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Submerged Landscapes

- Locating Mesolithic settlements in Blekinge, Sweden

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Submerged Landscapes: Locating Mesolithic settlements in Blekinge, Sweden
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Submerged Landscapes: Locating Mesolithic settlements in Blekinge, Sweden

Louise Hannon Bradshaw

Bachelor thesis, 15 credits, in *Physical Geography & Ecosystem Analysis*

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Abstract

Historic settlements are of great interest since they play a role in understanding our past and our cultural roots. The development of technology now makes it easier to map the seafloor and locate submerged settlements. Finding submerged Mesolithic settlements has led to hypotheses being made on what characteristics to look out for which could suggest Mesolithic settlement locations. This study focuses on such settlements between 11,600 – 6000 cal. BP in Blekinge, southern Sweden. Similar studies have already been done in this region, making it possible to compare already identified settlements to the submerged settlement locations suggested in this study. Many of the already identified settlements in Blekinge have been close to major rivers, and in this study, the suggested settlements are all in close proximity three rivers; the Bräkne, Vieryd and Ronneby rivers. Three beneficial characteristics for Mesolithic settlements and a fishing site location model are used to suggest potential Mesolithic settlement locations. Along with this, the three rivers Bräkne, Vieryd and Ronneby have been reconstructed in the submerged landscape. The main finding in this study show that only one of the nine suggested settlements in the submerged landscape met all three of the beneficial characteristics, with the other eight meeting at least one of these. When comparing the suggested settlement locations to the already identified settlement locations, there are not enough similarities to conclude that they are all located in similar landscapes. This could suggest that either more already identified settlements should be analysed before being able to compare their characteristics more accurately with suggested settlement locations, or that more research should be made into the characteristics that define the location of a Mesolithic settlement.

Key words: Submerged landscape, Mesolithic settlements, ArcGIS, Digital Elevation Model (DEM), fishing site location model

Sammanfattning

Historiska bosättningar är av stort intresse eftersom de kan hjälpa oss att nå en förståelse om vårt förflutna och våra kulturella rötter. Tack vare den teknologiska utvecklingen är det nu enklare att lokalisera vissa av de historiska bosättningar som blivit översvämmade genom att kartlägga havsbotten. Forskning om översvämmade mesolitiska boplatser har lett till att det finns utvecklade hypoteser om vilka egenskaper sådana boplatser kan tänkas ha. Denna studie fokuserar på mesolitiska bosättningar, från år 11 600 - 6000 cal. BP. i Blekinge, södra Sverige, som alltså idag är belägna under havsytan. Liknande studier har utförts tidigare i samma region, vilket gör det möjligt att jämföra redan identifierade bosättningar med de översvämmade boplatserna som föreslås i denna studie. Många av de redan identifierade mesolitiska boplatserna i Blekinge är belägna nära stora åar, och därför är även alla de föreslagna översvämmade boplatserna i denna studie lokaliserade i närheten av tre åar; Bräkneån, Vierydsån och Ronnebyån. För att lokalisera de submarina boplatserna användes tre kända egenskaper för mesolitiska boplatser, samt en fiskeplats modell. Dessutom har de tre åarna Bräkneån, Vierydsån och Ronnebyån rekonstruerats i det nedsänkta landskapet. Studiens viktigaste slutsats är att av de nio föreslagna boplatserna i det nedsänkta landskapet uppvisade endast en alla de tre kända egenskaperna. De övriga åtta boplatserna uppvisade åtminstone en av egenskaperna. När man jämför de föreslagna submarina boplatserna med sedan tidigare identifierade boplatser, kan man se att det inte finns tillräckligt många likheter mellan dem för att dra slutsatsen att de befinner sig i liknande landskap. Detta kan tyda på antingen att fler identifierade boplatser bör analyseras innan de kan jämföras med föreslagna platser, eller att ytterligare forskning om de egenskaper som definierar läget av en mesolitisk boplats är nödvändig.

Acknowledgements

I would like to thank my supervisor Ulrik Mårtensson for all the comments and suggestions that helped improve my thesis and make it to its finished state. I would also like to thank Björn Nilsson, a researcher in archaeology at Lund University for all his advice and allowing the use of his data in this study. The support from my family and friends also helped complete this work.

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1. Introduction

Cultural heritage sites such as Mesolithic settlements play a key role in understanding the past and our cultural roots. Identifying their location in landscapes that are now submerged is a major challenge for archaeologists, as identifying submerged cultural heritage sites is a little more difficult (Lund 1995).

The connection between coastal Mesolithic settlements and the exploitation of the nearby open water has already been established, so one of the next steps is to locate submerged settlement sites (Andersen 1995). This study looks at locating Mesolithic settlements in the Baltic Sea, most of which are now submerged due to the changing sea level.

Researching "lost" submerged landscapes is a topic which is becoming an increasingly interesting area of study. Mapping the submerged landscapes can also aid in habitat protection by playing a role when planning to develop coastal regions, as this can affect marine habitats as well as places with high conservation value, such as Mesolithic settlements (Fyhr et al. 2015).

Until quite recently, finding and excavating submerged settlements has been far more difficult under water than on land, because of the practical limitations of area covered, depth accessibility and time spent on site imposed by diving. In shallow Danish waters, there has been successful investigation of some Mesolithic settlements now located on the seafloor (Fischer 1995). However, diving is a very time consuming methodology and impractical when trying to cover large areas. New technological advances in remote surveying have now made it easier and more practical to map large areas of seafloor landscapes with the use of echo sounders such as the Singlebeam Echo Sounder (SBES) and Multibeam Echo Sounder (MBES) (Demoustier and Matsumoto 1993).

Submerged Mesolithic settlements tend to have better preserved objects of organic material as they will have been permanently saturated throughout the ages, from when they were deposited to when they are discovered. Another reason to study submerged landscapes is that they can provide information on environmental history, such as the sea level change. They can also suggest how people adapted to issues such as sea level change in the Mesolithic (Fischer 1995). On the other hand, the most well-preserved settlements are often found in sediment accumulation areas, which can also make them more difficult to find (Torebrink 2012). A fishing site location model which could help identify potential Mesolithic settlement locations was developed on existing Danish Mesolithic settlements by Fischer (1995), which is tested on locating potential Mesolithic settlements in southern Sweden in this study.

