Activities:

D.T3.7.2 GIS simulation of investigated area in 3-dimensional maps of target sites

D.T3.7.1 GIS maps of investigated contaminated areas

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3D modeling in Valmiera pilotsite

Overview of the software

Main software:

1. ArcGIS 10.3.1 for Desktop, license version ArcGIS for Desktop Basic with *3D Analyst* and *Spatial Analyst* extensions. Main programs used ArcGIS ArcMap 10.3.1 and ArcGIS ArcScene 10.3.1.

2. ArcGIS Pro 2.2.4, license version ArcGIS Pro Basic with *3D Analyst* extension. Main program used Arc GIS pro 2.2.4.

3. ArcGIS Online.

Data usage for visualization of the area and contamination

Scheme of the pilot territory was created by using ORTOPHOTO materials and topographic scheme found in project pdf document as a base.

3D maps of oil product contamination in percentage "%" of starting value in Valmiera city during next 60 years was made by using modelling data of first scenery. Contamination was modeled in 11 ground layers, results are displayed as grid data. Surface layers also are necessary for 3D visualization of contamination. Surface information also is stored in grid data that were prepared before in *Surfer* program. Grid data stores information about concentration values of contamination with oil and information about height information in surface layers. Each data layer can be visualized as raster layer.

For contamination data transformation into ArcGIS Online to make them visible for people all layers with their visualization were shared as *Web Scene.*

Excel data were used for visualization of ground and water contamination in wells. There is one excel file which consist of 671 record about ground or water information. These records includes information about coordinates of well, depth of the sample, information about type (ground or water sample), about type of which indicator is tested, result of each indicator into sample, uncertainty, number of well and other useful information for data reader. All this information is necessary to distinguish samples with similar properties to make separate maps for each type of chemicals.

