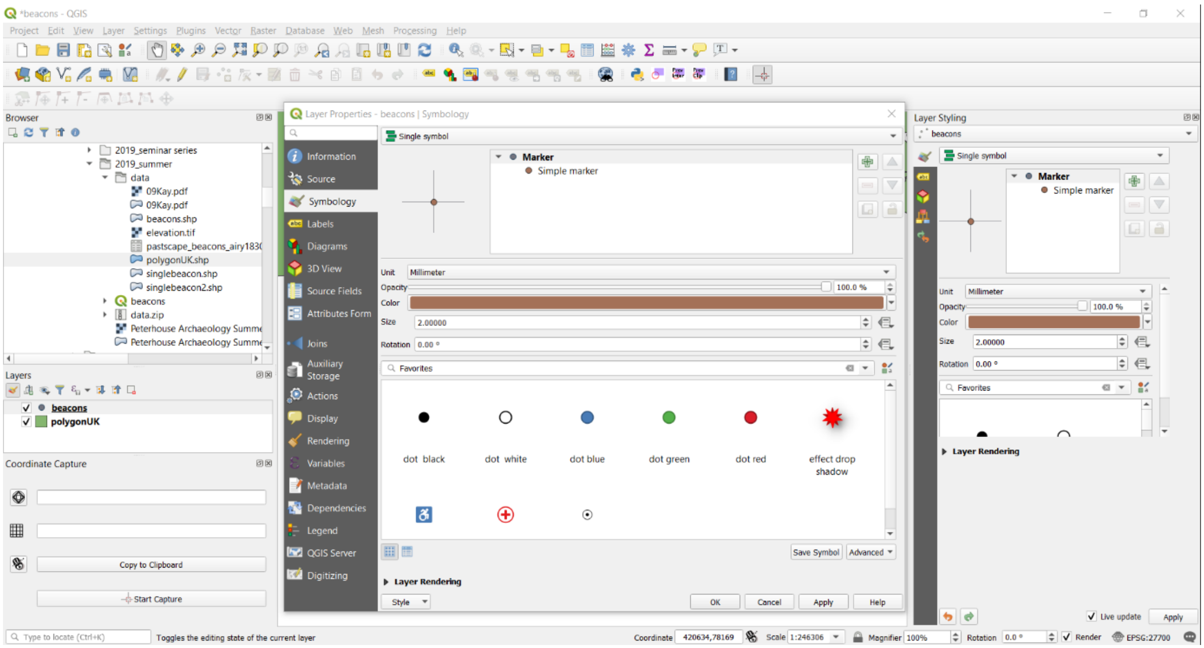


beacons :: Features Total: 30, Filtered: 30, Selected: 0

	mon_no	nmr_no	ngr	ngr_g	ngr_e	ngr_n	url	descriptio
1	460551	SZ 48 SW 59	SZ 43 83	SZ	43	83	http://www.past...	14thC Beacon (site of)
2	460788	SZ 49 SW 14	SZ 4470 9278	SZ	4470	9278	http://www.past...	14thC and later beacon site
3	461825	SZ 68 NW 17	SZ 6253 8600	SZ	6253	8600	http://www.past...	14thc beacon (site of)
4	460337	SZ 48 SW 1	SZ 4062 8469	SZ	4062	8469	http://www.past...	Probable site of Medieval beacon
5	461742	SZ 59 SW 15	SZ 543 929	SZ	543	929	http://www.past...	Pre A.D. 1324 Beacon (prob site of)
6	461513	SZ 58 SE 41	SZ 56 80	SZ	56	80	http://www.past...	MD Beacon (prob site of)
7	459387	SZ 38 NW 12	SZ 311 858	SZ	311	858	http://www.past...	Prob. site of 14thc beacon
8	459423	SZ 38 NW 20	SZ 3248 8532	SZ	3248	8532	http://www.past...	Tennyson's Beacon on site of 17thc Nodes Beacon
9	461678	SZ 59 SE 20	SZ 59 92	SZ	59	92	http://www.past...	14thC Beacon (site of)
10	461699	SZ 59 SW 2	SZ 514 944	SZ	514	944	http://www.past...	Possible site of a beacon; documented in the 14th century and possibly in 1634. The site is situated within the grounds of Osbourne House.
11	460166	SZ 48 NW 20	SZ 4408 8543	SZ	4408	8543	http://www.past...	Gallibury Hump or Heap - Bowl barrow; prob.late MD. Beacon
12	460011	SZ 48 NE 42	SZ 4736 8798	SZ	4736	8798	http://www.past...	Beacon (14thC) (site of)
13	461506	SZ 58 SE 36	SZ 5678 8014	SZ	5678	8014	http://www.past...	14thc Beacon (Prob site of)
14	459766	SZ 47 NE 7	SZ 47 79	SZ	47	79	http://www.past...	Beacon (site of)
15	461500	SZ 58 SE 34	SZ 59 84	SZ	59	84	http://www.past...	14thc Beacon (site of)
16	459732	SZ 39 SE 5	SZ 3989 9108	SZ	3989	9108	http://www.past...	Beacon (site of) 14thc and later
17	460320	SZ 48 SE 27	SZ 4796 8043	SZ	4796	8043	http://www.past...	14thC Beacon. Poss site of
18	461903	SZ 68 NW 39	SZ 62 89	SZ	62	89	http://www.past...	14thc beacon
19	459859	SZ 47 NE 34	SZ 45 79	SZ	45	79	http://www.past...	14thc beacon
20	460226	SZ 48 SE 3	SZ 4612 8357	SZ	4612	8357	http://www.past...	14thC and later Beacon (site of)
21	460057	SZ 48 NE 56	SZ 4774 8521	SZ	4774	8521	http://www.past...	Beacon (14thC)(site of)
22	460303	SZ 48 SE 22	SZ 4848 8276	SZ	4848	8276	http://www.past...	14thC and later Beacon (site of)
23	460705	SZ 49 SE 9	SZ 488 936	SZ	488	936	http://www.past...	Poss site of 14th-17thC beacon
24	459361	SZ 38 NW 2	SZ 3387 8980	SZ	3387	8980	http://www.past...	Beacon F.Y Carey's Sconce

