University of Tartu

Faculty of Science and Technology

Department of Geography

Master's Programme in Geoinformatics for Urbanized Society

Portfolio

3D MODELLING AND ANALYSIS (LTOM.02.024)

Alex Jarvis

This portfolio serves as a compilation and reminder of the project work, both completed and 'in progress' for the 3D Modelling and Analysis course.

Thank you to Merle Muru and Raivo Aunap for the clear and logical guides. The methods and instructions within this text are taken from these.

Lesson 3. Terrain models

This lesson was a continuation of lesson 2, which involved making a relief map from a scanned ordinance map.

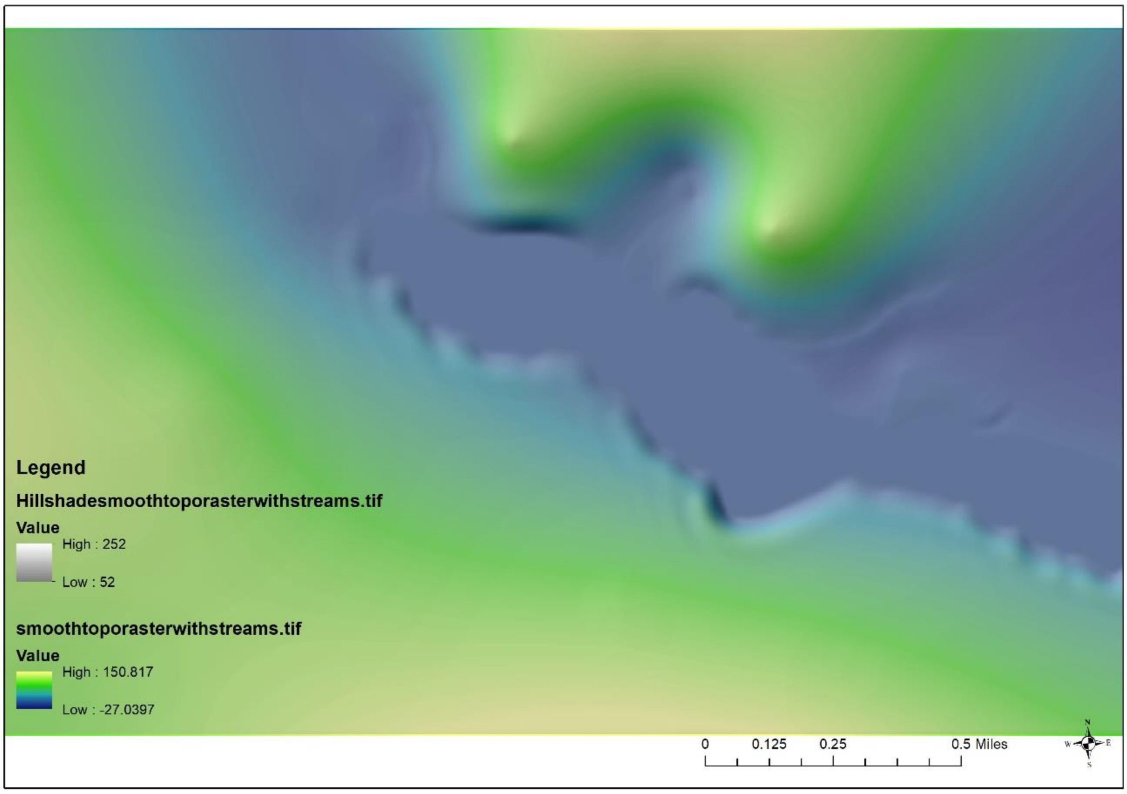

Figure 1 - Relief in hypsometric colour ramp with analytical hill shading

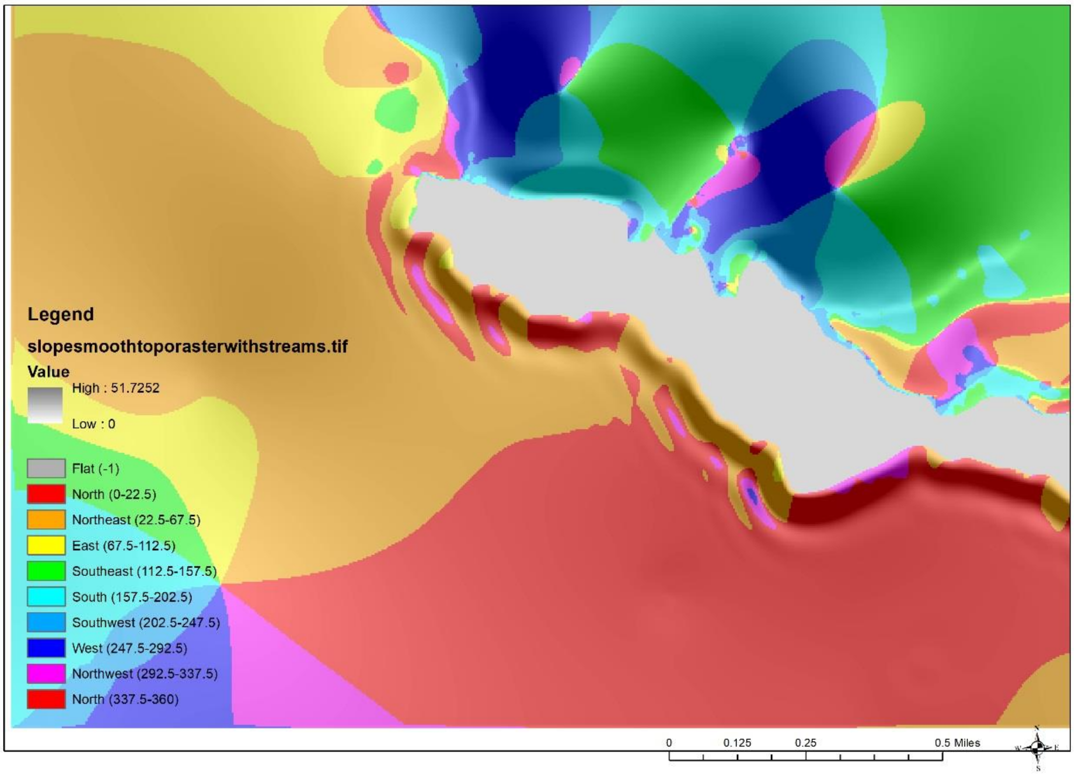

Figure 2 - Relief exposition (aspect) with slope shading

Figure 2 shows the same image as figure 1 except with a relief exposition using cardinal shading of the slopes.

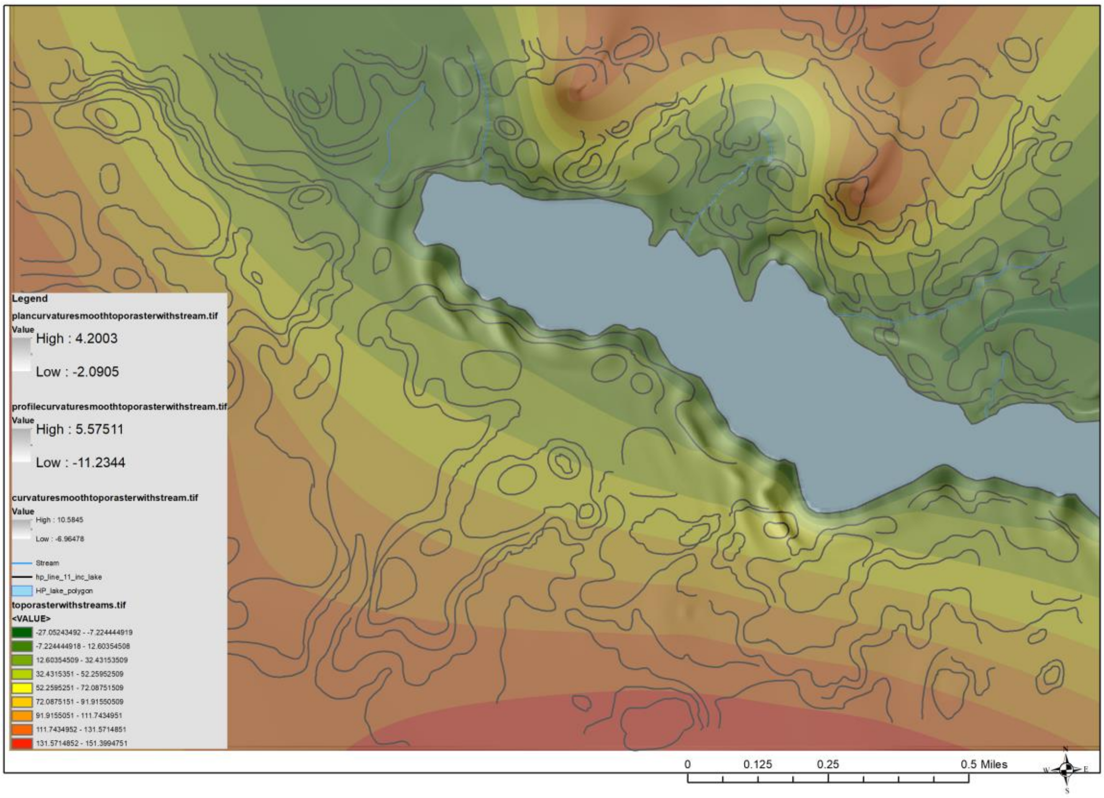

Figure 3 - Composition with a curvature relief

Figure 3 shows the raster relief which was composed of both a raster image and my drawn contours.

Lesson 4. LiDAR data

Lesson 4 was about making a terrain model based on LiDAR elevation data in ArcGIS; to learn about the structure of LiDAR data and the specific data structure developed for relief data in ArcGIS – Terrain Dataset.