When examining the physical landscape, the underwater landscape is often forgotten. In fairness, in some cases the underwater landscape is not an important issue, but due to this, its value is regularly forgotten. With this in mind, this study hopes to increase knowledge of underwater landscapes and its potential value, such as identifying Mesolithic landscapes which are of conservation interest for learning our history (Torebrink 2012).

This study focuses on a section of the coastline in Blekinge, Sweden which can be seen in figure 1. This particular area is interesting to study as there is evidence for a lot of early-Mesolithic settlements (Torebrink 2012). The basis of this this present work is to try and identify potential Mesolithic settlement locations in the now submerged landscape.

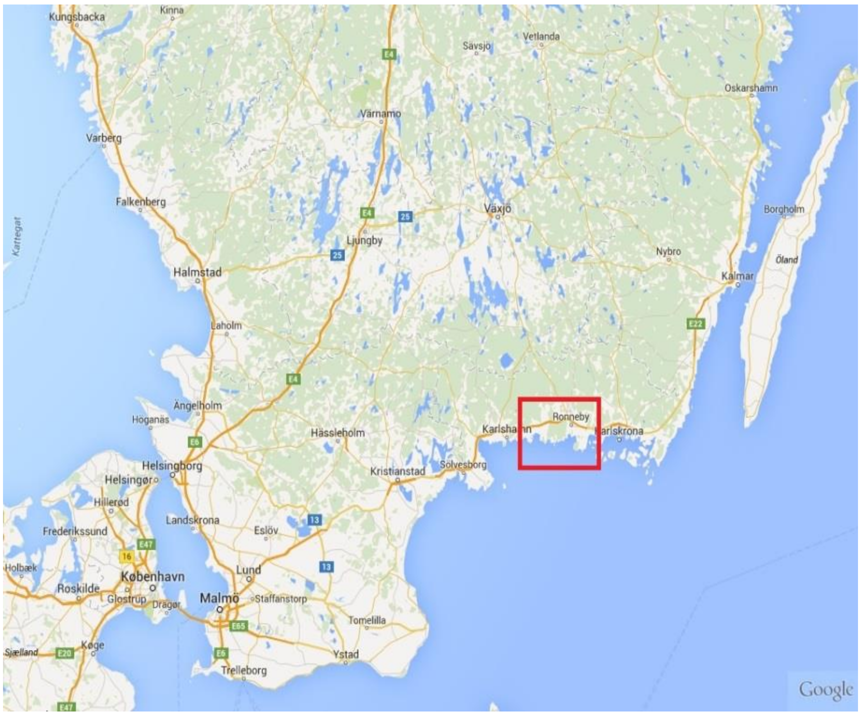


Figure 1. Southern Sweden - red box around the study area
Source: Google maps

1.2 Aim

The aim of this report is to try and locate potential submerged Mesolithic settlements in Blekinge, southern Sweden. In order to achieve this, three objectives will also be completed, which are:

- To test merging a bathymetry DEM with a landscape DEM
- To reconstruct three main rivers, Bräkne, Vieryd and Ronneby
- To test if the beneficial characteristics chosen and the fishing site location model are appropriate for locating Mesolithic settlements

The three rivers had to be reconstructed out to at least -25 m depth. After this, four locations along the three rivers were chosen for further analyses of locating Mesolithic settlements.

1.3 Background

1.3.1 Development of the Baltic Sea

The development of the Baltic Sea can be divided up into four stages which are shown in figure 2; Baltic Ice Lake at 14,500 – 11,600 cal. BP (calibrated Before Present), Yoldia Sea between 11,600 – 10,700 cal. BP, Ancylus Lake, 10,700 – 9700 cal. BP, and Littorina Sea spanning 9700 to present time (Berglund and Sandgren 2010). It was during the Yoldia Sea stage when the Baltic Sea was lowered by 25 m, an event which is referred to as the Yoldia low stand. This event has been dated to around 11,560 cal. BP, which is very close to the start of the Mesolithic (Andrén et al. 2007). This drop in sea level can be seen in figure 2 which shows a tentative shore displacement (changing sea level) curve for the Blekinge area presented in Berglund et al. (2005). The second, smaller shore displacement curve situated directly above the larger one in figure 2 is a slightly more zoomed in version of the changing sea levels between 10,000 cal. BP to present day. The labels A, B, and C highlight three distinct transgressions that occurred. The regressions and transgressions that will be incorporated into this study will be from 11,600 cal. BP. onwards, meaning that the information before this time is not of interest. So, all the bathymetry data that is below -20 m depth will not relate to Mesolithic settlement as the landscape would have already been submerged by this time.

The sea level changes seen in figure 2 occurred due to extending and retreating glaciers. Ice ages and glaciers have an effect on global sea levels, which is today still an important issue relevant to the location of Mesolithic settlements. About 20,000 cal. BP, at the end of the last glacial period, sea level was about 120 m lower than the present coastline due to large amounts of water that were bound in the continental ice sheets (Berglund and Sandgren 2010).

The sheer weight and pressure from glaciers makes the land sink, so when this ice melted the land slowly began to rise again; a process which is called isostatic rebound (Berglund and Sandgren 2010). This effect is still occurring today across Fennoscandia, with the largest rates of uplift reaching 8 mm/yr in central regions of the Baltic Sea. It is however debated whether all of this uplift is caused by isostatic rebound (Fjeldskaar et al. 2000).

The Weichselian ice sheet reached its maximum extent around 20,000 cal. BP. The deglaciation of this ice sheet lasted from 18,000 – 9,000 cal. BP. However, since the ice sheet extended further than just across Sweden, the ice covering Sweden began retreating around 14,000 cal. BP and only fully retreated from the north of Sweden at about 9,000 cal. BP. It was close to 12,700 – 12,600 cal. BP when the ice sheet had retreated completely from the region which is now called Blekinge (Wastenson and Fredén 2009).