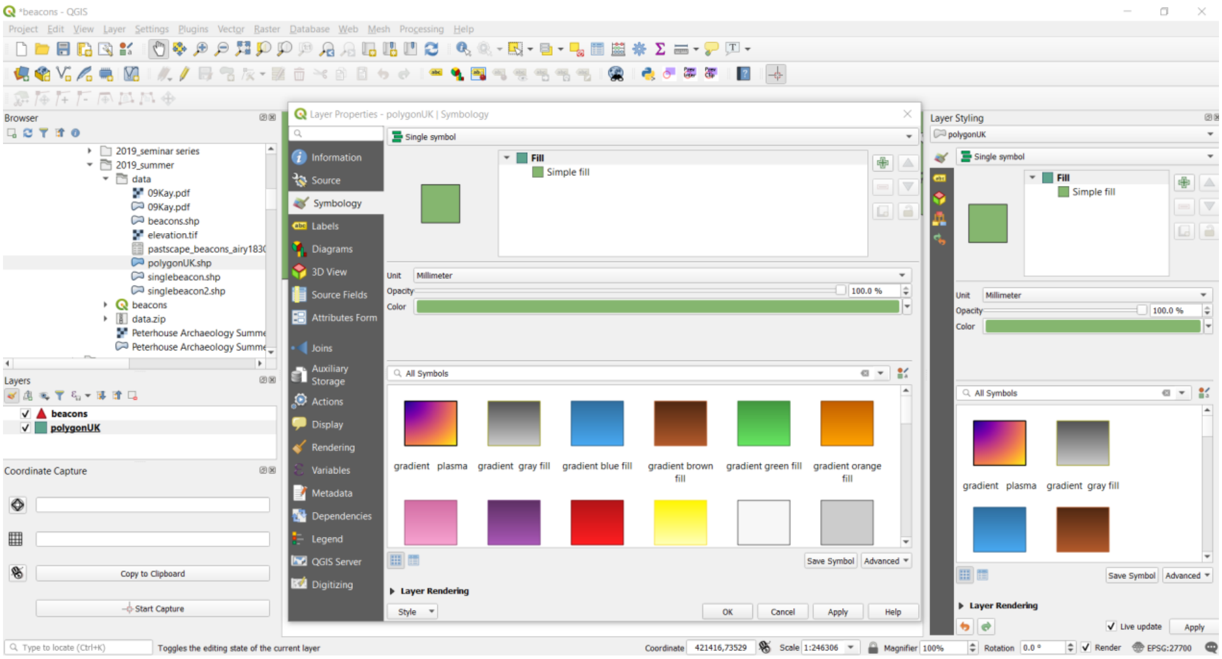
Show All Features

13. Now close the window (click on the x button on the top-right). Select "beacons" on the left menu again, double-click and this time select *Properties*. On the left-hand menu choose *Symbology*, this will open a window like the one the next page. The same options are also available on the *Layer Styling* panel (right). Both window and panel can be resized by dragging the edges.



14. We are now able to change the shape, the size, and the colour of the points representing our beacons. Feel free to choose any combination you'd like, then click on *OK*.

15. We can do the same with the colour of our polygon data. In the layer window, click on "polygonUK" then choose *Properties* and then *Symbology*. As for the points, feel free to choose any colour you like.

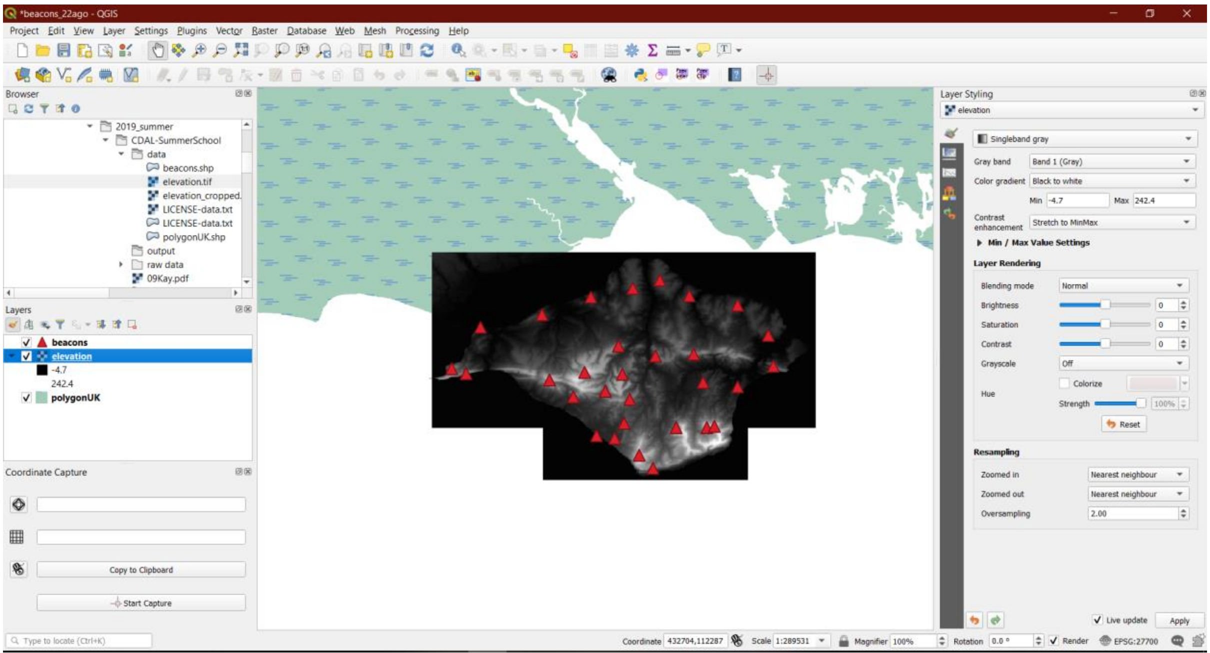


16. We are now ready to start doing some visibility analysis. In order to do so we first need a model representing the elevation or topography of the Isle of Wight. This is known as a DEM (Digital Elevation Model), a particular kind of raster data that is widely used to study the topographic settings of archaeological sites.

17. Select *Layer* in the top menu, then *Add Layer* and then *Add Raster Layer*. Click on "…" button" and navigate to "CDAL-SummerSchool/data". Select the file named "**elevation.tif**" and then click on *Open*, *Add*, and then *Close*. Feel free to use the *Browser* panel instead.