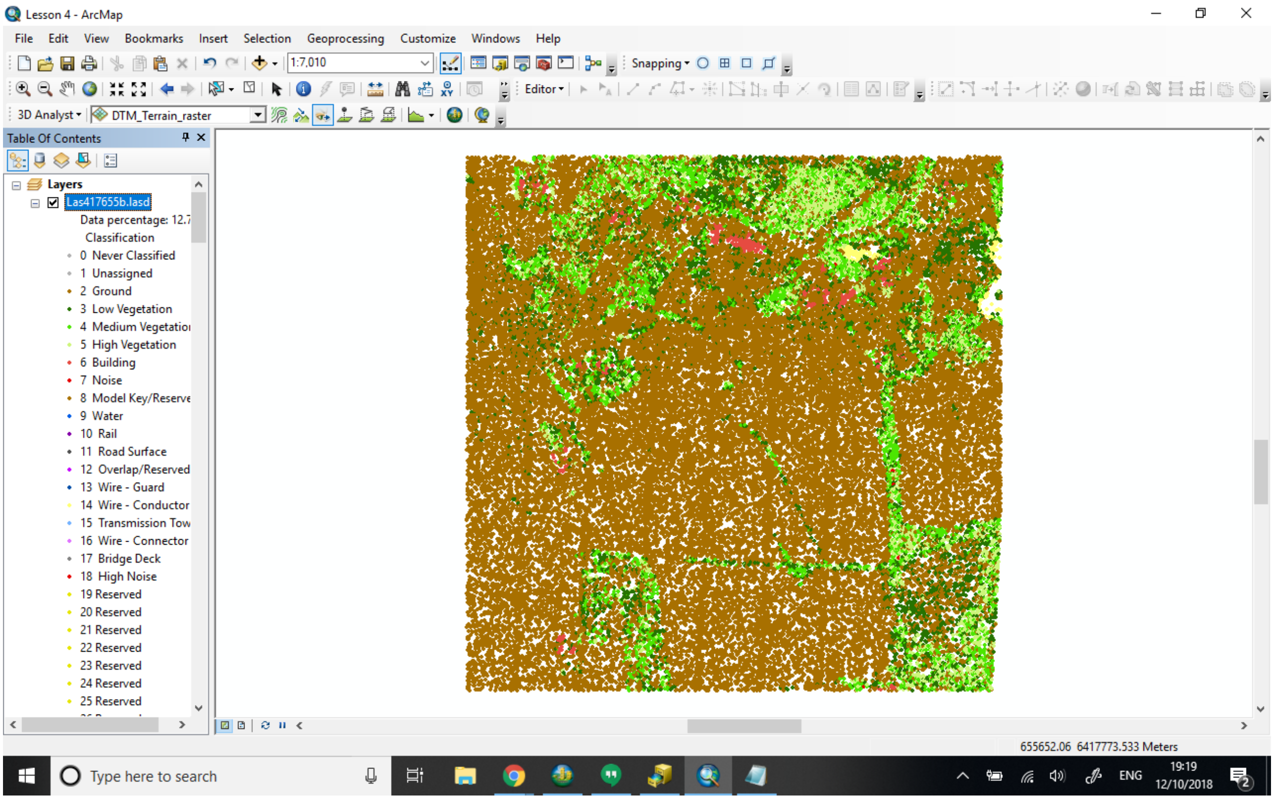

Figure 4 – LAS 3 vegetation types screenshot

Figure 4 shows the LAS dataset image with vegetation in 3 height classes

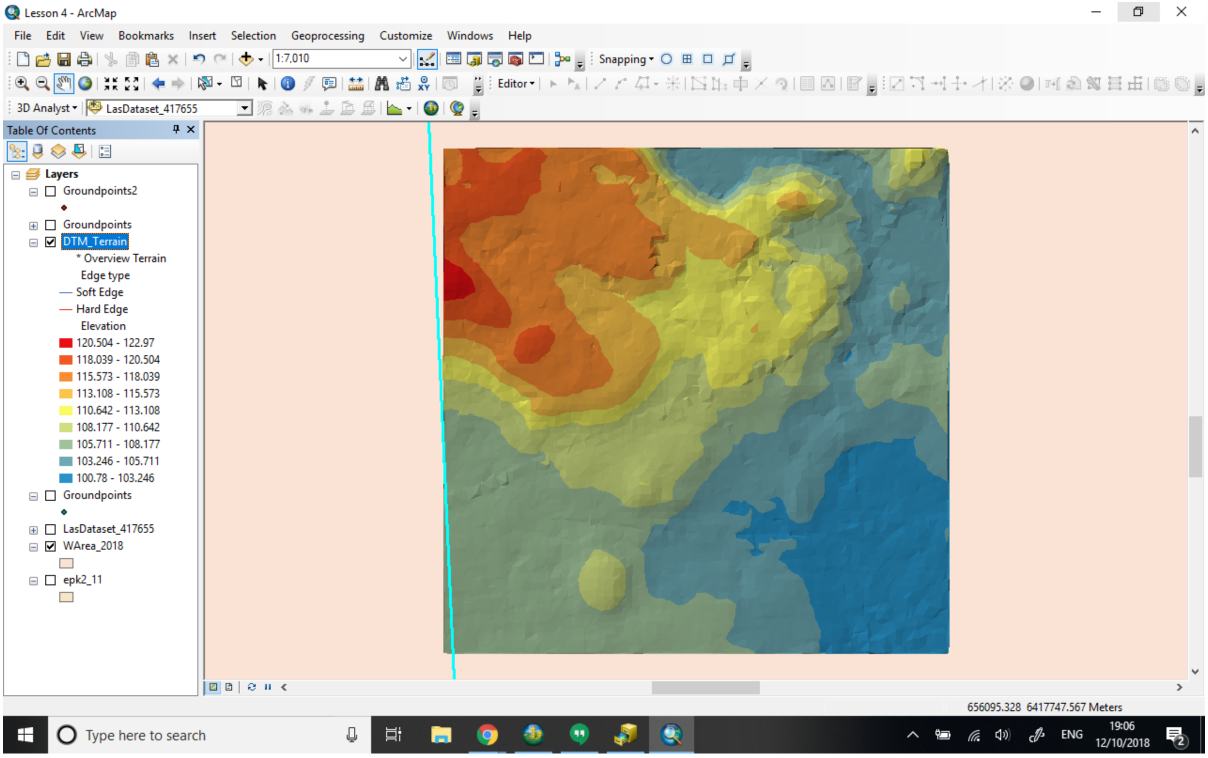

Figure 5 – Terrain model

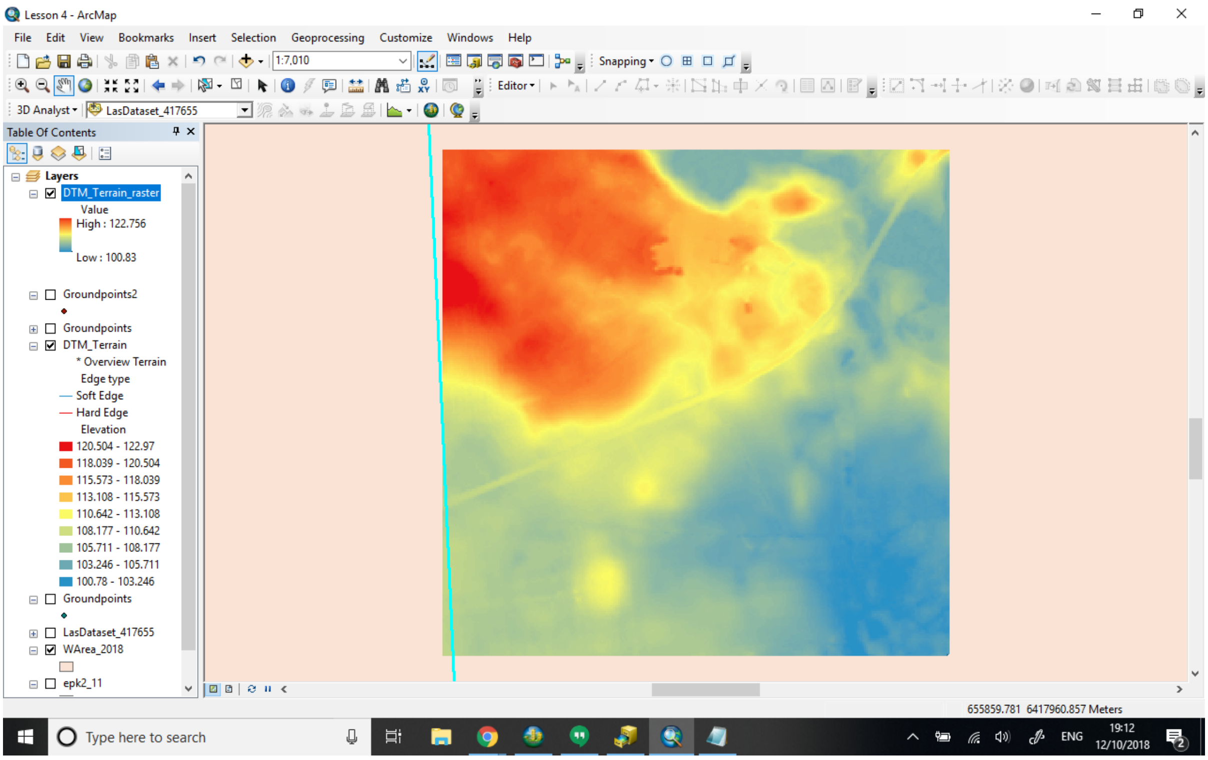

Figure 6 -Terrain to raster

Figure 5 shows the DTM model and figure 6 shows the model as a raster (tool used – Terrain to Raster). Rasters are easier for further analysis.

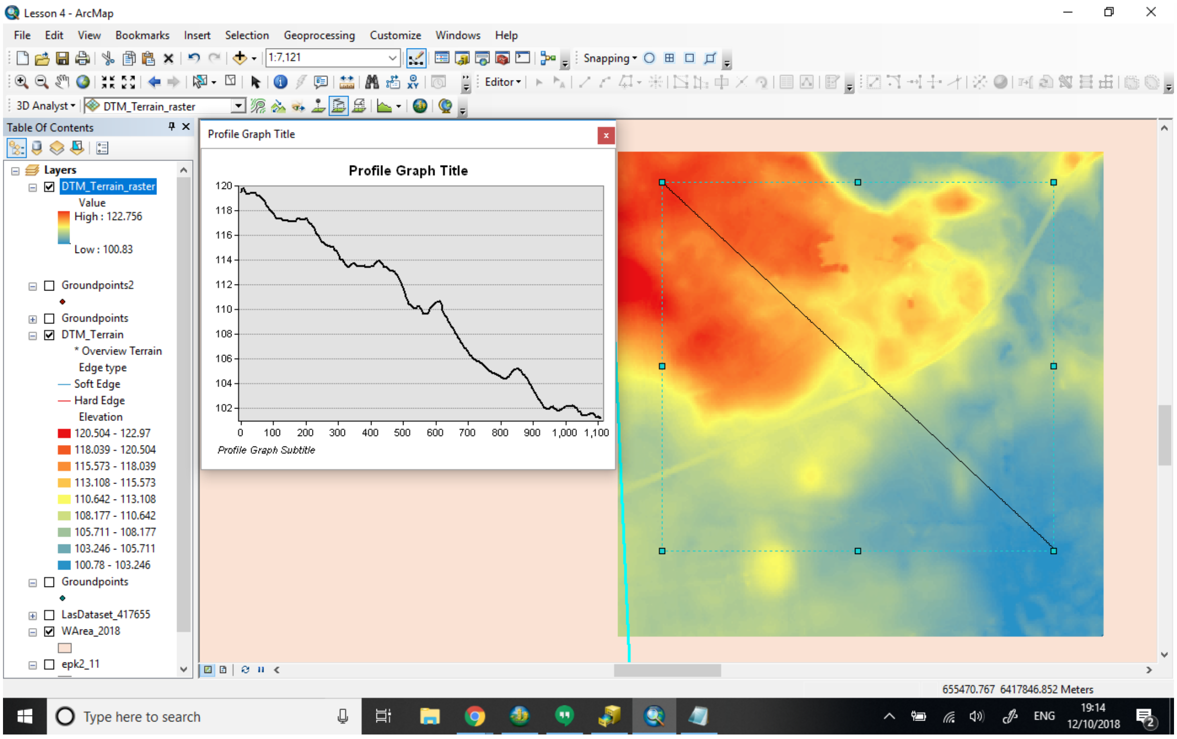

Figure 7 - Profile line

Figure 7 shows the profile line and profile graph, with the line going from a higher to lower elevation.

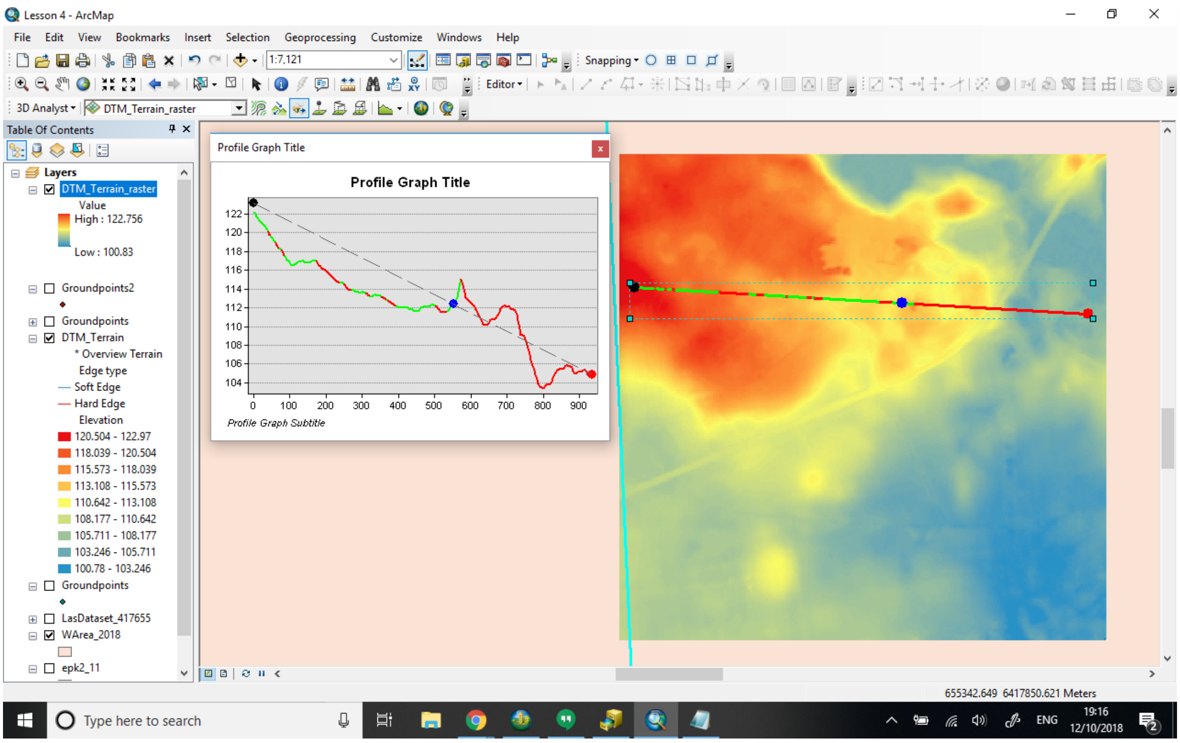

Figure 8 - Line of sight

Figure 8 shows the line of sight, with the red colours in the graph indicating no visibility and green indicating terrain which is visible.