Work on map preparation

Firstly the scheme of the pilot territory was made. Scheme was made by using simple tools of ArcGIS ArcMap 10.3.1. Objects of the scheme is stored into ESRI shape file. Shapes of the pilot territory were made by digitization from ORTOPHOTO. Information about object type was obtained from topographic scheme found on project pdf document and for better 3D visualization some height information was added to building shapes. Scheme of the territory see in picture 1. Objects of the territory are displayed in the most simple way as polygons in different colors. For better understanding name of the objects also are added to the map and ORTOPHOTO in the background.
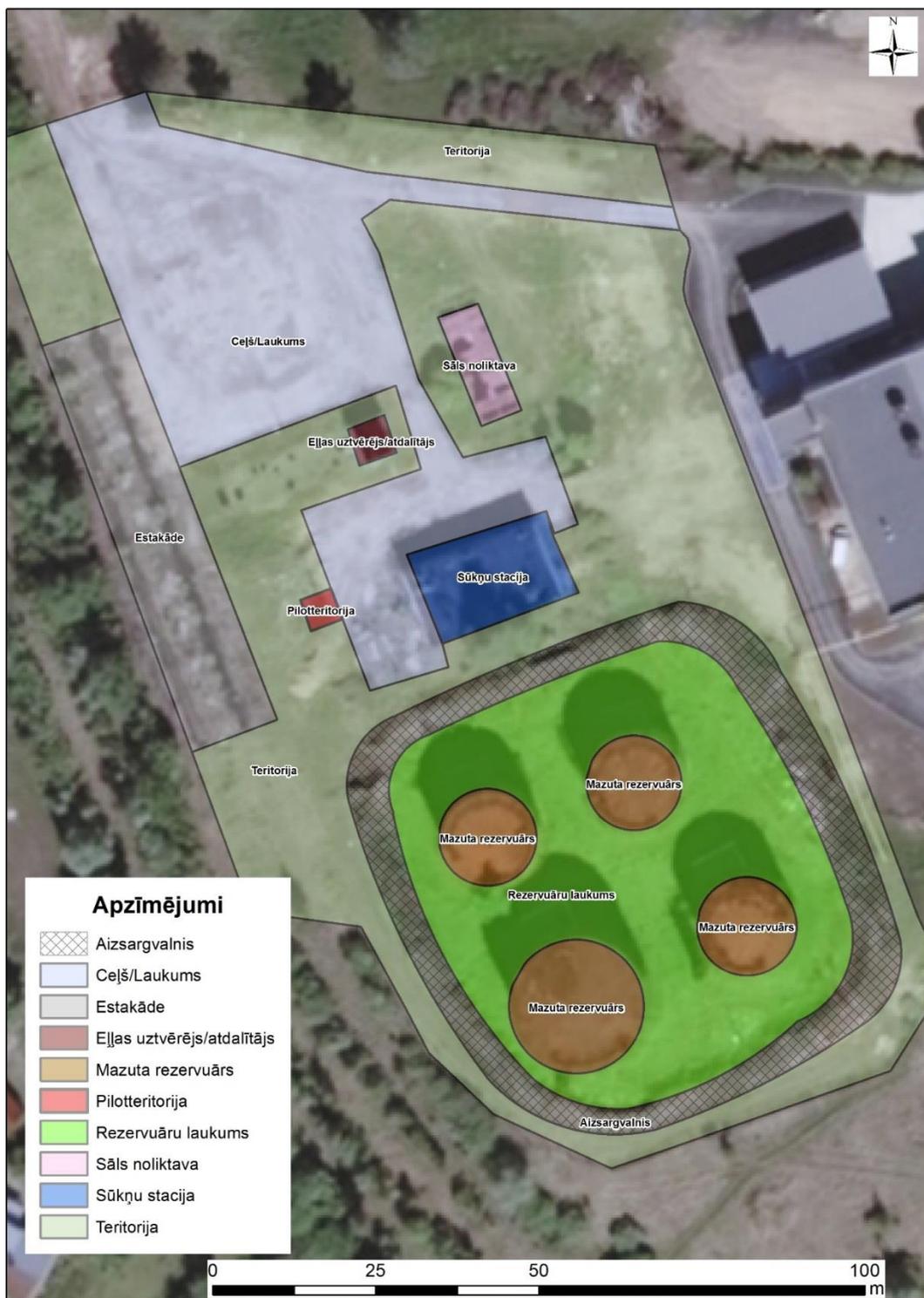
Picture 1. Scheme of the pilot territory.