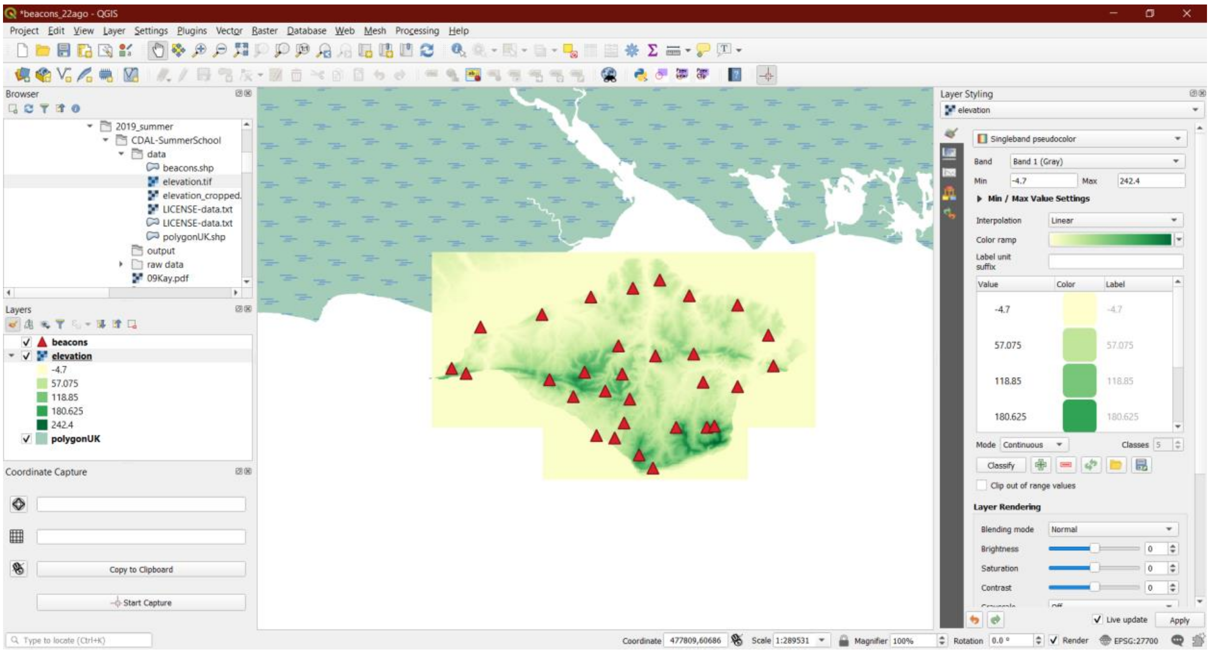
18. This is a 50-meter resolution DEM (i.e. cells are 50 m^2) obtained at the Ordnance Survey Open Data (www.ordnancesurvey.co.uk).

19. You should now see the Isle of Wight in black and white, and a new item added on the Layers menu on your left. The colours in this case represent different altitudes, darker colours are lower elevations and lighter shades of grey represent higher elevations.



20. You might want to change this colour scheme though. Select “elevation” in the *Layers Panel* on your left and go to *Properties*, then *Symbology* or simply take a look at the Layer Styling panel on the right.

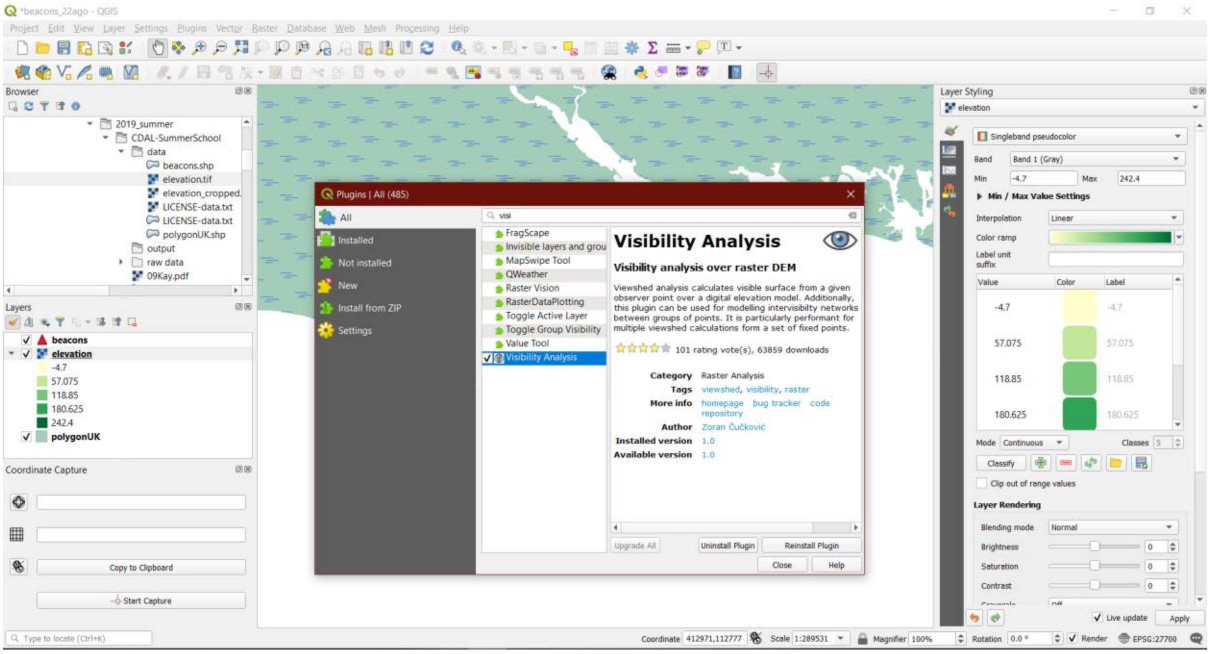
21. Now, click on “Singleband gray” in the section labelled “Render Type”. This will give you a range of options. Choose “Singleband pseudocolor”. Now click on “Color ramp”. Select “All Color Ramps” and choose “YlGn” (=Yellow Green) from the list. Click on *Apply*.



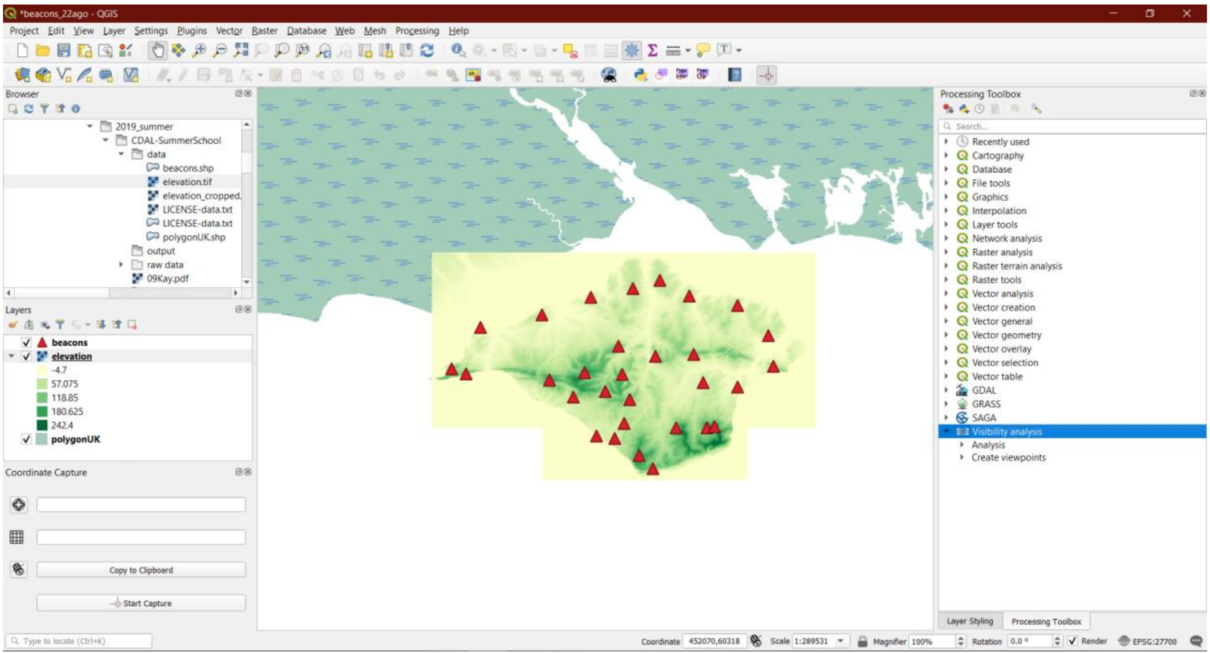
22. The DEM has now a nicer colour range showing low elevations in yellow and high elevations in green.