Lesson 5. Hydrological modelling

This lesson involved creating and classifying stream lines and watersheds. The next stage was to find the flow accumulation thresholds based on the raster terrain model.

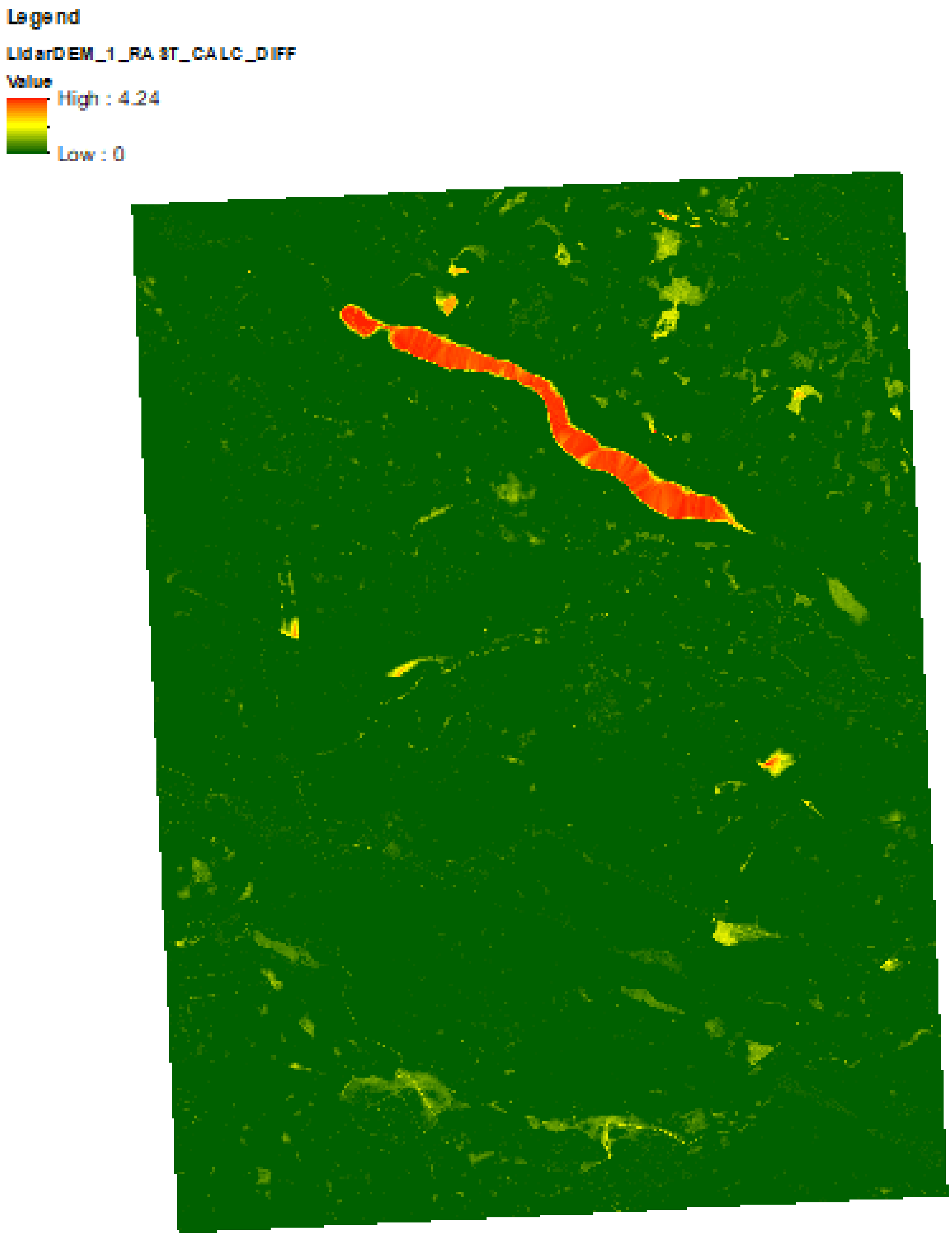

Figure 9 – Difference between the two rasters after sink-filling using the Fill tool from Spatial Analyst Tools – Hydrology and then visualising it using the Raster Calculator minus function.

Figure 9 shows the areas of change in the DTM after filling in the sinks (using the 'Fill' tool). The red area (the lake) shows the highest change. Dark green shows little or no change.

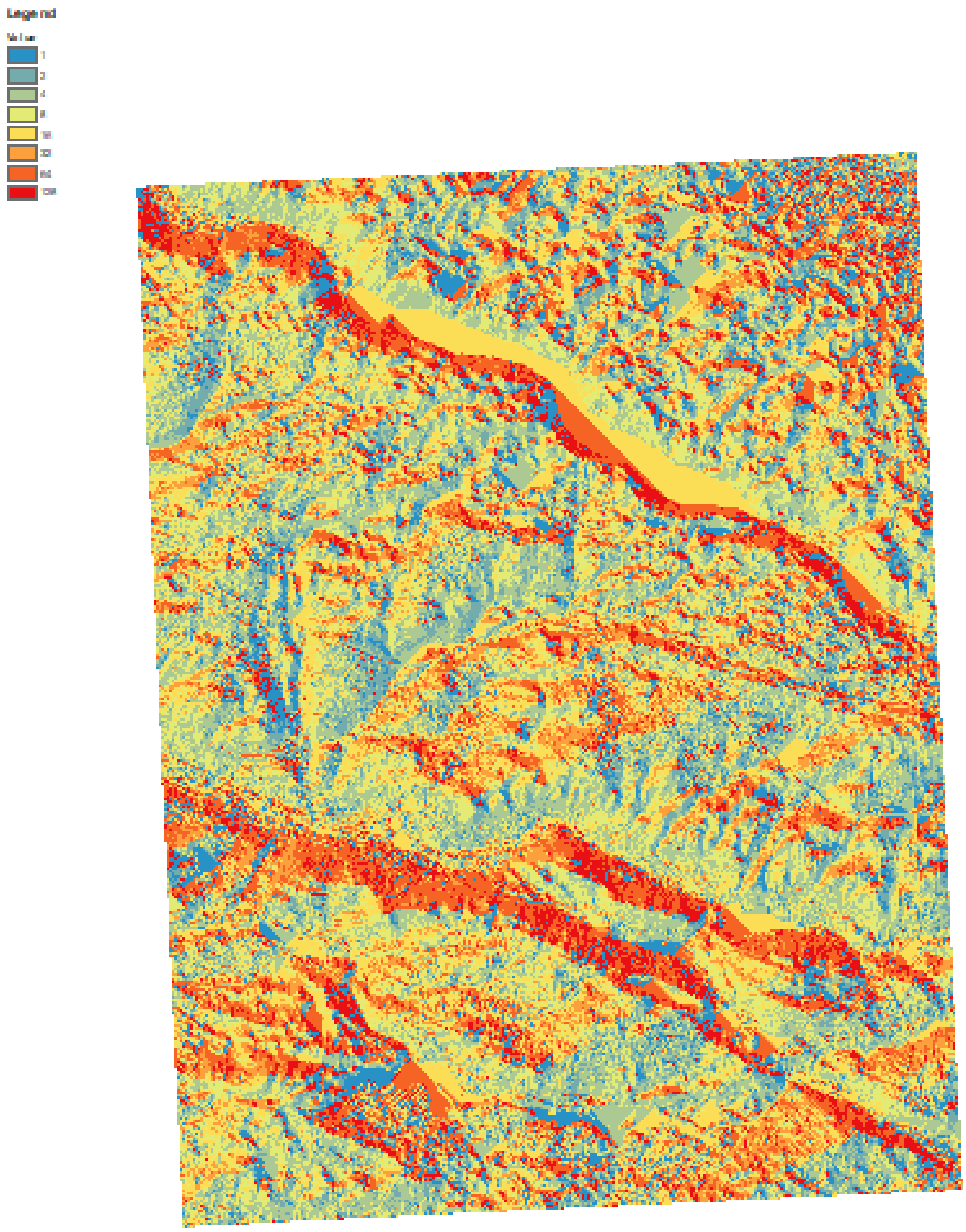

Figure 10 - Cardinal direction flows

The colours are:

Red: North

Blue: East

Green: South

Yellow: West

Figure 10 shows towards which neighbouring cell the water would flow from each cell of the improved DTM. This was achieved using the tool Flow Direction. The colours are then tinted using cardinal directions.

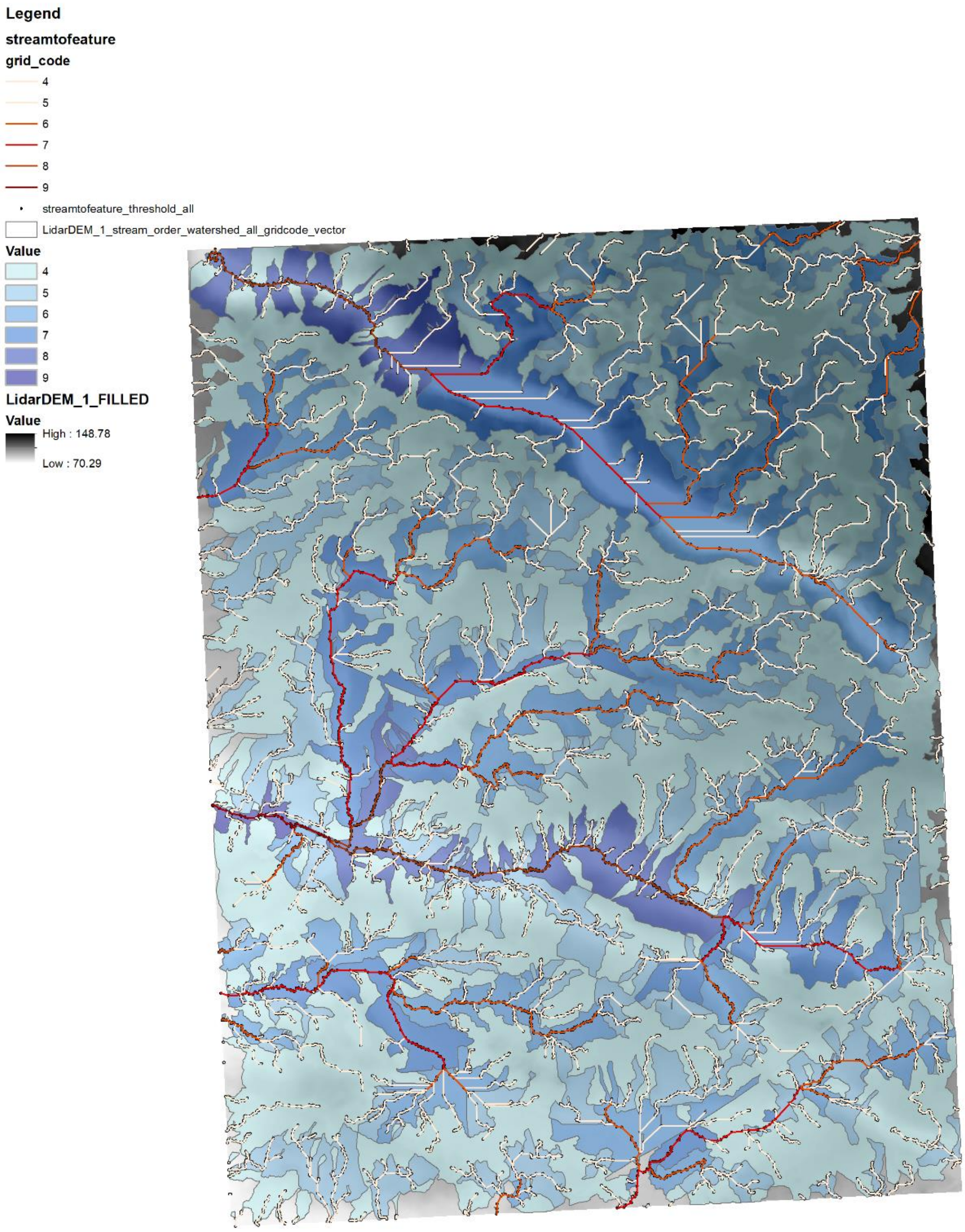

Figure 11 - All streams

To achieve the final map in figure 11, the following techniques were used:

Methodology:

- Flow Accumulation tool – to create a stream raster
- Stream Order (using Strahler's ordering)
- Reclassify (Spatial Analyst – Reclass) - Reclassify smaller streams (classes 1-4) as no data – in order to leave only the relevant streams
- Stream to Feature – convert raster stream network to vector
- Feature Vertices to Points – to create end points as points from the vector stream network – these are the threshold points/pour points.