Work on oil product contamination visualization in % from starting value for 60 year scenery started after the scheme was prepared. At first, grid data needed to be transformed into some useful data format, so grid data was exported as TIFF data by using ArcMap Desktop version. TIFF format is more appropriate for ArcGIS software. After data transformation and concentration flow visualization, data was opened in ArcScene to transform data in 3D view. Se visualized data in picture 2 below.
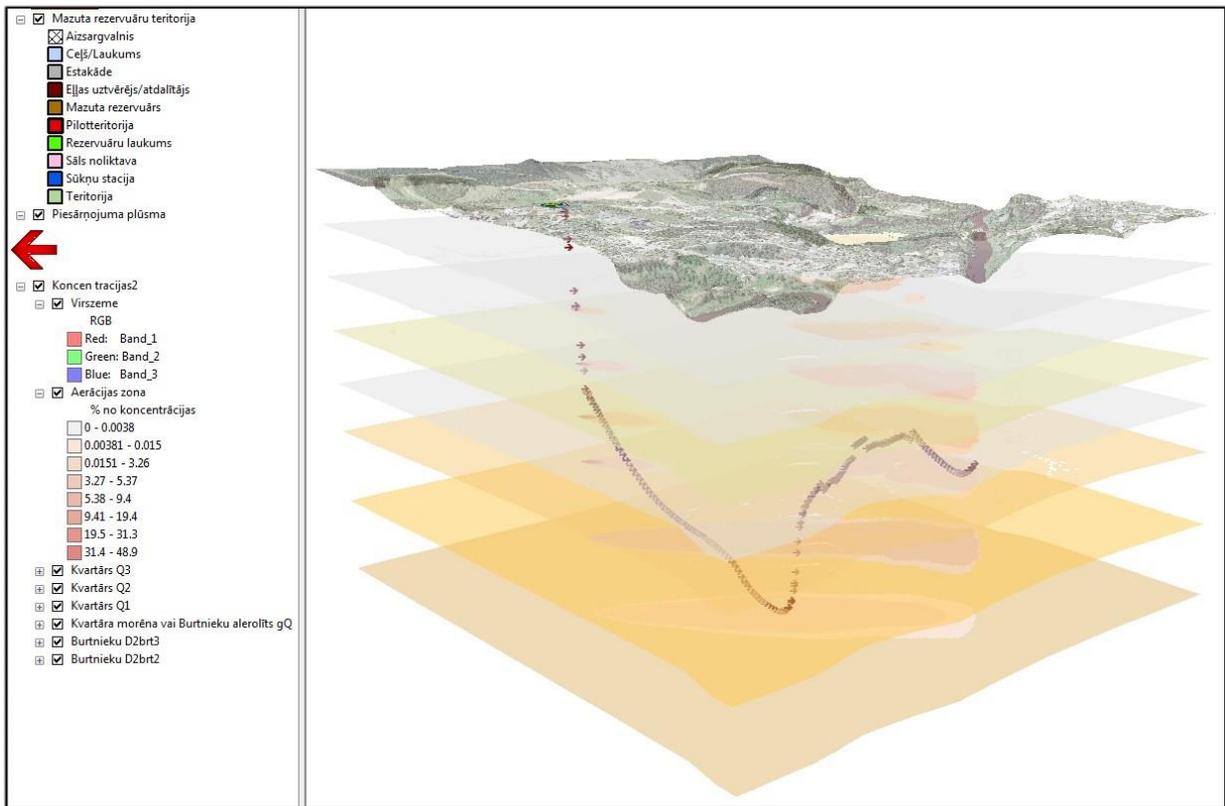
Picture 2. Contamination flow and % in 60 year scenery.

In the picture 2 you can see pilot territory, concentration of oil product contamination in different ground layers, relief of the territory and how it affects accumulation of oil products. Also the contamination flow path described as arrows is displayed. Visualization was chosen as the best possible way to display that kind of data. Concentrations were divided in the same amount of classes and the same interval size. For zero values some color was applied to see whole layer and transparency for each value to see through the layers.

For a better look and access to results, they were also displayed in ArcGIS Online. 3D data were uploaded in ArcGIS PRO software for better export option to ArcGIS Online. In online version layers were necessary to be displayed in scene viewer to see them in 3D view. Some formatting options were added to layers to see them in best point of view. This time only concentration flows were displayed - zero values wasn't applied for better look in application. Also for better look to concentrations, each layer should be displayed separately, because all of them are displayed on the ground. ArcGIS online doesn't support view underground yet. After the layers were formatted as needed, web application were made, added some tools to application and made slides for better view options and for the best way to understand results. People easily can turn on or off layers as needed and see results for each layer or turn all on to see how contamination spreads through ground surfaces. ArcGIS Online access allows people see the result if they have a link or when they are looking through the ArcGIS Online web map