23. We have now all the data we need to carry out our visibility analysis. We'll start by measuring the visual connectivity of our beacons.

24. Whenever using your own computer, you should first install the *Visibility Analysis* plugin. Search and install it in *Plugins* (top menu), and then "Manage and install plugins…".

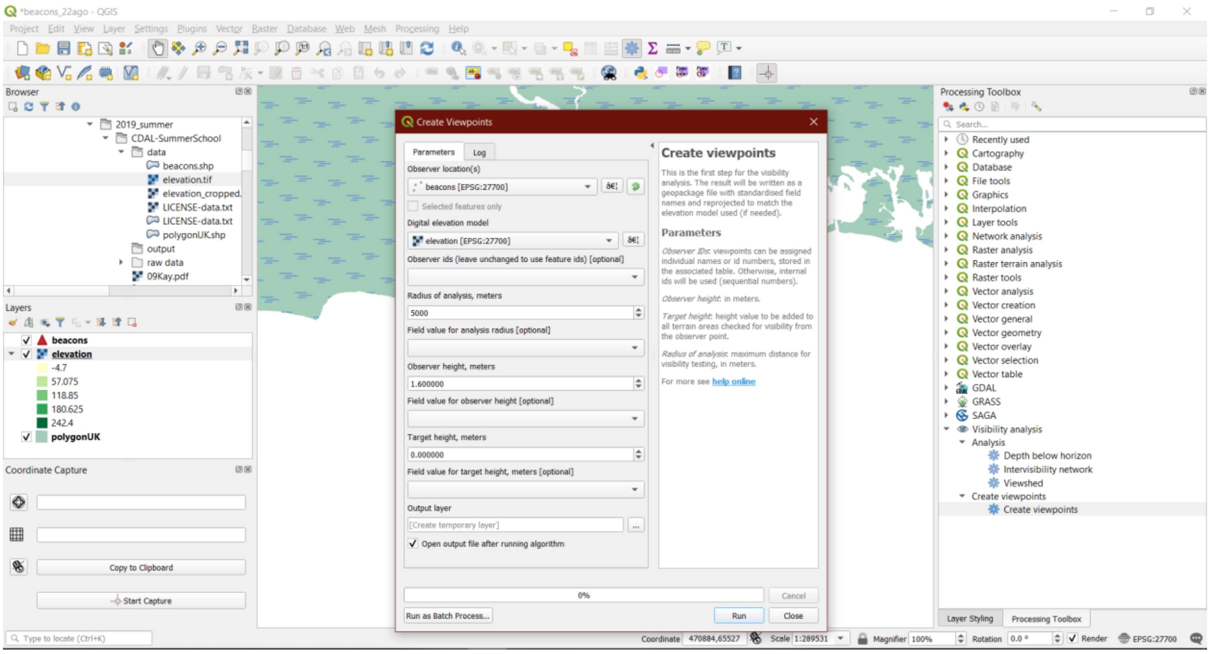


25. On the top menu select *Processing*, then *Toolbox*, which will open the *Processing Toolbox* panel (on the right). You can now see at the end of the list the different analyses offered by the *Visibility Analysis* plugin.



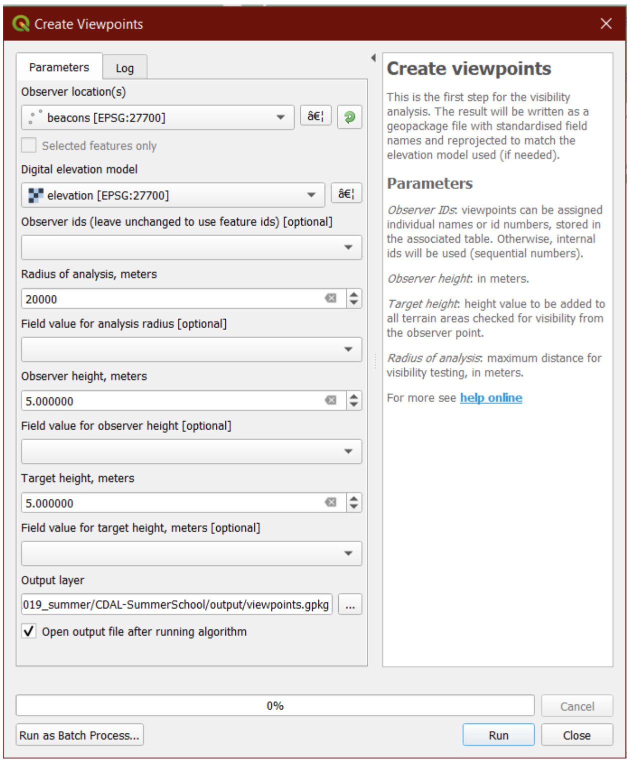
26. First, we need to generate viewpoints from the beacon positions in order use them in further analyses. Expand *Create viewports* (click on plus sign) and double-click on *Create viewports* (the one with a cog icon). Increase the size of the pop-up window, if necessary.

27. In the pop-up window, scroll down to *Output layer* and click on "…". Select "Save to file" and navigate to the folder named "CDAL-SummerSchool", then to "output", and type "viewpoints" under file name. Then click on *Save*.