- Watershed - delineate the watersheds of the 5th and higher order for the whole area
- ** to improve the result (ensure that all streams have a watershed, repeat Feature Vertices To Points and add points at both ends)
- Visualise the extent of each watershed (preferable the colours of neighbours are different).
- Conversion Tools - Raster To Polygon - Vectorize the final watersheds and use these as watershed borders (single shade) in your final map.

Lesson 6 - Landscape 3D visualization

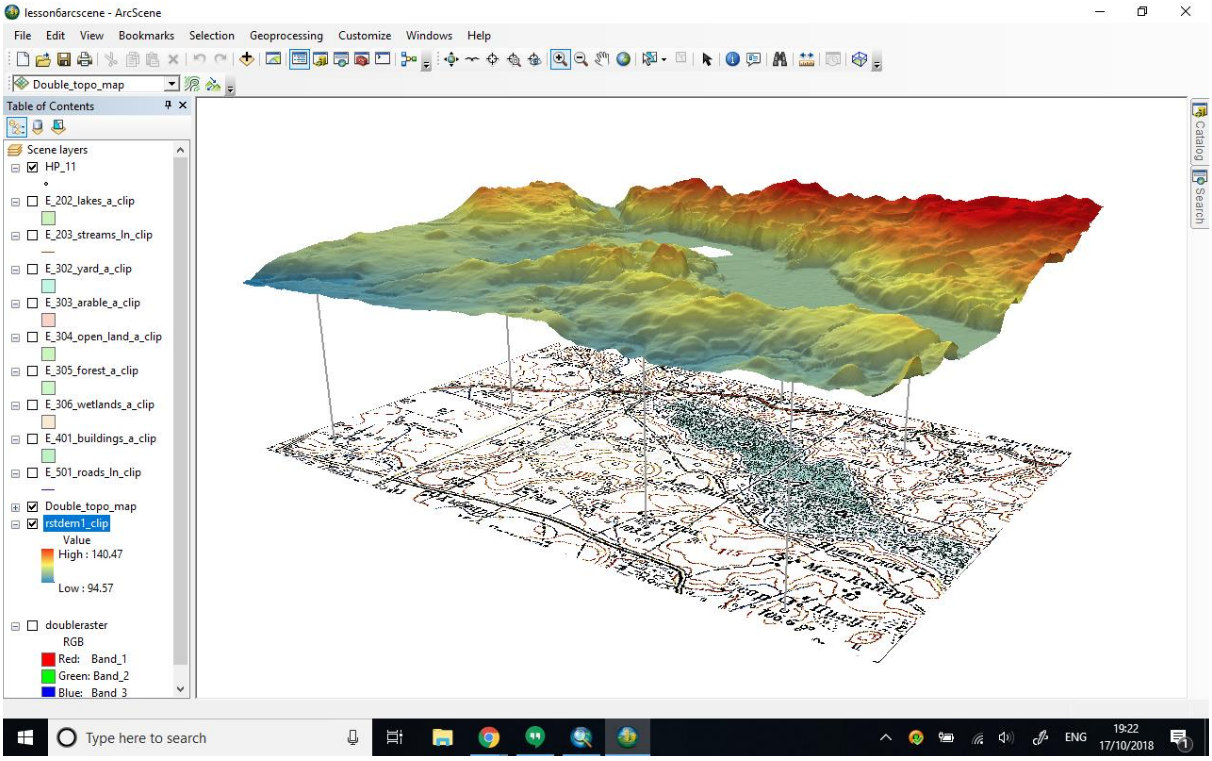

Figure 12 - Terrain and topo map connected with lines

For graphical presentation purposes, one can connect the terrain and topographic maps with lines, as shown in figure 12.

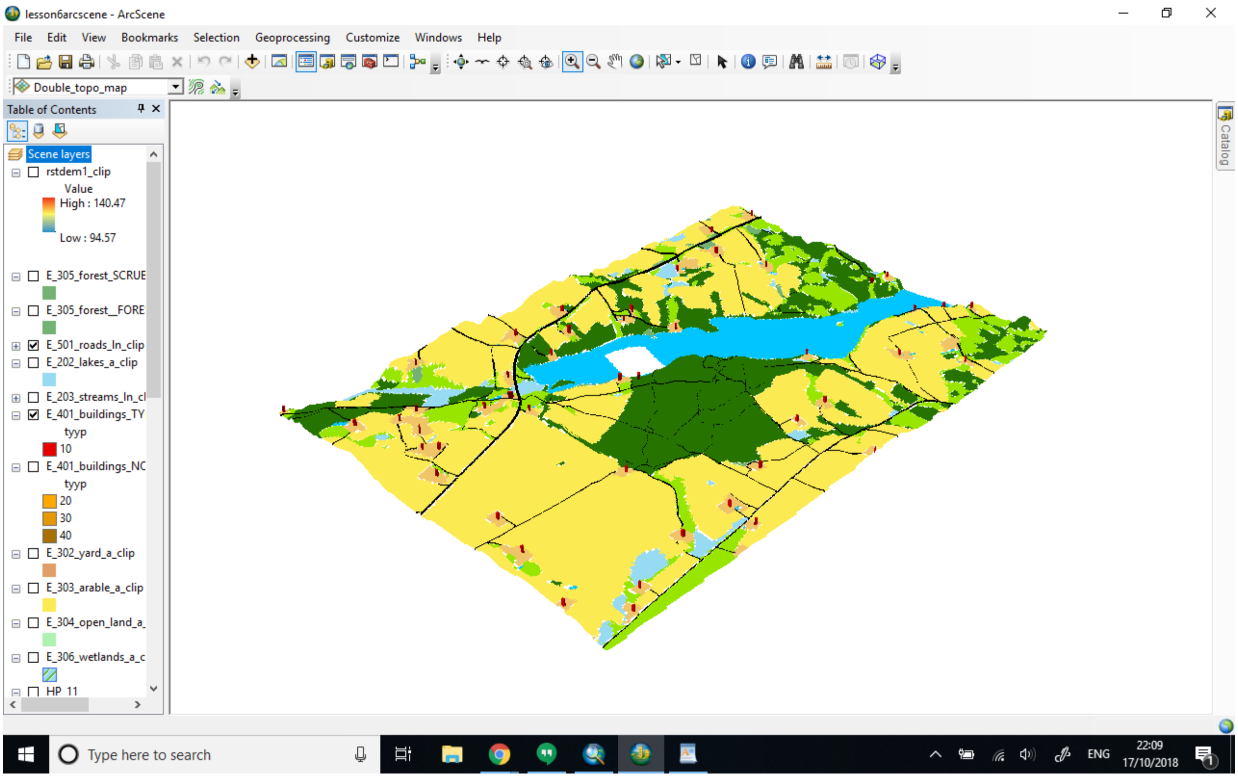

Figure 13 - Land cover surface and extrusions

In order to bring out the different features, the features such as forest and roads are extruded onto the surface layer raster, which in turn has been 'draped' or displayed onto the relief of another raster (figure 14)