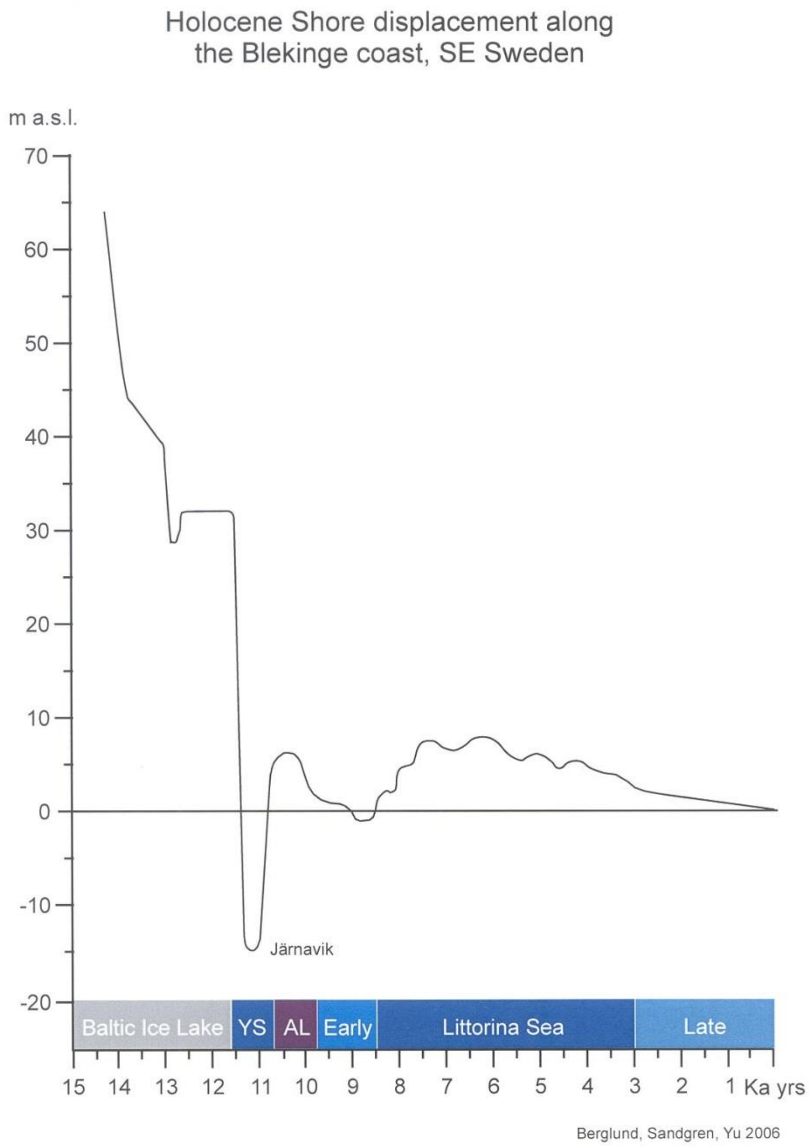


Figure 2. A tentative shore displacement curve for the Blekinge area showing the regressions and transgressions that have occurred (Berglund et al. 2005)

1.3.2 The Mesolithic, 11,600 – 6000 cal. BP.

The Mesolithic was a time period stretching from 11,600 - 6000 cal. BP and the ages of the settlements found within this time period seem to be related to the retreat (deglaciation) of the Weichselian ice sheet as the earliest settlements found were established less than a thousand years after this retreat (Bergman et al. 2003). The early Mesolithic is characterised by hunter-gatherer communities, which transitioned into farming communities at the start of the Neolithic (Sorensen and Karg 2014). Many moved settlements multiple times due to seasons or extreme changes, such as land uplift. Many coastal settlements served as base settlements to move to after relocating due to such changes (Wastenson and Selinge 1994).

Inflows and outflows from lakes and rivers are places where fishing opportunities would have been at their best, along with hunting game such as deer, making these areas interesting to study from an archaeological point of view for the possibility of finding Mesolithic remains or signs of settlements (Wastenson and Selinge 1994).

Other studies done in the same region have suggested three beneficial characteristics of the land, which in combination could suggest locations for Mesolithic settlements. These are: protection from cold winds, most available sunlight and a flat landscape, along with availability to food (Törnqvist 2012). Of course, there are other aspects which should also be considered, such as food availability/security. Since these settlements are close to the coast, it is plausible that fishing would have been an input as a food source (Fischer 1995).

1.3.3 Study area

The appropriate study area should include rivers and their connection with coastal areas that have become submerged since the Mesolithic period. The area should also contain evidence for previously discovered Mesolithic settlement sites. The three rivers that are studied in this report are Bräkne, Ronneby and Vieryd, which are located in Blekinge in the south of Sweden. Figure 3 outlines the study area with these three rivers and the present day coastline on the elevation and bathymetric data.

Figure 3 also depicts places where either signs of settlements or other archaeological discoveries have been made, mostly from the Mesolithic. The white dots represent the locations of these, and figure 3 shows that many of these discoveries are concentrated around the Ronneby river. Whereas most of these finds have been connected to the Mesolithic and provide accurate information about settlement locations, some of the finds are also connected to later time periods.

Geological research in Blekinge started as early as 1882 by Gerard De Geer, who wrote about what later became known as the Yoldia regression. Archaeological research has also played an important role in reconstructing beach displacement through the locations of Mesolithic settlements on the sea bank (Berglund and Sandgren 2010).

To actually identify potential Mesolithic settlement locations, hypotheses from two papers that look into this will be implemented. The first hypotheses is from Törnqvist (2012) who states that beneficial landscape characteristics for Mesolithic settlements include: protection from cold winds, availability of sunlight during the day and flat ground. The second hypotheses considered is from Fischer (1995), who suggested that settlement locations could be affected by fishing patterns as fish formed a major part of the Mesolithic diet.