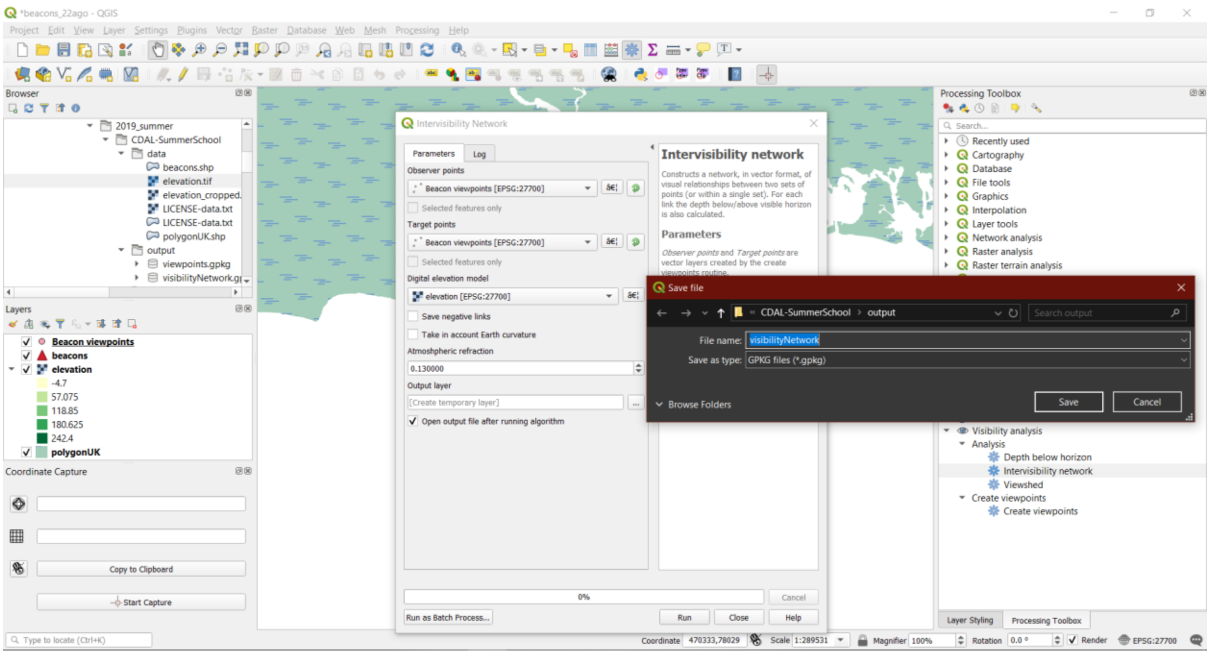
28. Fill the remaining parameters as follows:

   a. Under *Observer location(s)*, choose "beacons"
   b. Under *Digital Elevation Model*, choose "elevation"
   c. Under *Radius of analysis*, type in 20000 (This means we are assuming a maximum visibility of 20km; ideal settings should be calculated)
   d. Under *Observer height*, type 5 (This means that we are assuming that the beacons were 5 meters tall)
   e. Under *Target height,* type 5(This also means that we are assuming that the beacons were 5 meters tall)



29. Click *Run*. Wait until progress is 100% and click *Close*. The output will be automatically shown as a layer named “Output layer”. Right-click on it in the *Layers* panel (left), select “Rename Layer” and type “beacon viewpoints”.

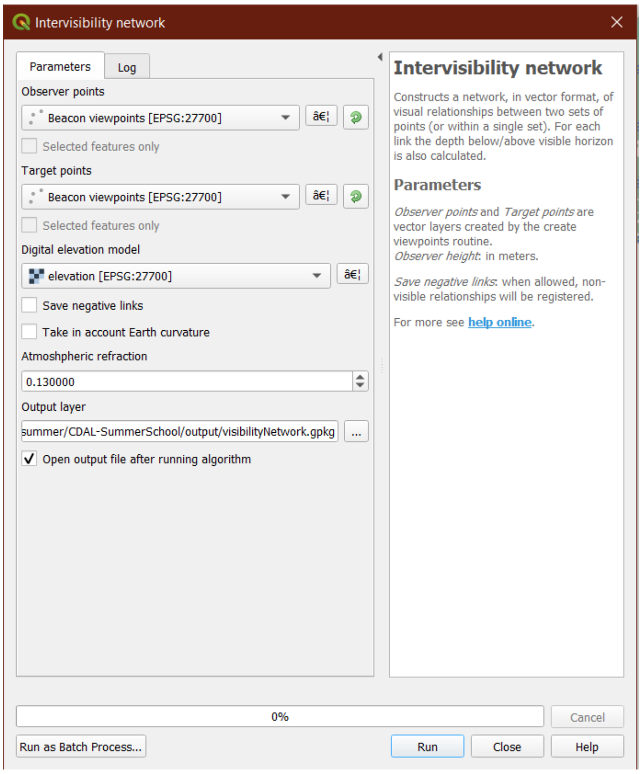
30. Now, in the *Processing Toolbox* (right), expand “Analysis” and then double-click on “Intervisibility network”. In the pop-up window, scroll down to *Output layer* and click on “…”. Select “Save to file” and navigate to the folder named “CDAL-SummerSchool”, then to “output”, and type “visibilityNetwork” under file name. Then click on *Save*.



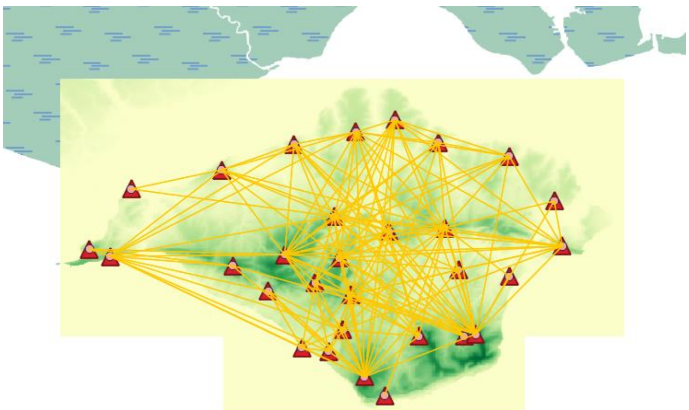
31. Now, we need to fill the parameters required:

    a. Under *Observer Points*, choose "beacon viewpoints"
    b. Under *Target points (intervisibility),* choose "beacon viewpoints"
    c. Under Digital *Elevation Model*, choose "elevation"
    d. Select the option *Intervisibility* in the section *Output*.

32. You should have a window with the following configuration:



33. Click on *Run*. Wait until progress is 100% and click *Close*. You should now see a series of lines connecting pairs of beacons. Again, the output will be automatically shown as a layer named "Output layer". Right-click on it in the *Layers* panel (left), select "Rename Layer" and type "beacon network".



34. What can we tell from this analysis? Firstly, most beacons seem to be connected to at least one another, which suggest that indeed **beacons were an effective means of communication, no matter what starting point**. Interestingly some of the beacons serve as "hubs", acting as a bridge for connecting more isolated beacons. These hub beacons are located at higher elevation towards the centre of the island and might have had additional strategic importance. It is also worth noting that while in most cases coastal beacons are connected to each other, there are some **cases where a beacon is connected to the centre of the island but not to its immediate neighbour**.