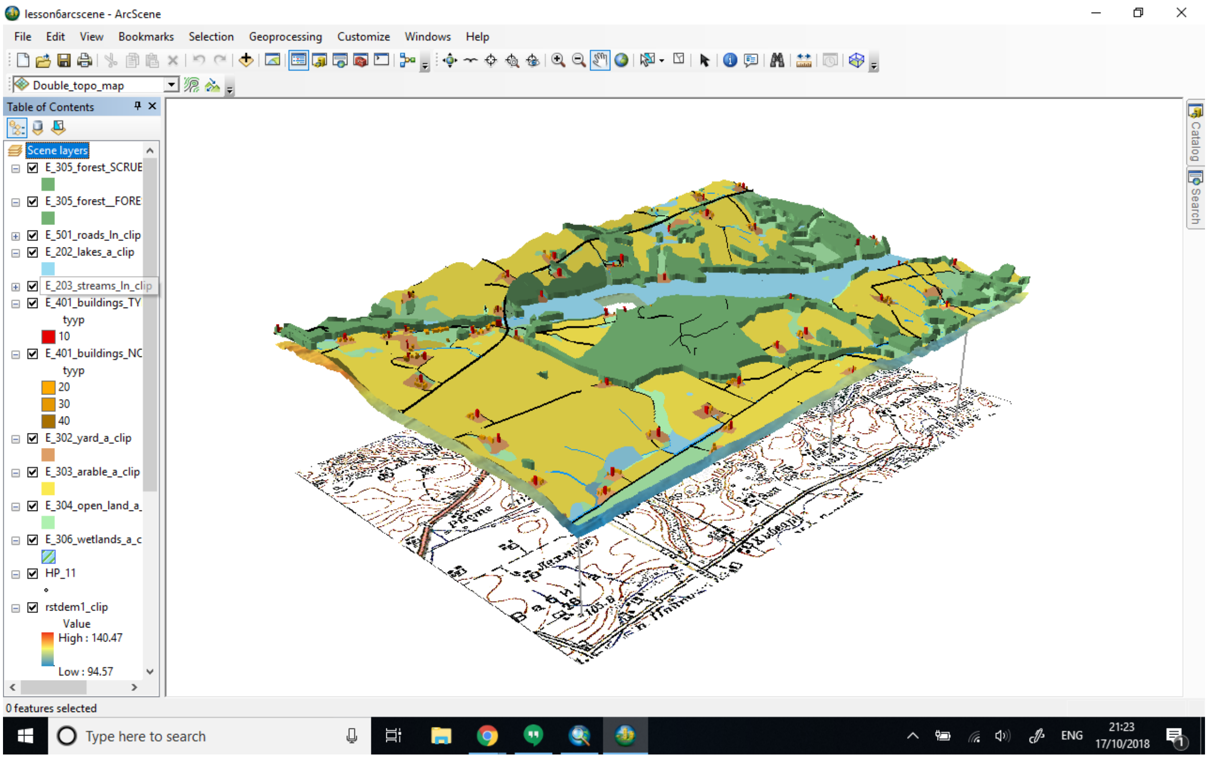

Figure 14 - Extruded layers draped over DTM

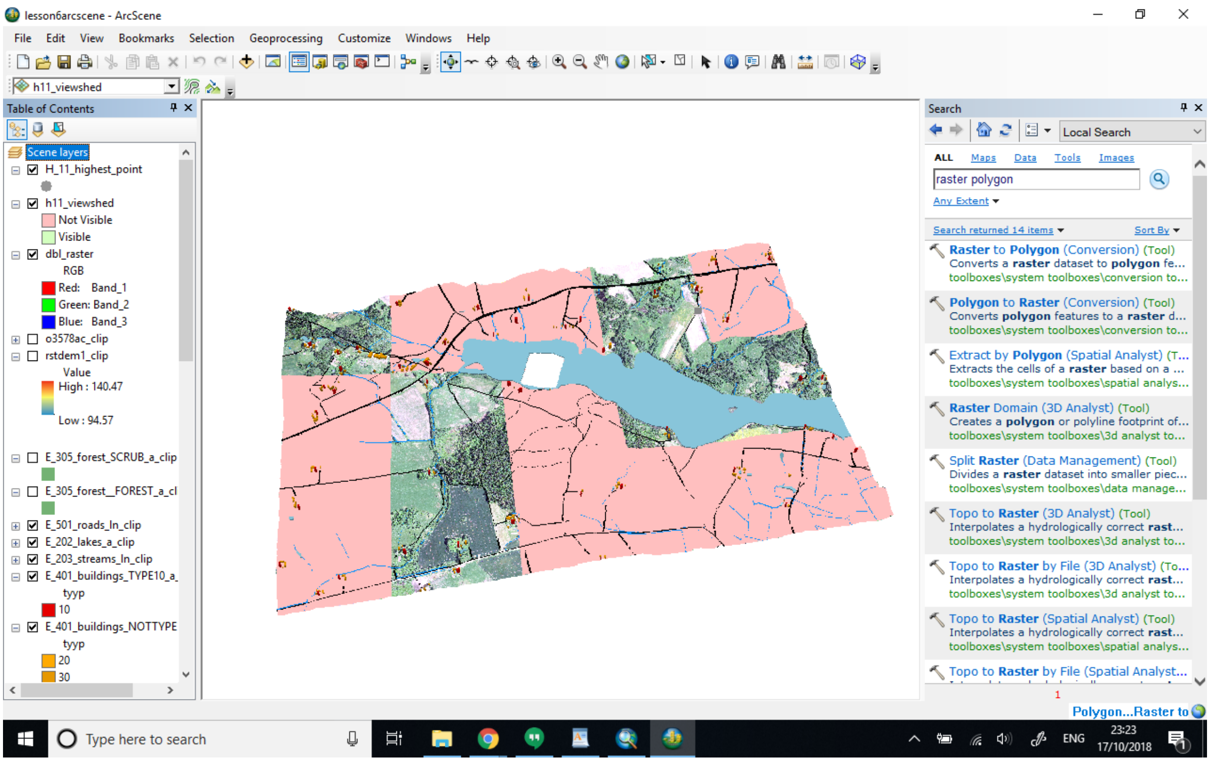

Figure 15 -Viewpoint image from tower. Unfortunately, this is incorrect

For some reason (?), the viewshed from the birdwatching tower did not display correctly.

Lesson 8 – Structure from motion – Multi View Stereo Workflow

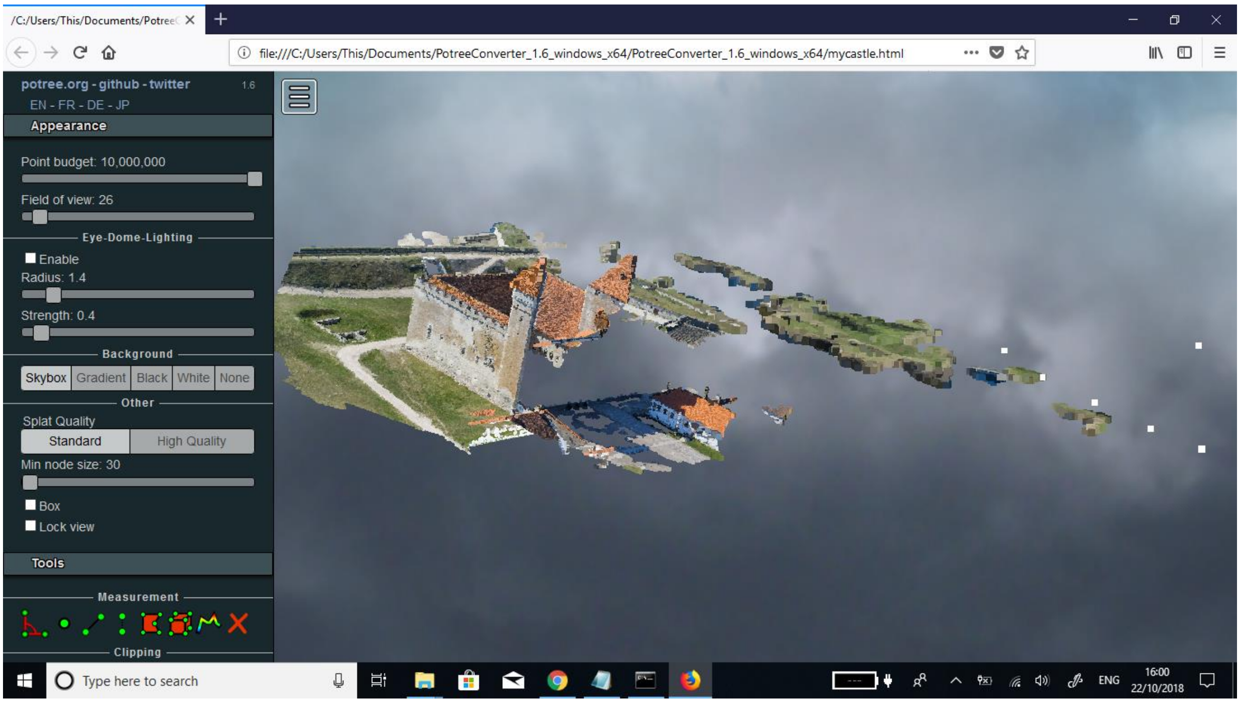

Figure 16 - Output of Visual SfM (which created a 3D pointcloud image) in Potree Converter (which transformed the pointcloud into a webpage)

Figure 16 shows a 3D view of Kuresaare Castle, which was created using the following programs and published online.

- Visual SfM (to generate 3D pointcloud)
- CloudCompare (to convert pointcloud to LAS format)
- Potree Converter (to transform pointcloud into webpage)

Lesson 9 – City 3D modelling´

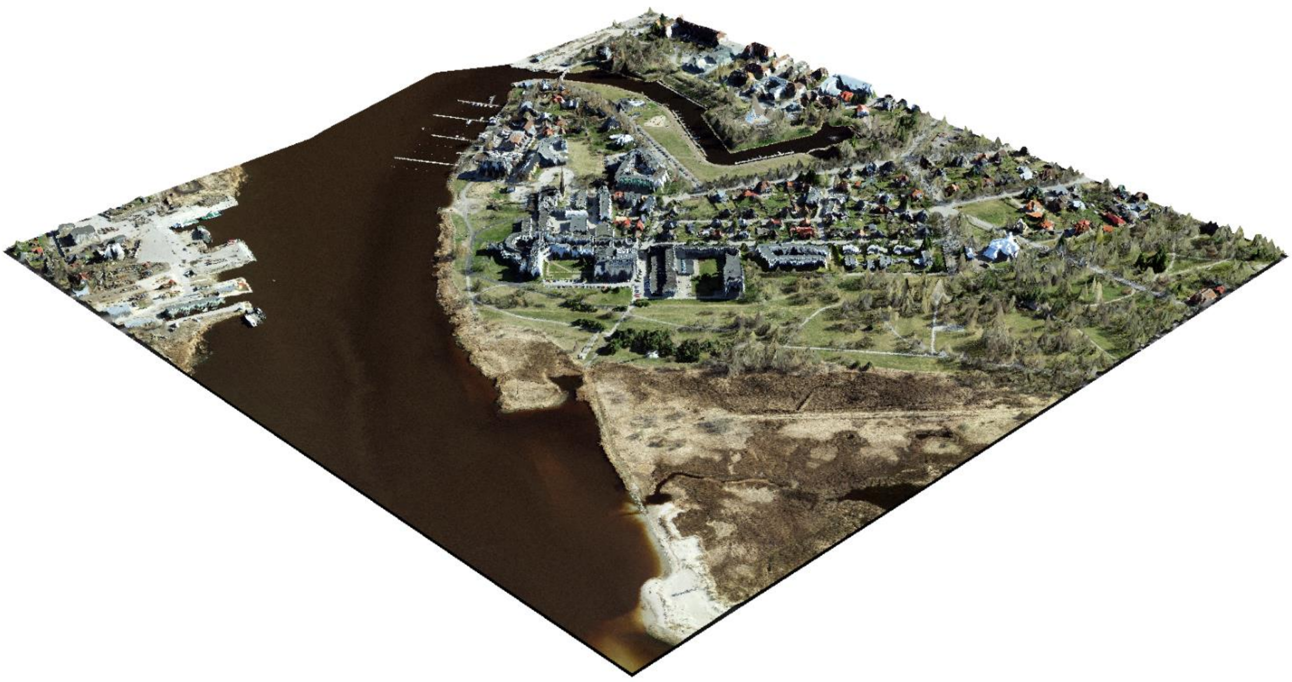

Figure 17 - The orthophoto over the raster image, creating a 3D effect

Figure 17 shows a 3D view with draped orthophoto over the DSM.

Figure 18 - The simplified TIN model including the new buildings (in pink) on landscaped ground

Figure 18 shows 3D view with a simplified DTM and simplified houses, trees, streets and waterbodies.

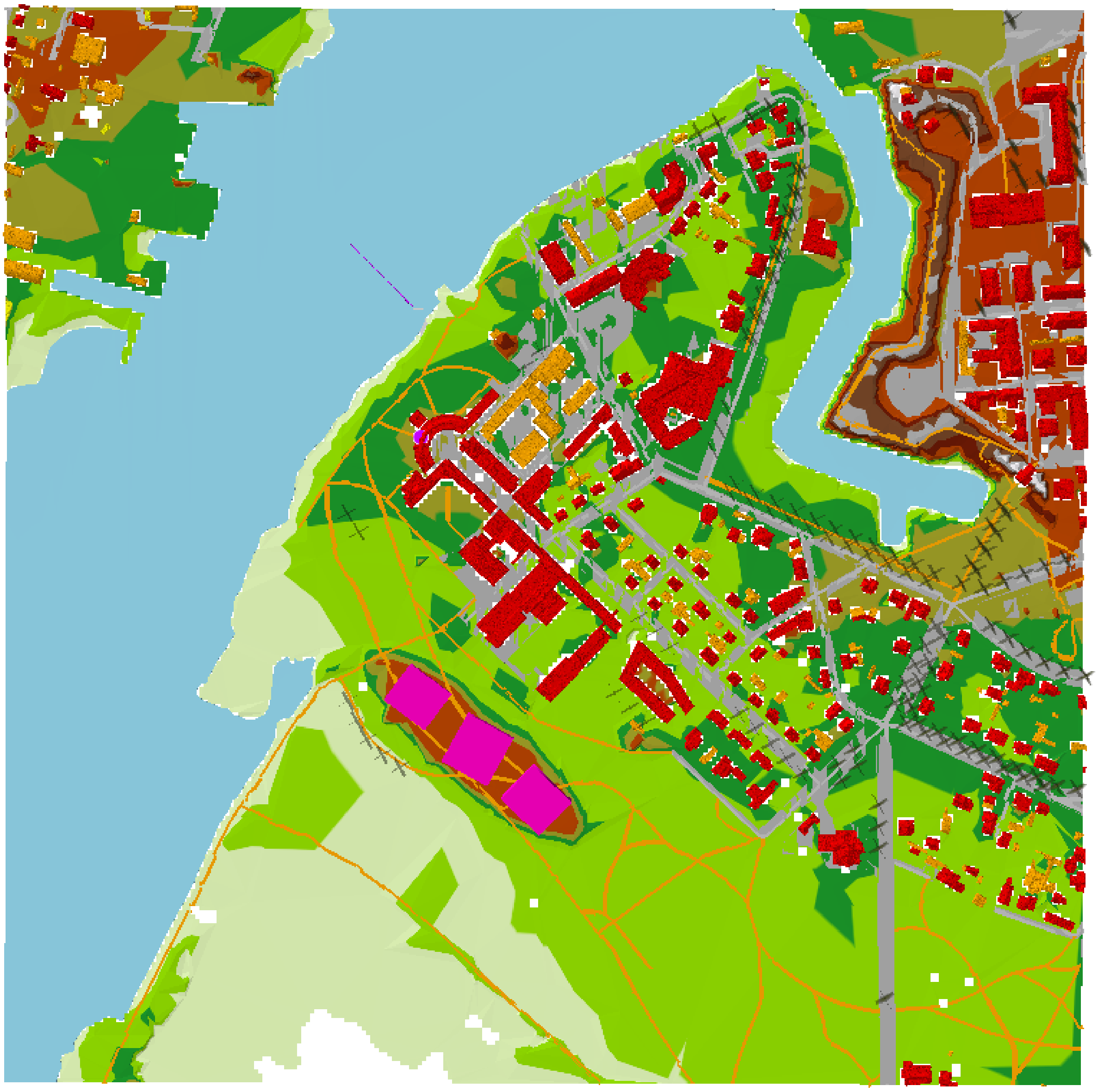

Figure 19 - Overhead view of the simplified TIN model including the new buildings (in pink) on landscaped ground

Figure 19 shows the overhead view of the simplified TIN model, which shows the roads, paths and tree lines in greater clarity.

