Although there has been an abundance of scholarship focused on viewshed analysis and intervisibility between sites and monuments in the landscape, there has been comparatively little research on investigating intervisibility within settlements and its relationships to the spatial organisation and development of settlements. One way to investigate this is through Visibility Graph Analysis (VGA) using the software programme *depthmap*. VGA calculates areas of intervisibility within a graph, so that '[…] all possible occupiable locations within the built environment (may) be categorised by their visual relationships to other occupiable spaces through a continuous map' (Turner, 2004, 2). It investigates the spatial and visual organisation of the built environment using ideas based on graph-based analyses of the configuration of space and its effect on accessibility, visibility, and movement (Turner 2001, 2003; Turner et al., 2001). VGA characterises the spatial arrangement of the interior of structures and urban environments by integrating space syntax theory and visibility fields, or *isovists*, to measure the visual arrangement of the built environment. Although the concept of VGA was originally introduced by Braaksma and Cook in 1980, it was refined primarily through the work of Alasdair Turner and colleagues at the Space Syntax Laboratory of University College London using the bespoke computer programme *UCL depthmap*, designed and programmed by Turner, (Turner et al, 2001; Turner and Penn 1999). This technique quantifies the connections of grid points within a graph based on space, movement, and visibility.

- VGA determines the portions of an analysed area (such as the floorplan of a house, or the plan of a settlement) that can see the most other portions of an area AND can be seen by the most other areas by interpreting the most and least visible portions of an analysed graph.

- The results of VGA are colour-shaded images that represent the most and least connected zones of a settlement or structure.

- VGA investigates two-dimensional plans of settlements and buildings by examining how structural elements (buildings, walls, doors) impede visibility and thus impact movement and activities, and measures these using a variety of space syntax equations focused on the connectivity of spaces. Although topography and other natural features (vegetation, water, etc.) undoubtedly played a role in the development of the built environment, VGA is still useful as a proxy to understanding the visual use of space and the development of settlements.

- The results of VGA can be compared using the colour-shaded outputs as well as through statistical analysis of the measurement scores. Turner (2004, 14-15) argues that the *integration, entropy, and mean depth* scores are the most reliable for analysing and comparing spaces, it is suggested comparisons be made using these scores. That said, all of the global measurements and images are included with the files for comparison.

Visibility graph analysis has seen fairly limited use by archaeologists, with the majority of studies using VGA focused on the analysis of space within ancient structures (for example see Chatford Clark 2007; Paliou et al., 2011; Tahar and Brown, 2003). More recent work has expanded the use of VGA outside of structures and investigating its utility for analysing intra-site relationships and patterns within cemeteries (Brookes et al., 2017) and settlements (Buchanan 2017). This expanded use of VGA outside of architectural space provided the basis to test VGA's utility to examine the Trypillia site of Nebelivka. The goals were to see if VGA could explore if there were distinct organisations of space in different regions of the site, and potentially link this to differing developmental histories or strategies at the site.

The VGA of Nebelivka investigated if there were broad comparisons or differences in the spatial and visual organisation of eight different regions - here termed 'Quarters' - of the site. Additional configurations of three of the Quarters (labelled RF Stage 1-3; BG Model Stage 1-3) were also tested to examine potentially different stages of development. Georectified plans of the Quarters, which preserved the scale and form of the structures identified during the geophysical survey, were imported into *UCL depthmap*. A grid was overlain over these plans at a defined interval of 2 metres, and this grid was used to perform VGA to calculate how connected each grid node is to the other points in the graph (Turner, 2004, 1). The grid spacing of 2 m was used, as too large a spacing lost resolution and too small a spacing increased the processing time exponentially beyond the memory capabilities of the program. Visibility graph analysis was run based on the grid spacing and attempted to connect each grid node to all the other visible nodes not blocked by the structures. The total number of connections for each nodal point are known as the *vertex's neighbourhood,* and depthmap displays these using a colour range from indigo for low values of connection through blue, cyan, green, yellow, orange, red, and magenta for higher values (Turner, 2001, 2).

The visual imagery and statistical results were used to examine which portions of Nebelivka were more or less integrated or, as Hillier and Hanson (1984) describe, the distribution of more permeable/public spaces vs. less permeable/private spaces. As previously discussed, Turner (2004, 14-15) recommended three of the many measurements VGA produces as especially good for analysing space:-

- *Mean depth* calculates the fewest number of turns required to connect grid points in the graph to the other visible points. These calculations are added and divided by the total number of vertices within the graph to give a mean depth score for each node, which are then averaged for the entire graph (Turner, 2004, 14).

- *Integration* investigates how visually connected grid points are to the other nodes and approximates the relative "depth" or permeability of a point to all of the other points. Turner notes integration is an important measurement as it is a normalised version of mean depth and has been found to correlate well with pedestrian movement (Turner, 2004, 14).

- *Entropy* refers to the overall complexity of a graph by calculating the distribution of depths within the graph. Entropy was developed as a measurement because *UCL Depthmap* appeared to be prioritizing open spaces, and by analysing the distribution of locations near a node, a relative measurement of complexity could be met (Turner, 2004, 15, Turner 2001, 7).

Depthmap produces a range of global and local measurements that are also useful for comparison.

- *Connectivity* refers to the overall 'connectedness' of a graph. The measurement calculates the number of nodes that are visible from any single node based on walls, structures, or other impediments blocking visual sight lines. The connectivity score is an average of how well connected the all of the grid nodes are to one another in a graph (Turner 2004).

- *Point First Moment/Point Second Moment* are measurements related to the approximation of polygonal shapes of isovists in a graph. Point first moment refers to the sum of the distances from a generating point of an isovist (or viewshed) to every visible grid point in a graph (Al_Sayed et al., 2014, 34). Point second moment is a measurement of the jaggedness of an isovist's perimeter compared to the area of the perimeter of a graph (Kruker and Dalton, 2013, 16). Both of these measurements appear to be more useful for analyzing the visual environment within structures but are included here as one of the outputs of VGA.
- *Visual Node Count* refers to the total number of nodes within a graph, and is the basis for many of the other mathematical measurements discussed above.

The results of the VGA of Nebelivka suggest similar patterns of spatial and visual organisation across the mega-site, with no significant differences noted in the measurements discussed above between the various Quarters as noted in the Excel spreadsheets and in the .tiff images of the zones. The datasets demonstrate a high degree of similarity between the Quarters in the spatial and visual organization of the site. This suggests that the inhabitants of the site were following similar patterns of spatial organisation based on visibility and movement and that the successive occupations of the Quarters were replicating traditional spatial structures. The image results also indicate that the most visually connected areas of the investigated zones were near the large Assembly Houses, with highly connected linear corridors leading to these visually connected, and presumably quite public structures. That said, there were differences noted in the RF and BG Model stages as compared to the overall plans, but the connected areas were still concentrated near the Assembly Houses. The RF and BG Model stages were more visually connected than the examinations of all of the structures. Taken together, the VGA initiated at Nebelivka provides quantitative data to investigate the development and organisation of the mega-site and early urbanism.