35. You will notice that one beacon, located at the North-West coast, does not connect with any other beacon. Was it communicating with the opposite coast instead? Zoom on this beacon using the mouse wheel. With enough zoom in, you will able to see that there is a ridge (stronger green) blocking this beacon from all others. However, what if we considered that all beacons project a column of smoke in daylight and a glare in night-time that rises much higher than the beacon itself? Repeat the visibility network analysis using a target height higher than 5 metres. Can you find what height is required to connect this beacon to the network?

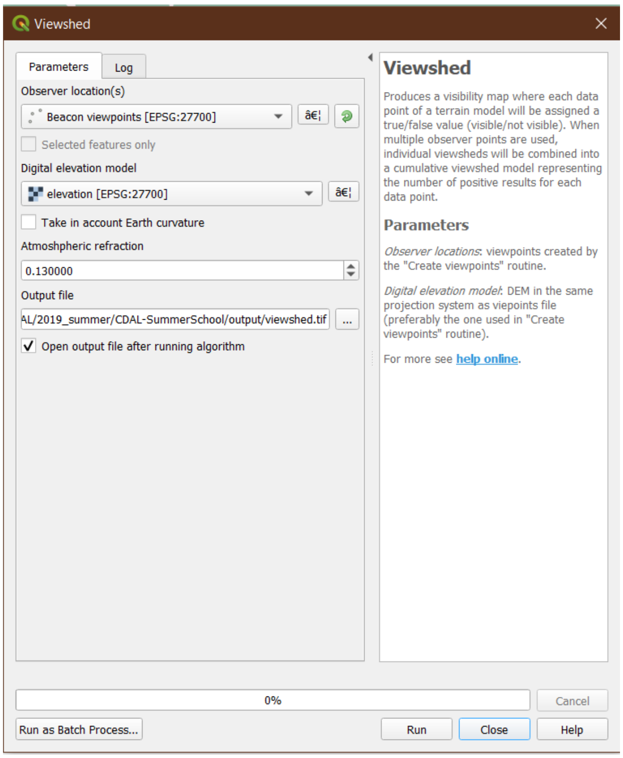
36. Another question we might be interested in pursuing is to determine how much of a given portion of land was observed from the beacons, and whether there were any "blind spots". A cumulative viewshed analysis can help answering this question. By calculating the viewshed from each beacon we can generate a raster map where each cell value records the number of beacons from which its location can be observed. Given we have 30 beacons, a value of 30 would mean that the cell (i.e. the portion of land) is visible from all beacons, while a value of 15 would mean that it was visible only from half of the beacons, and a value of 0 that it was not visible from any of the beacons (i.e. a "blind spot").

37. In the *Processing Toolbox* (right), go to "Analysis" and then double-click on "Viewshed". In the pop-up window, scroll down to *Output layer* and click on "…". Select "Save to file" and navigate to the folder named "CDAL-SummerSchool", then to "output", and type "viewshed" under file name. Then click on *Save*.

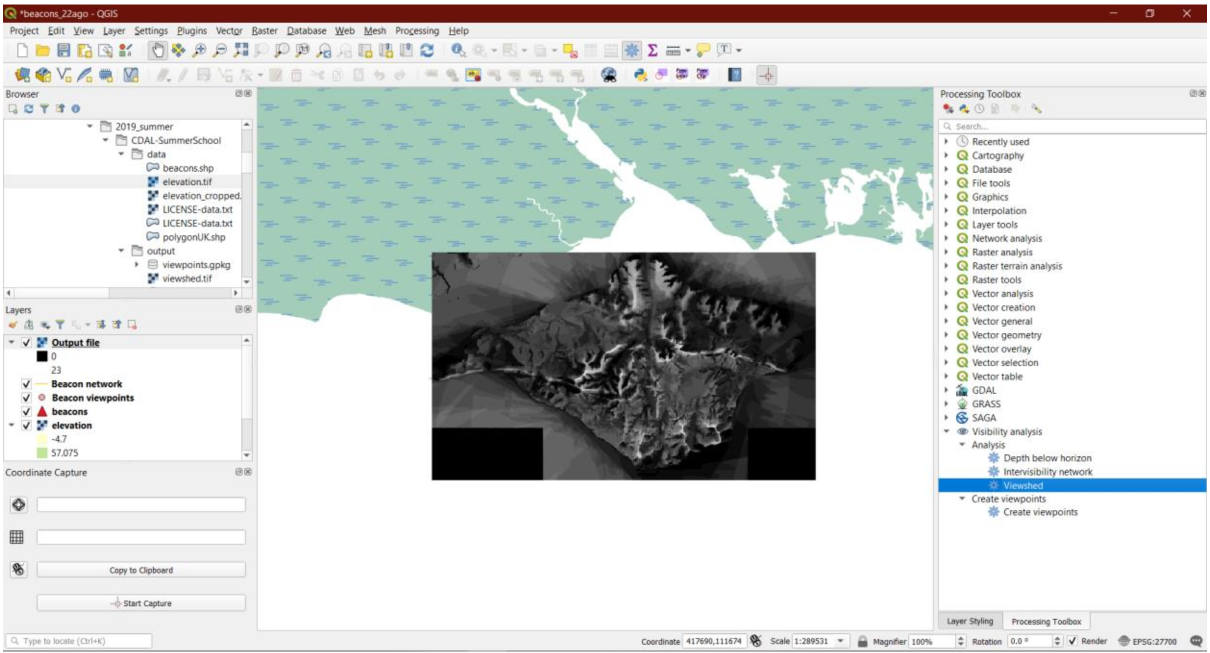
38. Now, we need to fill the parameters required:

    a. Under *Observer location(s)*, choose "beacon viewpoints"
    b. Under *Digital Elevation model*, choose "elevation"