catalog. You can access this 3D map trough the following link: https://arcg.is/15urCu. An example see in the picture 3 below.
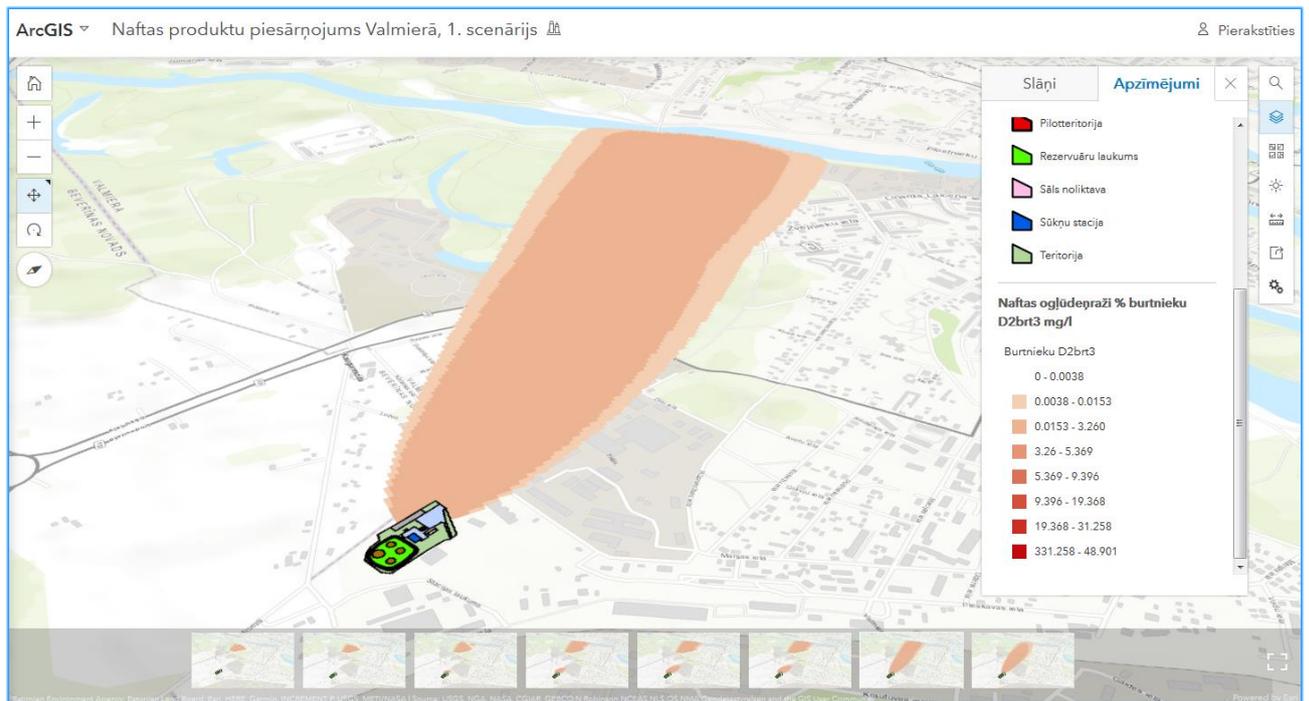