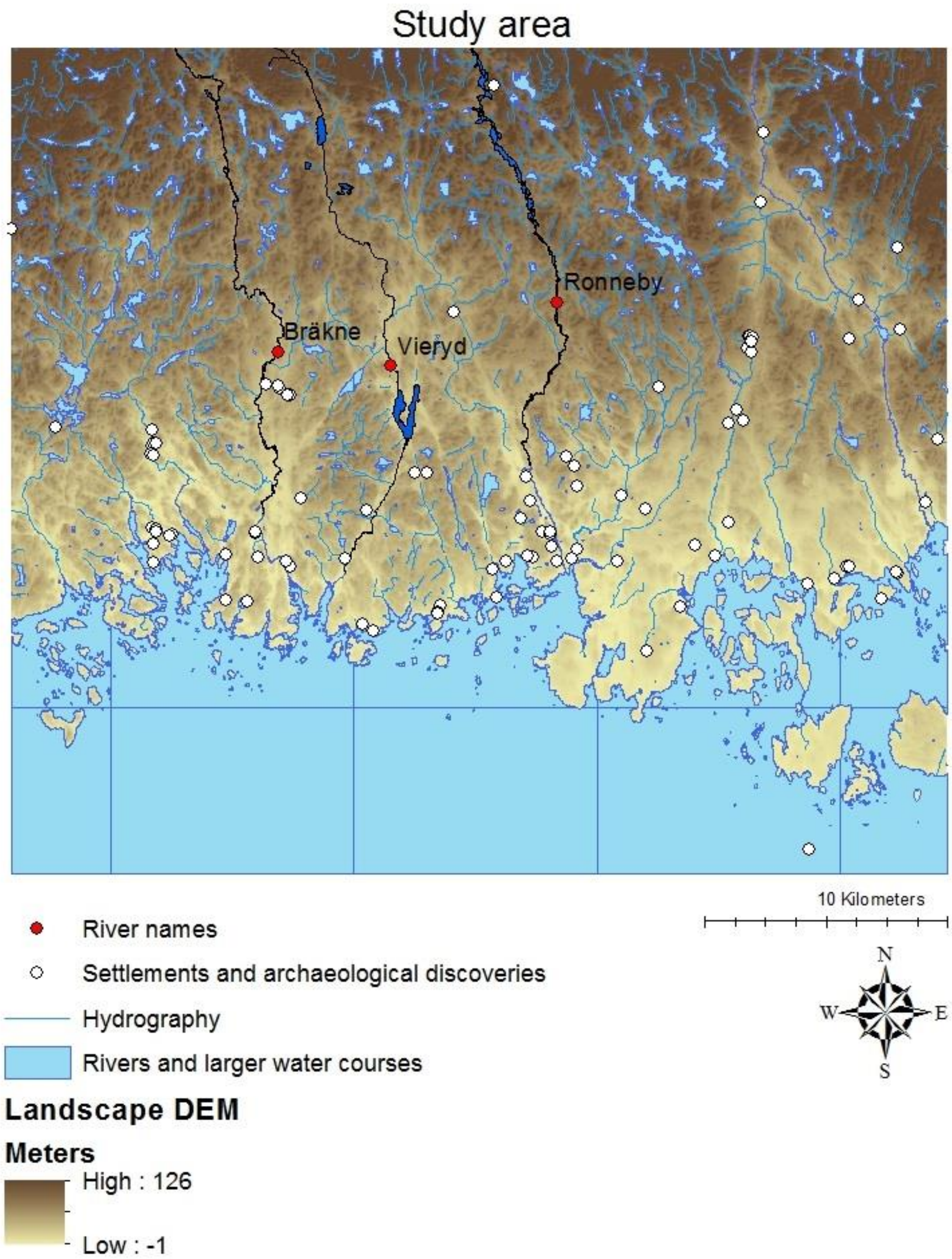


Figure 3. The study area, depicting the locations of the three rivers of interest: Bräkne, Vieryd and Ronneby along with the landscape elevation. The white dots represent previously identified Stone Age settlements and other archaeological finds in the region

2. Methods

This section will describe and explain how the results were created from the data used. The software used for all data preparation is ArcGIS.

2.1 Data

The data that has been used in this study are shown in table 1.

Table 1. The data utilized

Data				
File	**Type**	**Description**	**Geometric resolution**	**Source**
djup_wgs2	raster	bathymetry of Scania	10x10 m	Björn Nilsson
dem_6213128_495896	raster	landscape digital elevation model	2x2 m	Lantmäteriet
hl_get	shapefile	hydrography		Lantmäteriet
mv_get	shapefile	rivers and larger water courses		Lantmäteriet
FMIS_Blekine_L_SWEREFF_point	shapefile	point layer with Mesolithic settlements		Riksantikvarieämbetet

The simplest form of bathymetry is made through “sounding” the seafloor using a rope with a rock tied to one end. Thanks to technological advances, this technique has been replaced with Singlebeam Echo Sounders (SBES) and Multibeam Echo Sounders (MBES). These both work in a similar way by using swath mapping sonars, apart from that the SBES only uses a single beam and the MBES uses a narrow fan of ‘multiple beams’ which map the seafloor (Demoustier and Matsumoto 1993).

The collected depth data are often presented in the form of nautical chart rasters. Due to their schematic nature, they are of high enough quality to use for safe navigation of ships. From an archaeological perspective, nautical charts have been a source of depth data needed, but are not always of high enough quality for archaeological requirements. However, no matter the qualities of the geometric resolution, they provide vital data that can be combined with other databases and techniques to identify Mesolithic settlements (Maritimarkeologiska forskningsinstitutet 2014).

In this study, Digital Elevation Models (DEMs) were used to identify and analyse past and present river networks. Information about the drainage networks were extracted from the DEMs since this should show the water courses where the water is transported from a higher elevation to a lower elevation (O'Callaghan and Mark 1984). Two DEMs in the form of rasters were utilized in this study. These are the landscape DEM for the landscape up to the current coastline. The bathymetry DEM has all the submerged elevations, that is, all the elevations below the sea level (0 m) in the study area. The details of these two DEMs are shown in table 1.