39. You should have a window with the following configuration:



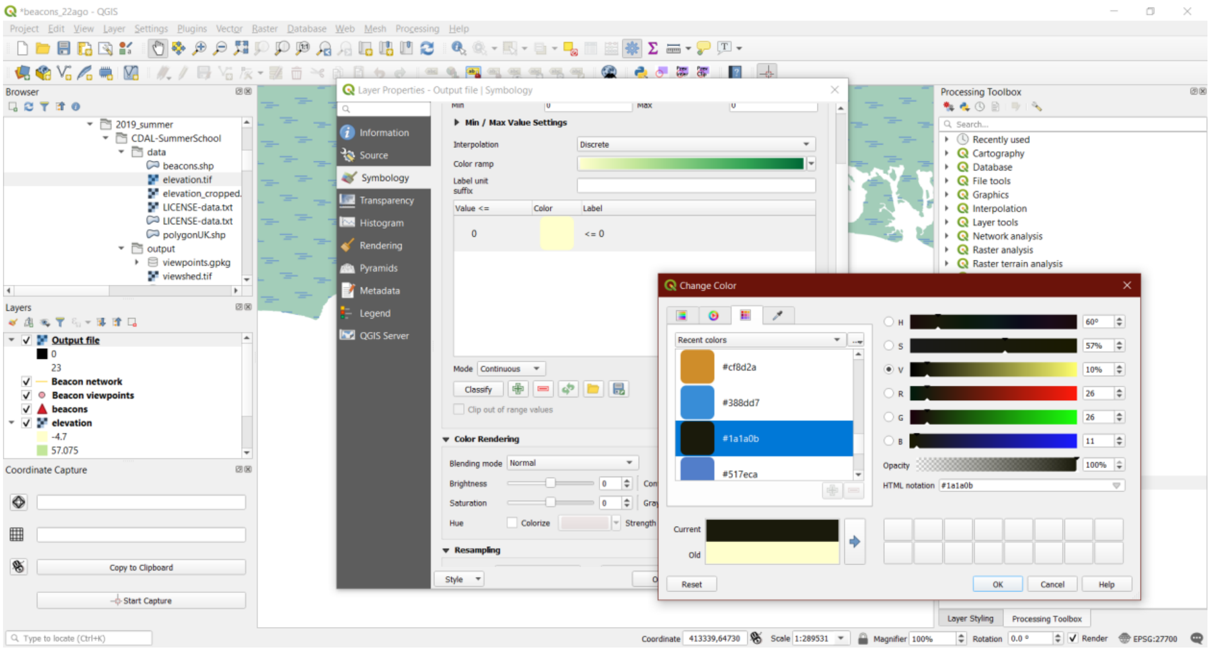
40. Click on *Run*. Wait until progress is 100% and click *Close*. You should now see a grey-shaded map representing the cumulative viewsheds of the isle beacons.



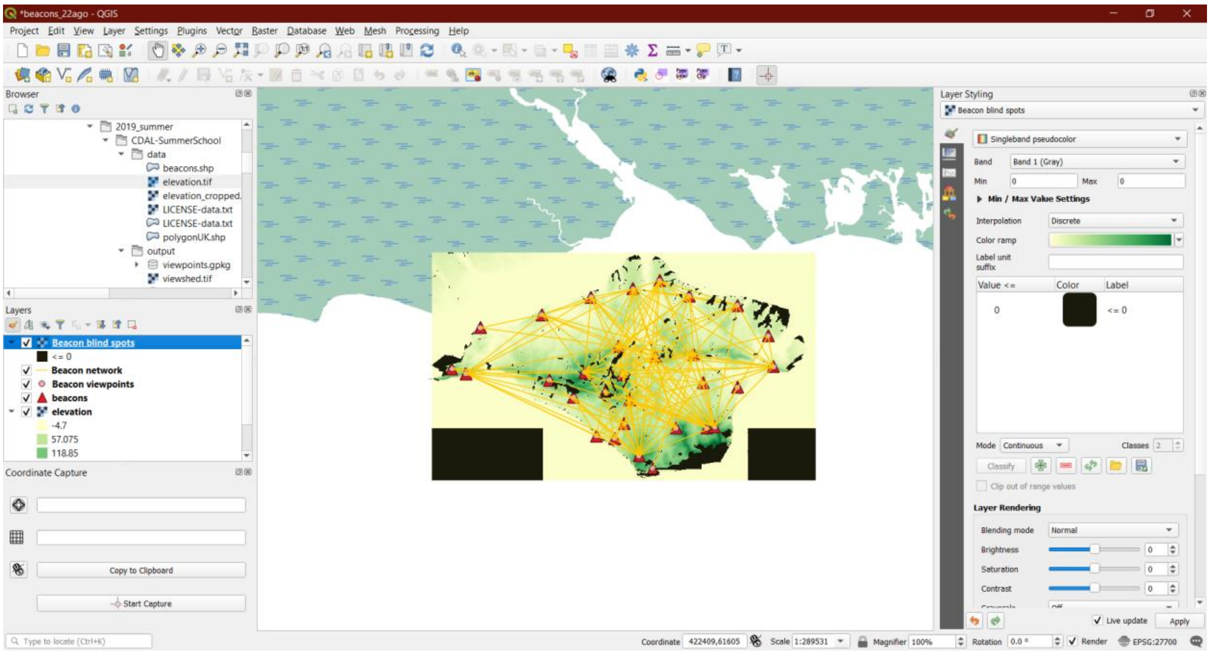
41. The portions with darker colour are visible only from a small number of beacons, while lighter shades of grey displays area with high visibility.

42. As for our digital elevation model we can change the colour scheme to make things clearer. This time let’s focus only on the possible “blind spots”. In the Layers panel, double-click on this layer or right-click and click on *Properties*. Now choose the section