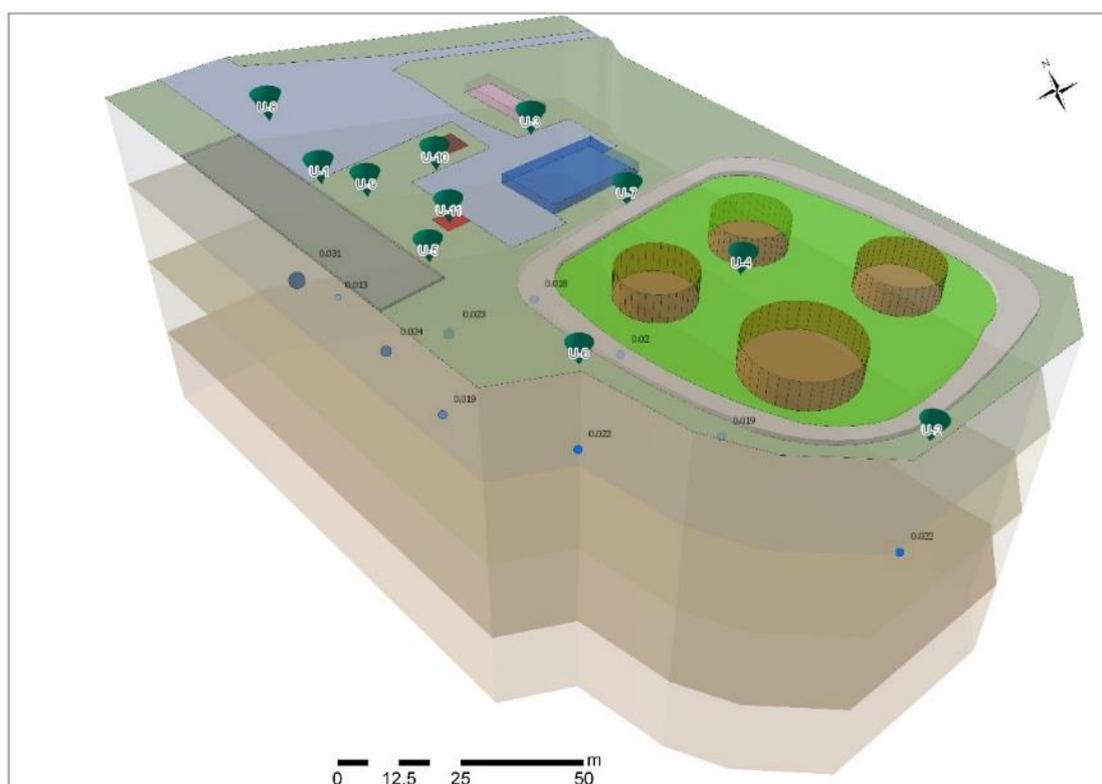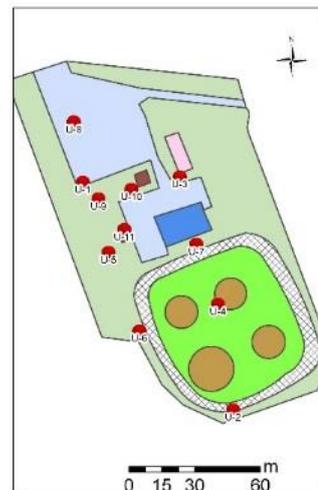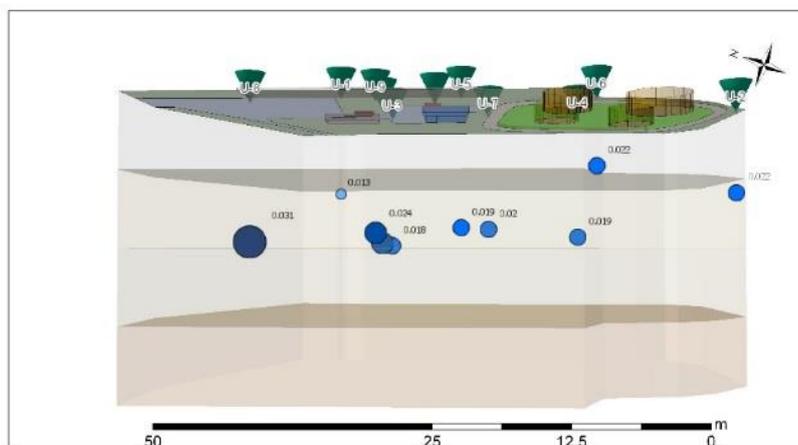Picture 3. Example of web map in ArcGIS Online.