Figure 20 - Simplified TIN model with 3D buildings showing the location of UT Pärnu College

Figure 20 shows a zoom in to the waterfront where the college is located.

Of the new houses (figures 25 and 31), the area of the houses surfaces that is shadowed is 0%. None of the new houses are in the shadows of the current buildings, as per the shadows on 10th November at 15.00. Infact, it would appear that the new houses would cause shadows on some of the current first row of houses to the shoreline.

Lesson 10 – Landscape Reconstruction: Sea Level Changes

1. Sea level reconstruction

Due to the relative sea level fall that has occurred to Estonia over many millennia, due to glacial isostatic land uplift, the coastlines have changed. Figures 21 and 22 show the coastlines as they were 7500 and 2000 years ago respectively. The isobases shows the relative sea level in metres.

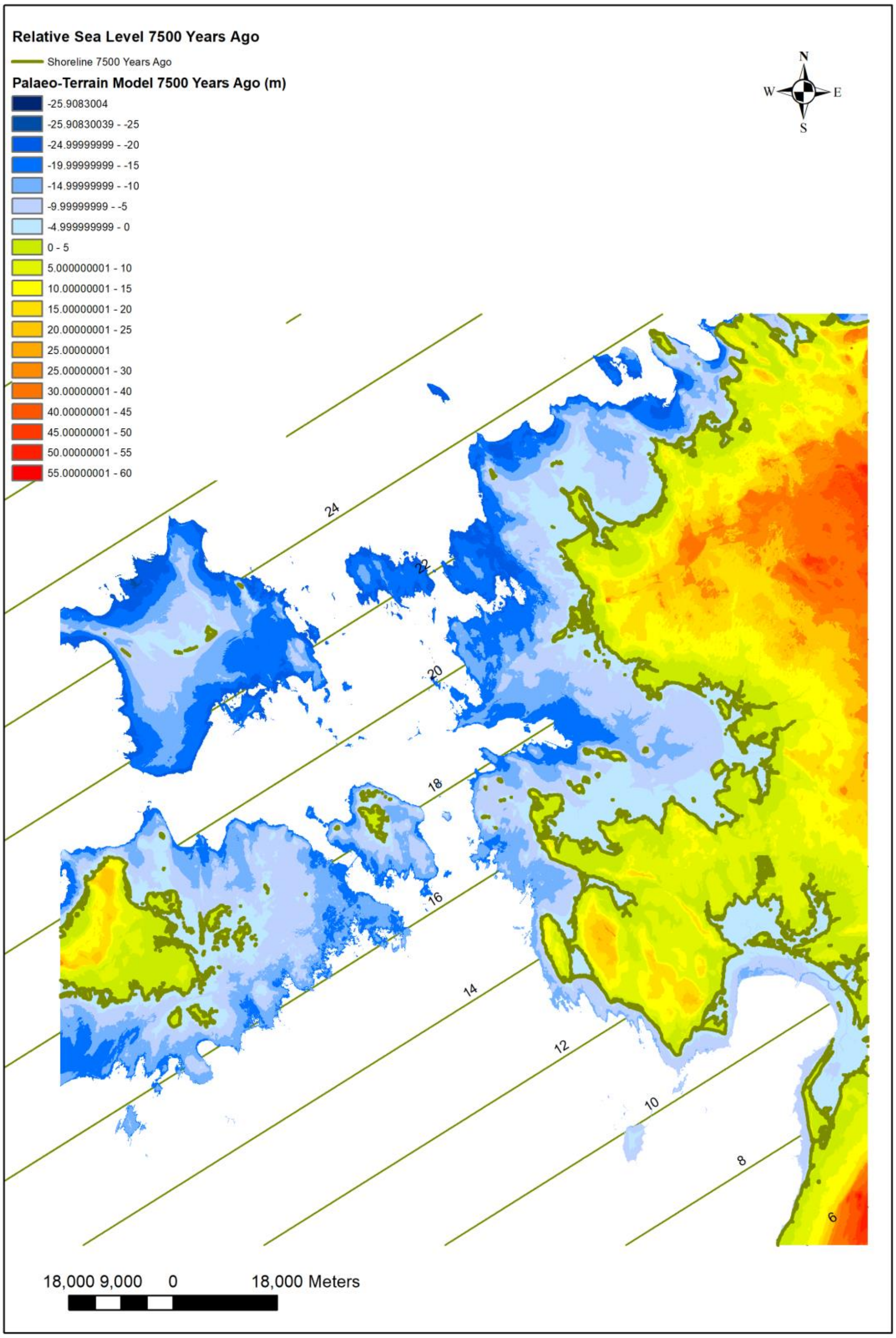

Figure 21 -The relative sea level and shoreline 2000 years ago.

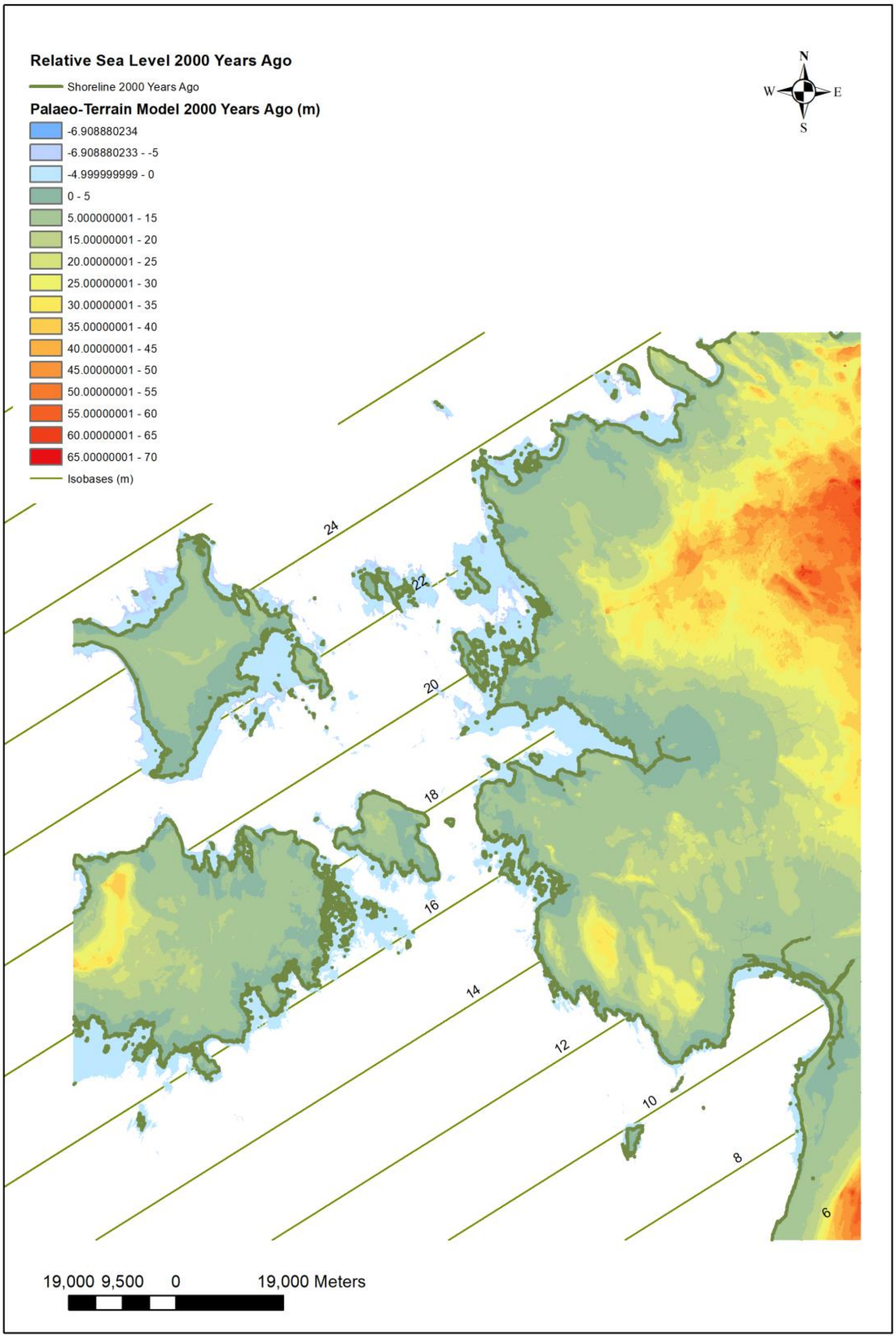

Figure 22 - The relative sea level and shoreline 2000 years ago.

2. Flood visualization

Value for land rise in Pärnu is 0.77m

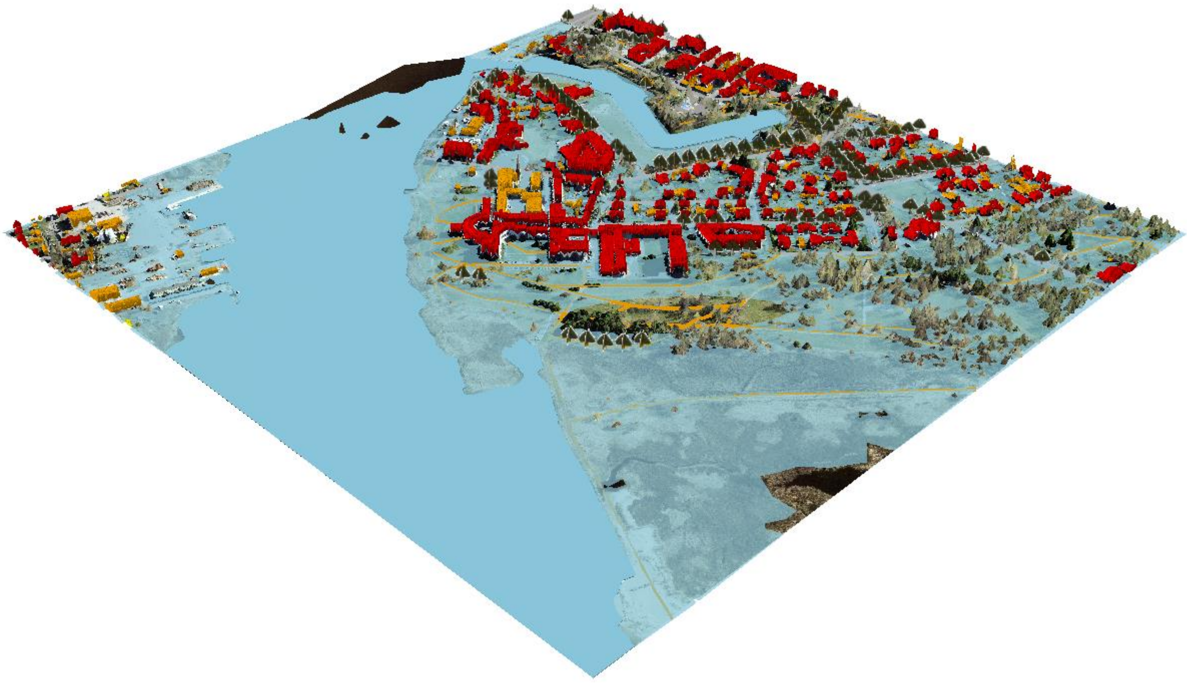

Figure 23 – Visualisation using orthophoto and various layer models of flood of 2005 with increase in water height of 275cm