The archaeological data for existing Mesolithic settlements were extracted from the Riksantikvarieämbetet Fornsök database (Riksantikvarieämbetet 2015).

2.2 Data preparation

The D8 flow accumulation algorithm available in the ArcGIS software was selected to reconstruct past river flows in the study area. However the landscapes looked at in this study are now submerged and flow direction and flow accumulation functions in ArcGIS do not work with negative elevation values, so it was necessary to recalibrate the submerged bathymetry data by lowering the datum reference elevation to remove all negative values.

Data preparation was carried out in several steps before application the flow accumulation algorithm could be used to reconstruct the past river flows properly. Figure 4 shows a flow chart of how the data were prepared to reconstruct the three rivers.

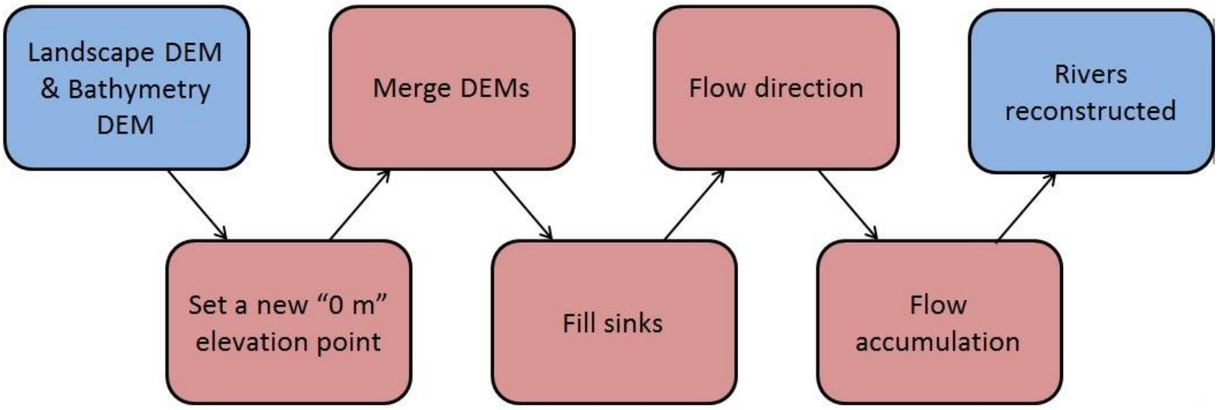


Figure 4. A flow chart of how the data was prepared before the river reconstructions could be done

2.2.1 Setting a new "0 m" elevation point

In order to merge the two raster layers from the landscape and bathymetry DEMs, the elevation data had to be recalibrated. The bathymetry DEM is made up mostly of negative values since it shows the elevations below sea level, whereas the landscape DEM shows the elevations above sea level.

To remove the negative values a new "0" m level was set in all the elevation data, by changing the lowest elevation value to 0 m. The lowest value in the bathymetry DEM is -47.8 m which then became the new 0 m. This was done by adding 47.8 m to all the other elevation values for both raster layers changing the highest elevation value of 126.58 m on the landscape DEM to 174.38 m.

2.2.2 Merging the DEMs

The two DEMs had to be merged, as to accurately reconstruct river paths in the bathymetry DEM, their paths on the landscape DEM had to be taken into account. It was important to merge these layers for the flow accumulation function to work properly.