Next and the main step of result visualization was to create 3D visualization about well data. It was the hardest task to find out the best and possible way how to visualize them. After some time it was clear that visualization in ArcGIS Online isn't that good as it was with oil product contamination % after 60 years. Firstly the data that are stored in excel tables have to be corrected and changed to be suitable for ArcGIS, mainly the problem is with titles of columns that can't contain spaces, symbols or diacritic marks and in other ways table should be arranged that there are no holes between lines and information is made correct to be sorted in excel and ArcGIS . When corrections are made, then excel table needs to exported as csv document (see example in picture 4), it is best option to import table data with coordinate information into ArcGIS and save as ESRI shapefile.

Picture 4. Example of data table in csv file format.

In ArcGIS each measurement is displayed as point and it stores all information about measurement. It has coordinates and height information (XYZ information), that allows it to be displayed in 3D space. When shape files are made, then they were exported into ArcGIS PRO that has a possibility to display information in 3D view and make layouts. There are two kind of results in wells that are displayed, there are samples from ground measurements and from underground water. There are chain in each measurement point of different chemicals that concentrations have been measured. To visualize only needed ones, it is necessary to use Definition Query where only needed parameters are chosen. In that way need to select each type of sample to visualize only data that are needed for one map. That's why there are plenty of 3D visualized maps that shows results only for one type of chemical concentration into ground or underground water. Examples of result visualization in ground and underground water see picture 5 and 6.

Picture 6. Aluminum concentrations in underground water.
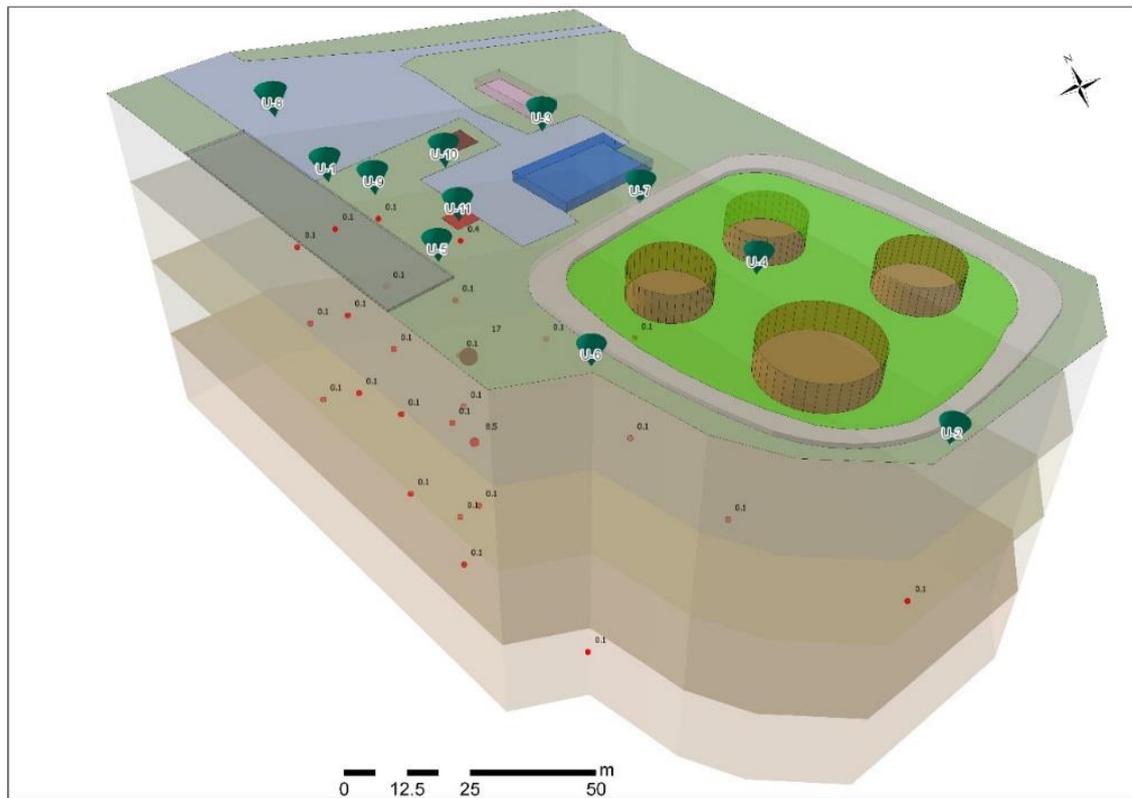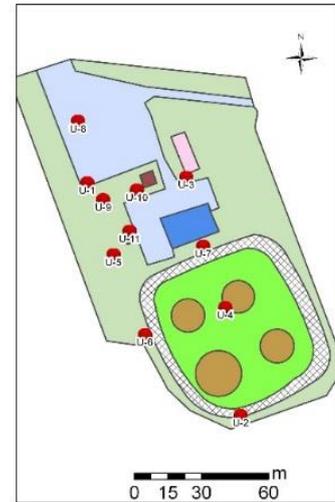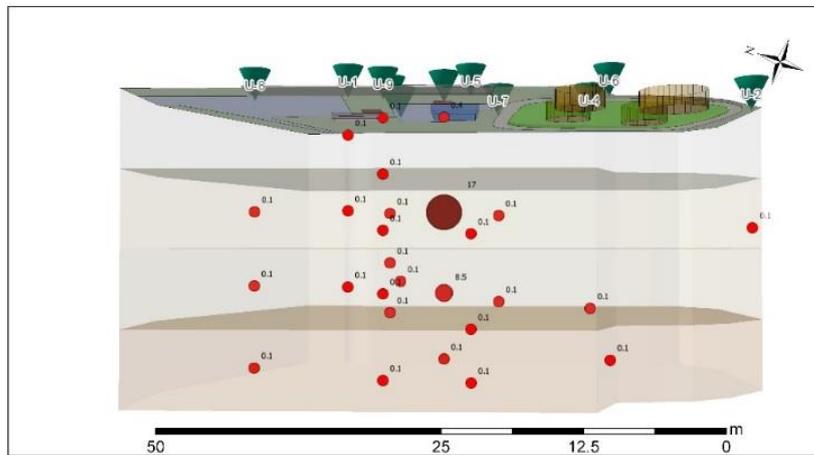
Picture 7. Benzene concentrations in ground.