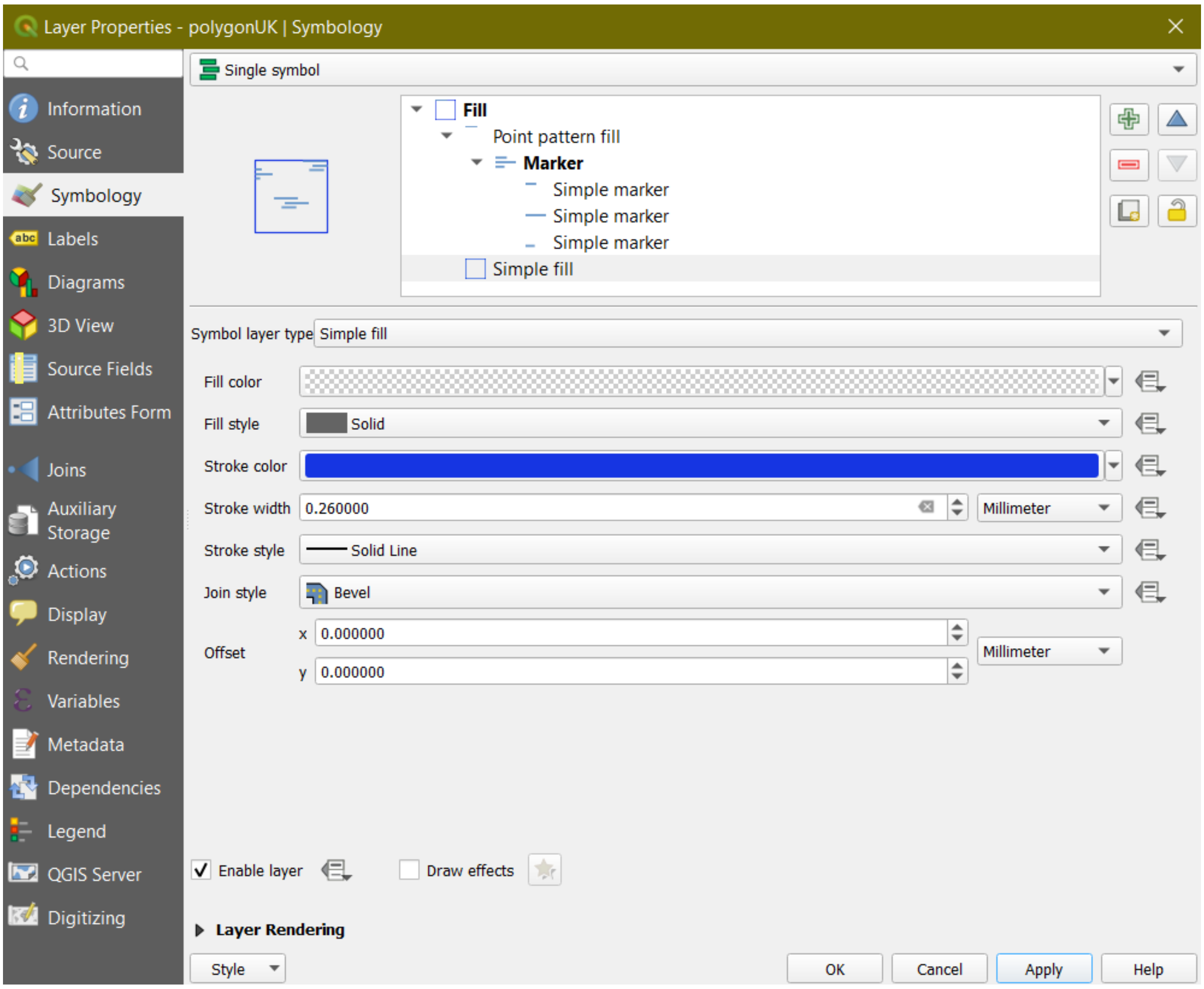
Symbology on the left panel. Remember that the same section is present as the Layer styling (on the right side, if you close the *Processing Toolbox* panel). Select *Singleband pseudocolor* as *Render Type*. Now choose *Discrete* for the option *Interpolation*. Modify the *Color ramp* to "greys". In the frame below those options, delete all categories that were generated automatically (select a row and click on the red "-" button below), except the one corresponding to "0". Double-click on the colour rectangle of that category and choose absolute black. Click on *OK*, then *Apply* and *Close*.



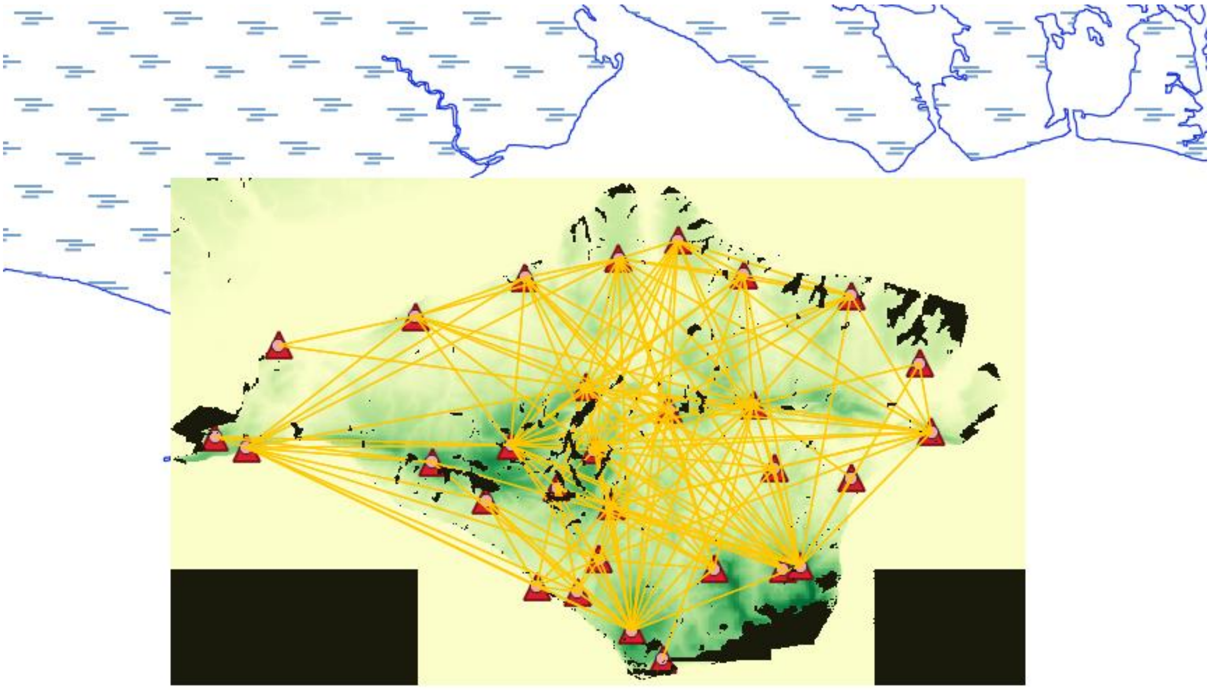
43. You should now see black patches of land (and sea): these are areas that are not visible from any of the beacons on the island. Right-click on this layer in the *Layers* panel (left), select "Rename Layer" and type "Beacon blind spots".



44. In order to make things even clearer (so we know where are the coastlines) let's make our polygon transparent but keeping the coastline visible. Click on "polygonUK" in the *Layers Panel* then choose *Properties* and then *Symbology* (or use the *Layer Styling* panel). Click on the text reading "Simple Fill". Now click on the down-facing arrow in the rectangle named *Fill color* and select *Transparent Fill*. Click on the down-facing arrow in the rectangle named *Stroke color* and select a shade of blue. Last, click on the down-facing arrow in *Stroke style* and select "Solid Line". *Apply* and *Close*.



45. Now click and drag "polygonUK" on top of all other layers in the Layers panel. You should now see in your map canvas something similar to the figure below.



46. How can we interpret these results?

While most of the land and sea are visible from at least one beacon, there are still some blind spots in some coastal areas of the southern, western, and north-eastern portions of the island. Such "blind spots" might be useful to certain groups of people, e.g. smugglers.

Perhaps there are other beacons that we still haven't identified, or maybe because these represent fairly limited portions of land and sea, they were truly blind spots (beacons were most likely able to spot ships at larger distances before they could reach the "blind spots").

47. You reached the end of this tutorial, well done! The analysis you carried out is just one example of the many possibilities offered by GIS and more in general by computational archaeology.

If you want to learn more about GIS in Archaeology I strongly recommend Conolly and Lake's *Geographic Information Systems in Archaeology*, published by University of Cambridge Press. Although slightly dated in terms of software, it's an excellent introduction and manual for this topic.