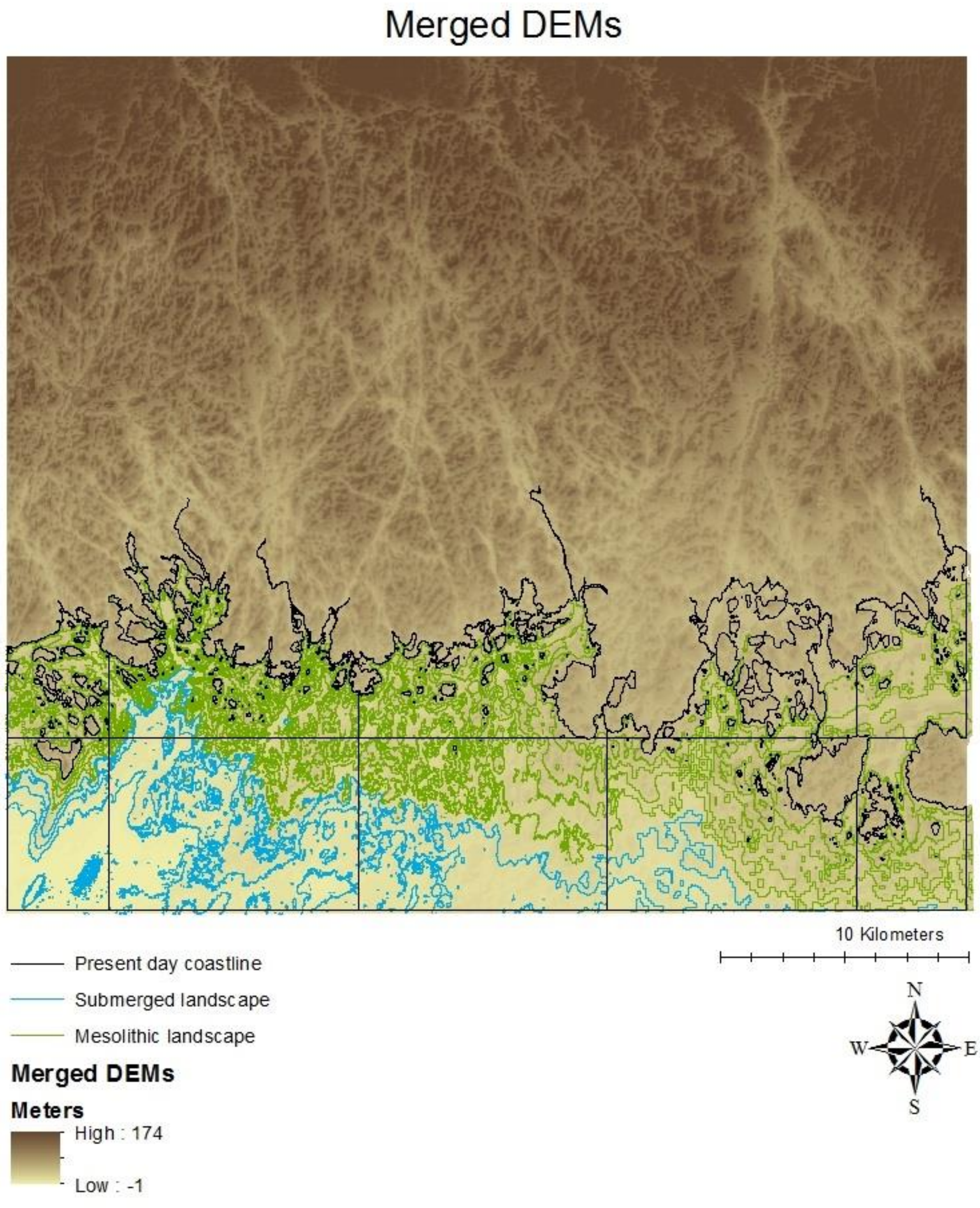


Figure 5. The results of merging the landscape DEM with the bathymetry DEM after the elevations have been altered. The black line represents the present day coastline, the green lines represents the terrestrial Mesolithic landscape, and the blue lines

Figure 5 shows what the DEMs look like after their elevations have been altered and then merged. When the layers were merged, the coastline elevations from the bathymetry DEM were used. The green contour lines in this figure represent the landscape that would have been above sea level during the Mesolithic; which is above -20 m in this study. The blue contour line represents the older landscape which is below -20 m depth, roughly where the Mesolithic coastline would have been located.

2.2.3 Filling sinks

Almost all DEMs are affected by sinks, which are small topographic depressions lacking outlets. These sinks can both be single cells or a combination of cells with elevations lower than the neighbouring cells. The problem with this when trying to calculate flow accumulation these depressions can disrupt the direction of flow, which can lead to inconsistencies and incorrect results. This happens when the flow accumulation is calculated as the water will get trapped in the sink (Arnold 2010). Many of the sinks found in such data are as a result of mistakes that were created when the data was interpolated. However, some of the depressions can also be actual features, such as grottos, present on the DEMs, although this is mainly an issue in karst landscapes and is not so relevant for the present study area (Zhu et al. 2006).

One way to solve the problem of sinks is to use the function “Fill” in ArcGIS. This function raises the heights of all the cells in the depression to match that of the minimum height present in the neighbouring cells (Arnold 2010).

2.2.4 Flow direction

Once all the sinks had been filled, the flow direction tool in ArcGIS was implemented. One of the most commonly used flow direction algorithm was created by O’Callaghan and Mark (1984), which is used in soft wares such as ArcGIS (Schäuble et al. 2008); the software that was used in this particular study as well. The algorithm works with a 3x3 cell window and directs flow to one neighbouring cell of eight along the steepest elevation gradient. The algorithm also identifies points where flow is sufficiently concentrated for fluvial processes to dominate over slope processes (O'Callaghan and Mark 1984).

Flow direction is an important function since it looks at how the downhill flow path of water is affected by the flow direction until the water reaches the drainage divides, which is when the function sums up the values of the raster cells that were identified in the flow path (Schäuble et al. 2008).

2.2.5 Flow accumulation

Flow accumulation algorithms are used to predict how water might flow across a landscape using the weight information of each cell. There are two fundamental groups of algorithms that were created to calculate this; the single-flow (D8) algorithms and the multiple-flow algorithms such as FD8 (Schäuble et al. 2008).The D8 algorithm is called single-flow since it calculates water flow by transferring the contents of one cell into the deepest neighbouring cell; only showing single flow directions. The FD8 algorithm however transfers the contents of a cell into a lower neighbouring cells after calculating their weights and determining how much should flow into each cell (Schäuble et al. 2008). This study focuses on the single-flow D8 algorithm.

In ArcGIS the D8 model was implemented, and this was the algorithm used to reconstruct the submerged rivers in the study area. This produced a new raster layer with thousands of river networks.

2.2.6 Digitising

Since the flow accumulation produced so many small and large river networks, it was deemed necessary to digitize the main rivers to try and visualize them better. With the flow accumulation raster layer, it was almost impossible to see the river networks without zooming in – which then made it difficult to see any of the other information on the map, such as which river you were actually looking at. Therefore, the threshold values on the flow accumulation values were altered so that the main rivers could be identified. These rivers were then digitized into a new polyline layer. This was purely done to better visualize the data on the large scale maps. Some detail from the flow accumulation is lost in this new digitized layer but the channel locations are retained which are important features in this study.

The original flow accumulation figures without the simplified digitized lines can be found in the appendix I.

2.2.7 Aspect, contours and slope

Finally, the aspect function was used to determine the slope direction of the region. Creating aspect maps allows analysis of the amount of solar radiation that is received in cells and which places are more affected by specific wind directions. What aspect does, is determine the downslope direction of the maximum rate of change in elevation from each cell to its neighbours giving the compass direction of the slope (E.S.R.I. 2001). Such maps will be relevant to this study as they could help determine the location of settlements depending on how well protected areas are from the wind, amongst other things. This function was used to analyse the sun and wind exposure with consideration to the slope direction which is included in the analysis of where settlements might be found.

The slope function was used to identify the maximum rate of change in a slope from each cell to its neighbouring cells and provides the gradient (degree) of the slope (E.S.R.I. 2001).

Contours were created to show elevation changes. This function creates a polyline where each line represents all contiguous locations with the same elevation (E.S.R.I. 2001).