Contamination maps are made from three points of views. In the right corner the smallest map shows the scheme of territory and wells with their numbers. In upper picture to the left there is a side view of concentration results. Concentrations are divided in 4 equal interval groups. Mostly for each chemical groups are different, because of different highest values. But count of groups are up to map producer, groups can be more or less, as necessary and best way to show results. One of numbers is showed as threshold for better understanding of results to see if there is overrun of chemical contamination into ground or underground water. As the thresholds are different for each chemical, each map has to be checked more careful. Depth of the ground is showed as different colors, each color is 10 m depth. Height values are extruded in options for better view and understanding of results, also concentration values are attached to each point to see exact value.

In the biggest map you can see the concentrations from perspective view and also the well number and location. Results with more contamination and biggest concentrations are displayed as bigger and darker rounds to highlight problematic places.

Problems. Ways to improve maps. Software requirements.

Problem in visualizing scheme of the territory is that the topographic plan is only found in pdf format, but if there would be **dgn** or **dwg** format, then visualizing would be possible more accurate and in more detail. Problem in visualizing 3D data is that there is no vertical (Z) scale. Also a bit harder to visualize and read concentrations properly makes the fact, that each chemical has different thresholds. There are the same size of visualized concentration points, but values are different for each chemical. To make data more understandable threshold values has been added in legends.

ArcScene has no option to make layouts, that's why it is needed to make or import maps in ArcGIS PRO. ArcGIS PRO needs to have more options for 3D visualization or more easy understanding tools and better data compatibility between ArcMap and ArcGIS PRO. Good way for data visualization could be possibility to see results in pdf or some other popular formats with possibility to move it or rotate it as it is possible in ArcGIS, but needs to be more common for usual people. Also possibility to add line from well point on the ground trough measured points in depth are needed to take a better view and understanding from perspective view to see which point is under which well.

And also there is one problem with data visualization. When 3D map is imported in ArcGIS Online, data are visualized in 2D, but there is problem that some data are possible to

be displayed as it is on ArcGIS PRO, but some data fails to be displayed in 3D view as it is possible in ArcGIS PRO.

One tool that misses, is 3D interpolation tool that could interpolate values through ground vertically and horizontally similar as it is in simple interpolation tools, but making dimensional layer. In this way could be possible to visualize results in different ways or maybe more considered. And for better result interpolation, more well and data gathering are needed for better territory cover.

It is needed to have ArcGIS for Desktop and ArcGIS PRO Advanced license level instead of Basic license to perform more advanced maps and results.