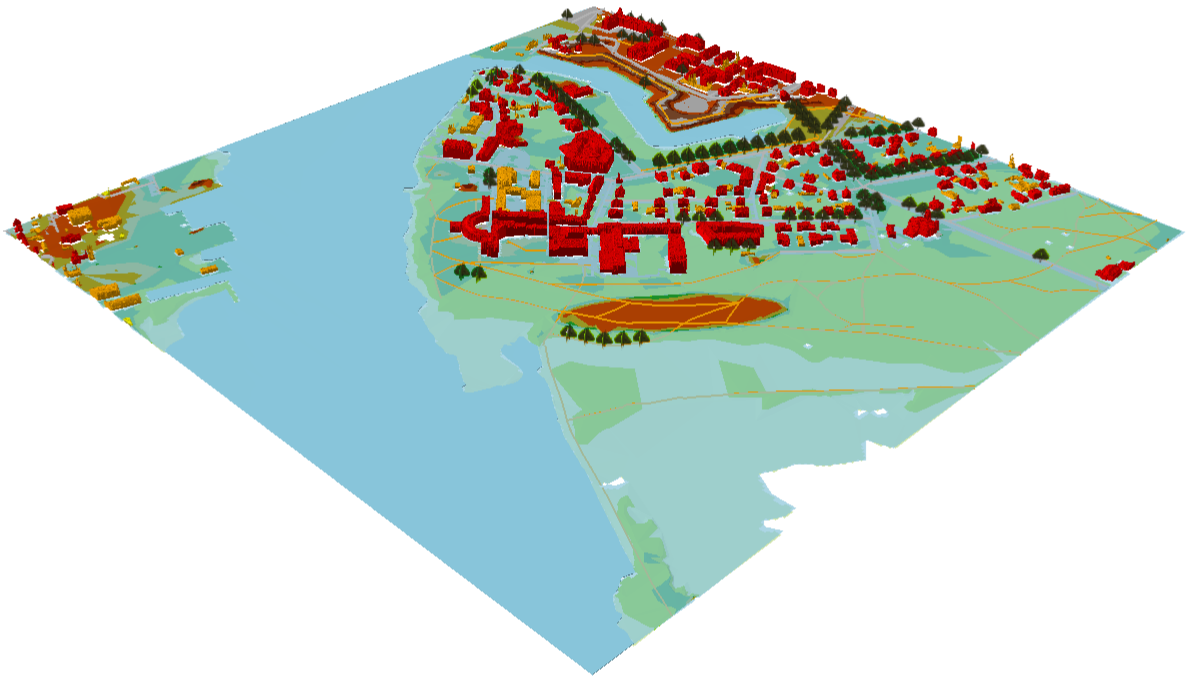

Figure 24 - Visualisation using simple TIN and various layer models of flood of 2005 with increase in water height of 275cm

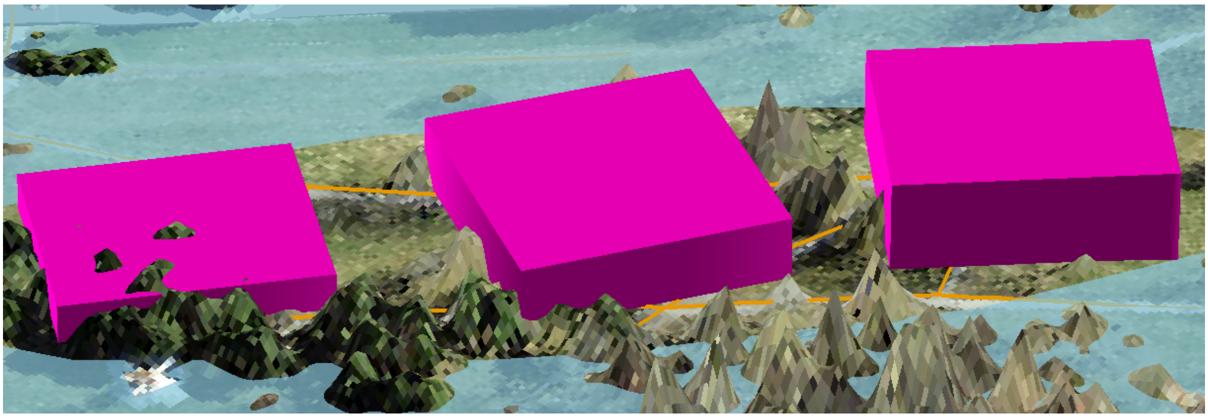

Figure 25 - 2005 flooding scenario shows the new buildings constructed on landscaped ground at 3m elevation would be above the flood water levels