2.2.8 Selected Mesolithic settlements already identified in the study area

In order to identify potential settlement locations in the Mesolithic landscape, it is first important to try and identify the landscape characteristics that might have an effect on where such settlements were located. In order to achieve this, four already identified sites for Mesolithic settlements were chosen and analysed. Since the potential Mesolithic settlements suggested in this report are in close proximity to either the Bräkne, the Ronneby or the Vieryd river, the four already identified settlements were also selected in close proximity to these. The settlements have been given the labels 1, 2, 3, and 4. Settlements 1 – 3 are in close proximity to the Ronneby river and settlement 4 is in close proximity to the Bräkne river.

2.2.9 Selected areas – identifying Mesolithic settlements

After all the data had been prepared, four regions were selected to conduct specific settlement analyses on. Two of these regions are in the Ronneby area and the other two are in the Bräkne and Vieryd area.

The areas that were selected for analyses to see if a Mesolithic settlement may be found were chosen during a meeting with archaeologist Björn Nilsson (oral communication 25/4/2015), who gave insights as to where the settlements are most likely to be located. Two are located close to today's coastline (areas 1 and 3) and the other two (2 and 4) are located a 2-3 kilometres south of settlements 1 and 3, slightly further away from the coast.

To actually identify potential Mesolithic settlement locations, established characteristics for Mesolithic settlements including; protection from cold winds, availability of sunlight during the day and flat ground were used (Törnqvist 2012). When considering the protection from cold winds, north facing slopes would be the ideal location since the prevailing winds come from the south-southwest (Törnqvist 2012). In terms of availability of sunlight, southeast and south facing slopes are likely to be the most beneficial as they are in a position to receive morning sunlight and the most sun during the day. This also means, however, that the slopes that receive most sunlight will be exposed to the prevailing winds. Generally flat landscapes would be good for building the settlements, but other elevation characteristics must also be considered – such as the occurrence of isolated vantage points. Vantage points would make it possible to for example scope out the surrounding landscape for animals when hunting. Table 2 shows the three functions (elevation being the contours) and the reasons as to why they are accounted as beneficial characteristics for a Mesolithic settlement as suggested by Törnqvist (2012).

Table 2. The beneficial characteristics for a Mesolithic settlement, along with the attributes of these characteristics and the reason why they are beneficial

Beneficial landscape characteristics for a Mesolithic settlement		
Characteristic	**Beneficial attribute**	**Reason**
Aspect	South facing	Most sun during the day
	Southeast facing	Morning sun
	North facing	Protection from prevailing winds
Elevation	Level landscape (same elevation)	
	Close to a vantage point (high elevation)	Scope out surrounding landscape
Slope	Level landscape	Small gradients (degrees)

These characteristics were taken into consideration, along with the fishing potential as many Mesolithic settlements have been found close to present day locations renowned for large salmon catches or other spawning and seasonally accumulating fish (Fischer 1995). The topographical characteristics that are linked to potential fishing sites are presented in table 3.

Table 3. The characteristics of the Fishing site location model as proposed by (Fischer 1995)

	Fishing site location model
	Characteristics
1	Along a narrow inlet connecting large water surfaces
2	Along a narrow inlet between an island and a mainland
3	On the tip of a headland
4	At the mouth of a larger stream or river

The submerged selected settlement locations that were used for the identification of potential Mesolithic settlements were chosen by analysing the selected areas and selecting two or three locations that seemed to meet the beneficial characteristics and fishing site location model presented above.

3. Results

3.1 The river reconstructions

The main river lines were digitized and they are represented as the blue lines in figure 6. In this figure it is also possible to see a confluence between the two rivers Bräkne and Vieryd. The original, non-simplified flow accumulation results can be seen in appendix I.