3. Modelling future sea level and storm flooding

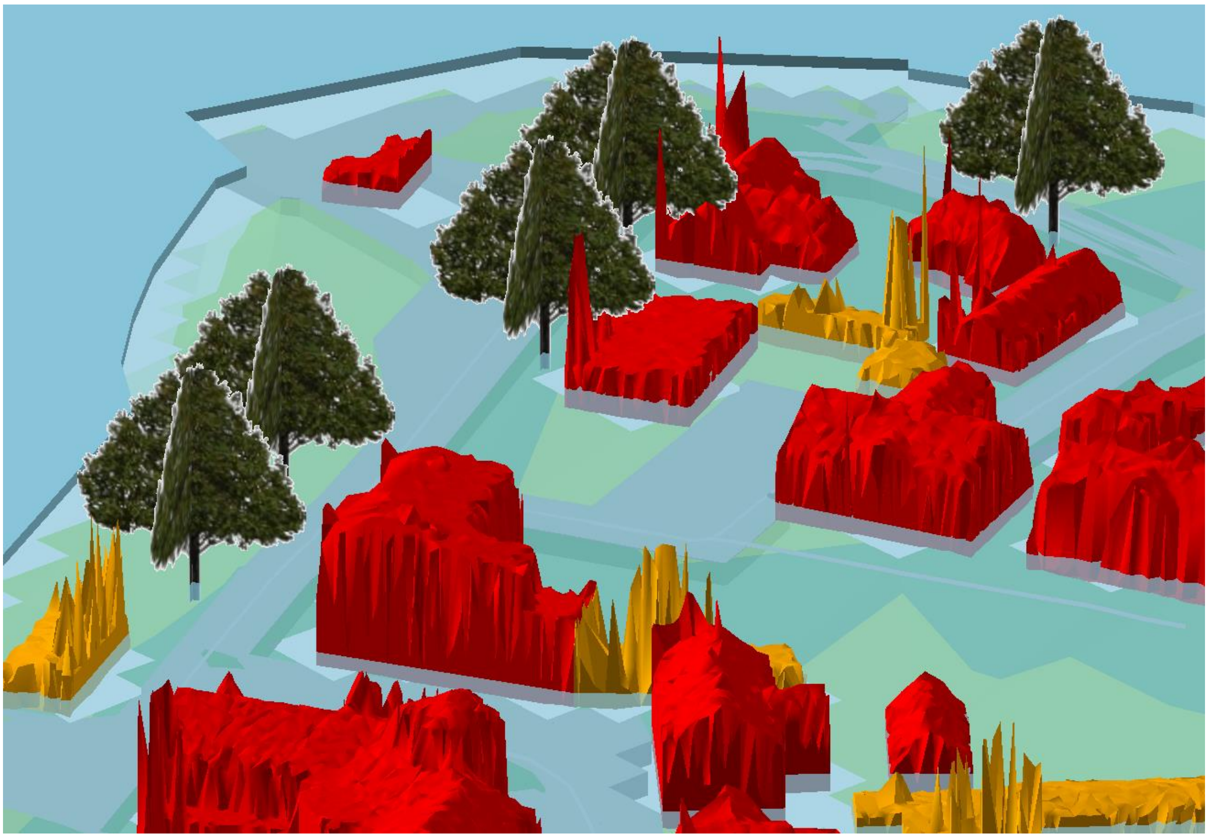

Figure 26 -Closeup of 2100 potential flood visualisation using simple TIN

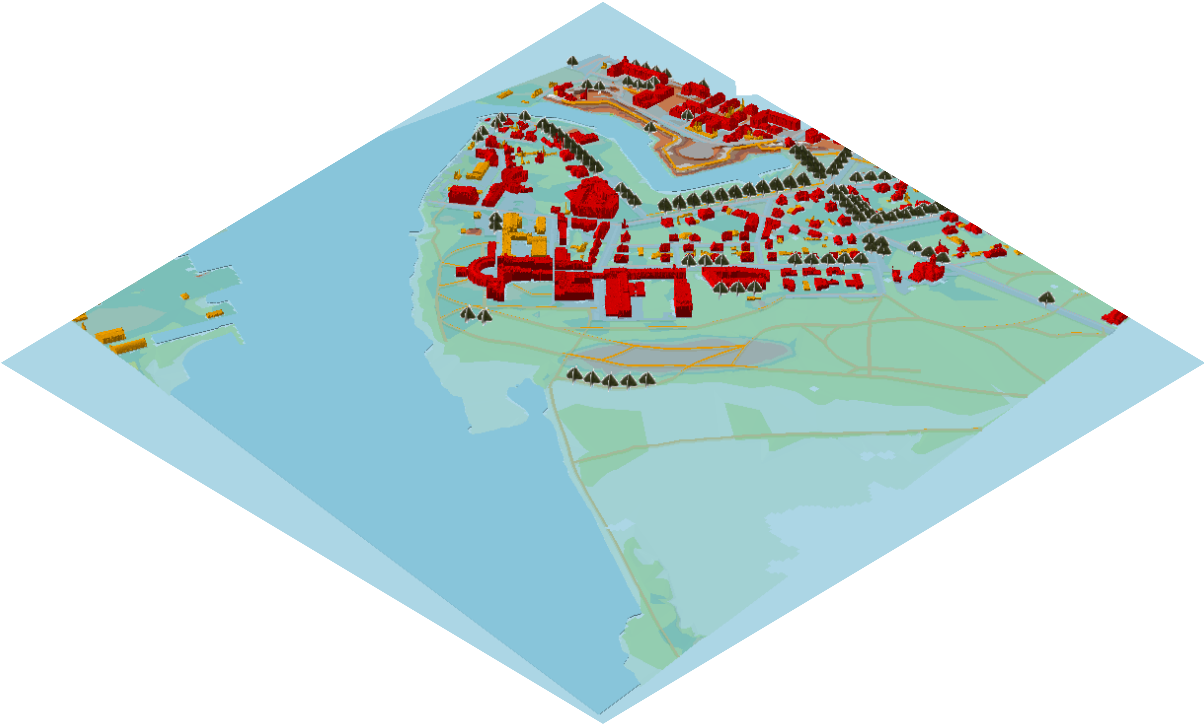

Figure 27 - 2100 potential flood visualisation using simple TIN

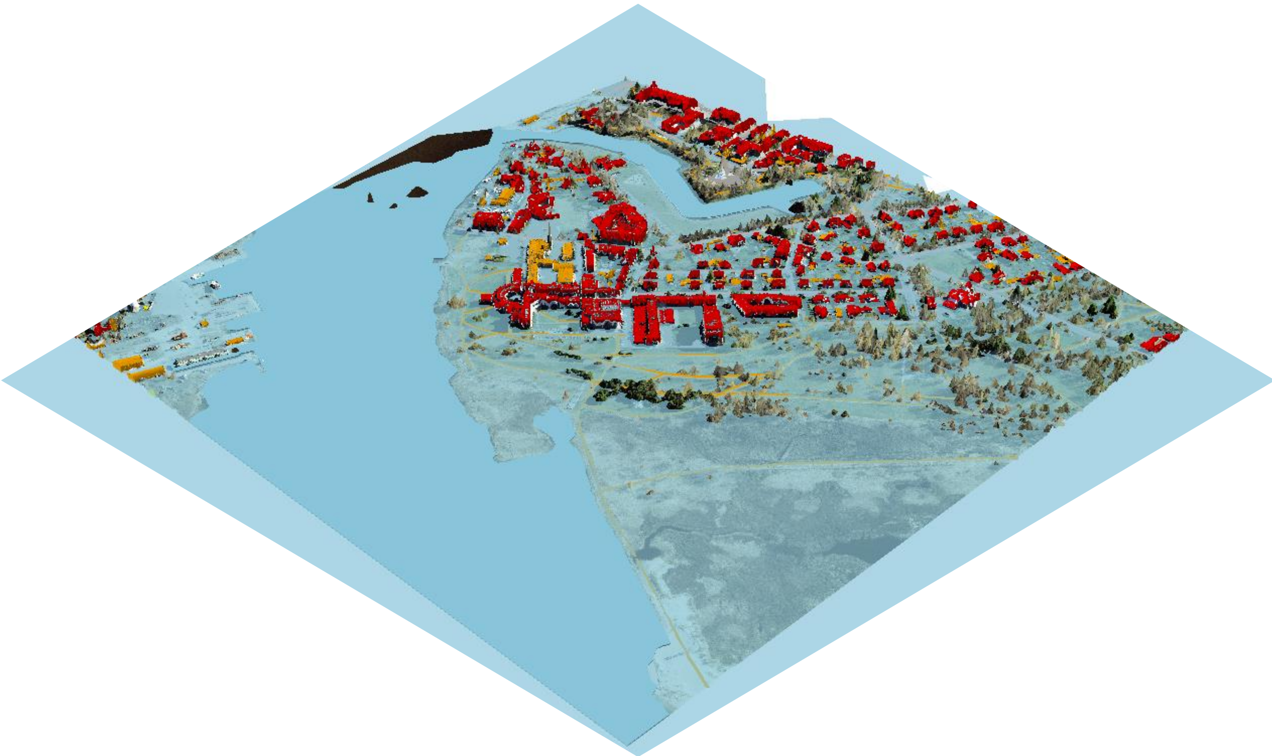

Figure 28 -2100 potential flood visualisation using orthophoto and building model layers

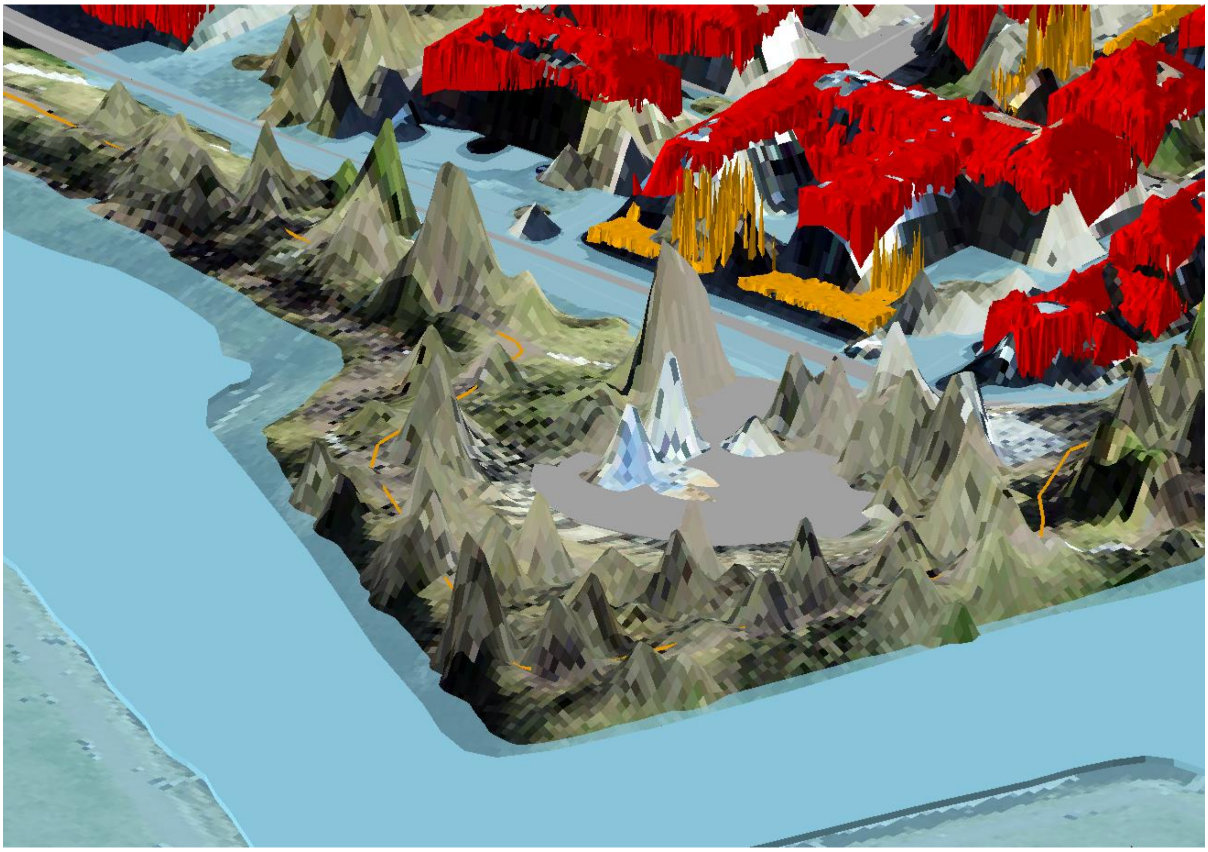

Figure 29 – Closeup of 2100 potential flood visualisation using orthophoto and building model layers

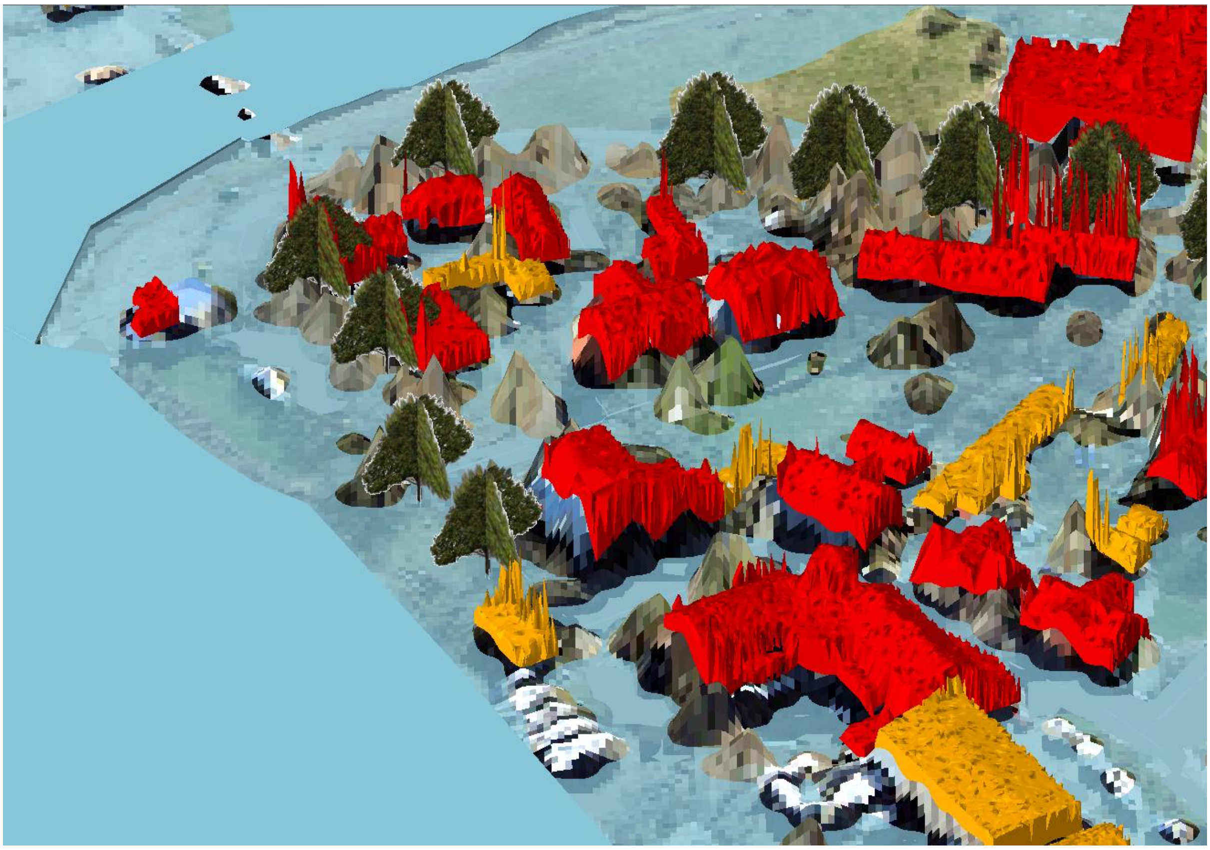

Figure 30 - Closeup of 2100 potential flood visualisation using orthophoto and building model layers

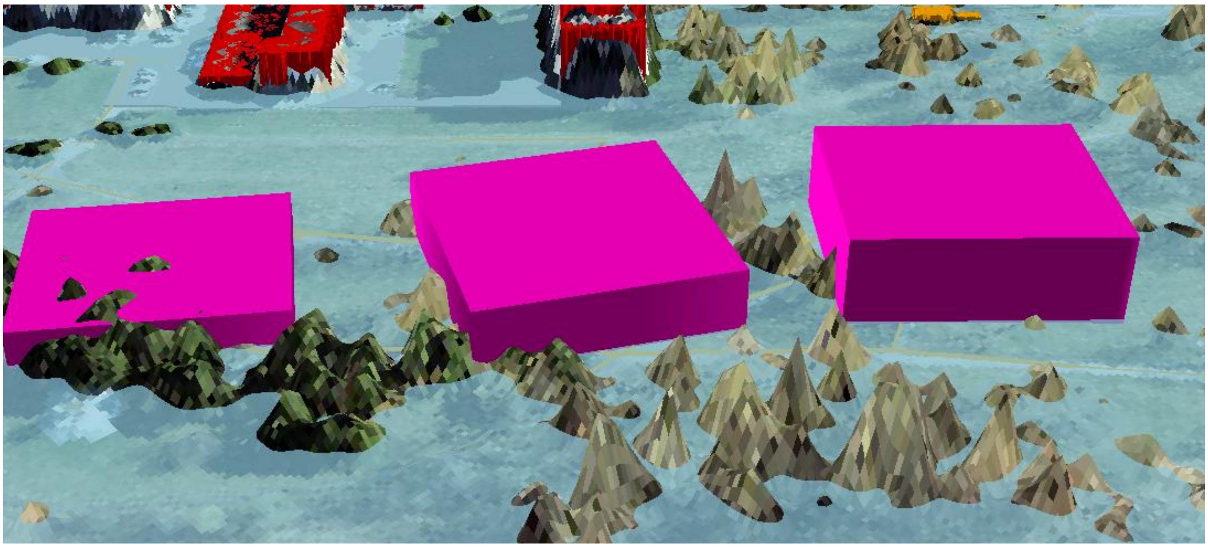

Figure 31 – Potential 2100 flooding scenario shows the new buildings constructed on landscaped ground at 3m elevation would be partially submerged

Using zonal statistics, whereby I took the flooded sea level of 2100 raster as input and used the original raster which was created from the multipoint layer in lesson 9, the output was an average flooded water level of 1.95 metres.

Concluding comments

Lessons nine and 10 provided an interesting and comprehensive approach to modelling with sea-level rise. Using Arc-GIS as the tools to both visualise and analyse the relative sea-level change of the Baltic, the clear outcome is that Pärnu Is particularly vulnerable to storm surges. Figures 23, 24 and 25 shows graphically how Pärnu was inundated by the 275 cm storm surge of 2005. The model landscaped area of construction which is above 3 m would have survived this event.

However building regulations may need to be adapted further, with figures 26 to 30 showing how much Pärnu Is vulnerable to further storm surges if there is sea-level rise at the predicted scenario of 74 cm. Using such models, planners can understand, re-assess and help mitigate issues. However, this may mean changing the planning laws of the city including building on higher ground or creating systems to block or channel floodwaters.