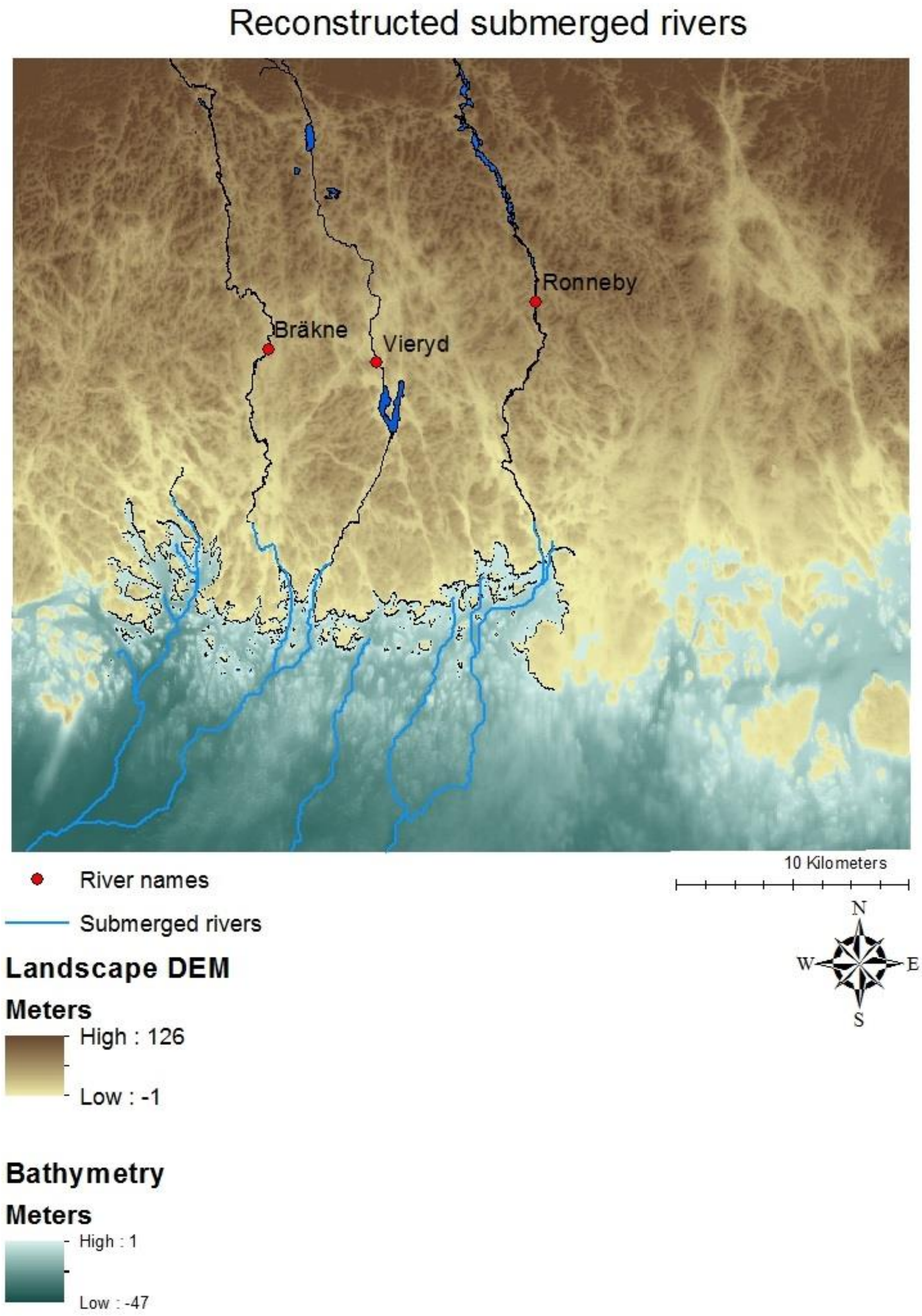


Figure 6. The reconstructed submerged rivers

3.2 The selected Mesolithic settlements already identified in the study area

As mentioned earlier, in order to suggest potential settlements in the Mesolithic landscape, it is important to identify reasons why settlements would be located in certain areas. Figure 7 shows three already identified settlements that are in close proximity to the Ronneby river. These settlements are not securely dated to the Mesolithic, but the descriptions of the findings at the sites suggest that they from the Mesolithic. Settlement 4 (figure 8) shows the fourth Mesolithic settlement which is in close proximity to the Bräkne river.

Figure 7. The locations of the already identified Mesolithic settlements. The settlements have been numbered from 1 through to 3

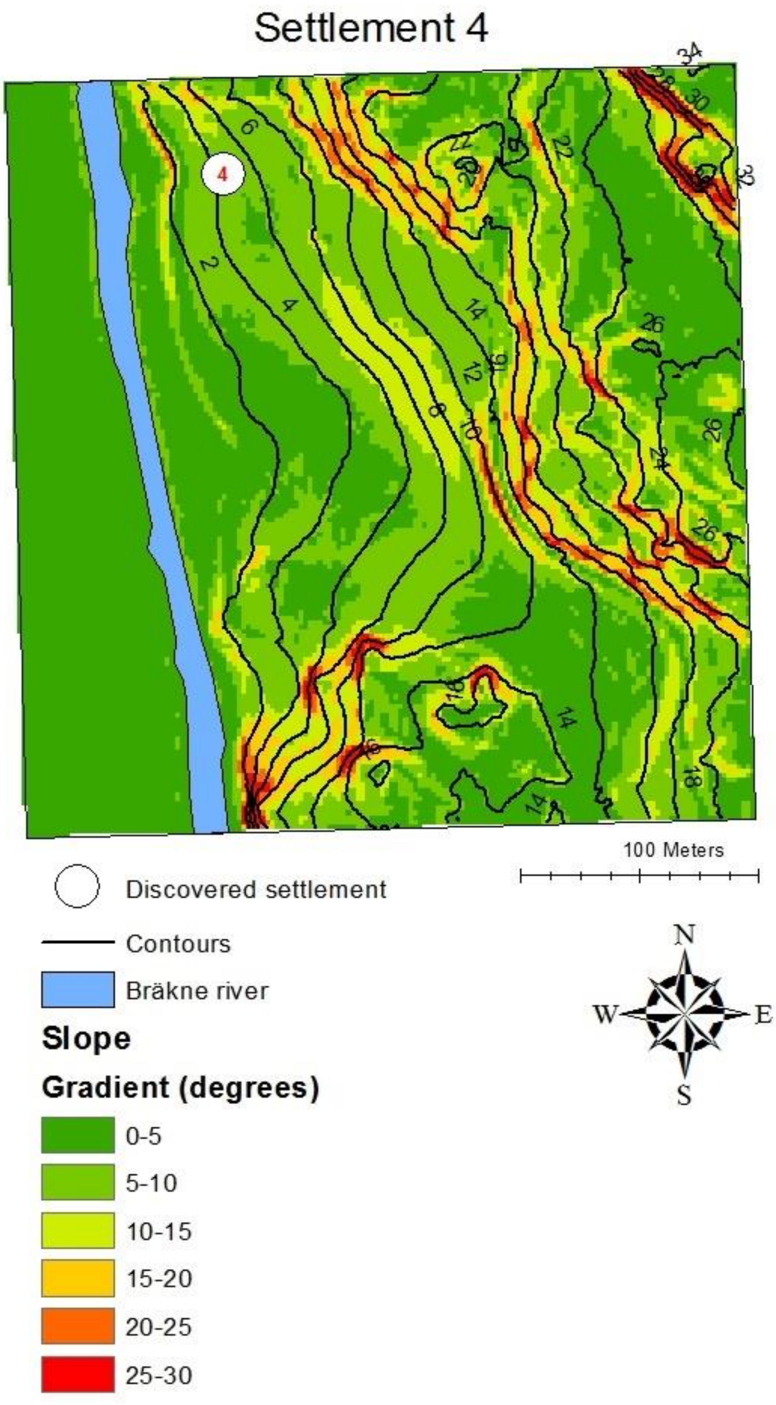


Figure 8. The location of an already identified Mesolithic settlement. This settlement is numbered 4

The next series of figures will show the locations of these settlements on a smaller size scale to visualize the slope, contour and aspect information of each settlement.

3.2.1 Settlement 1

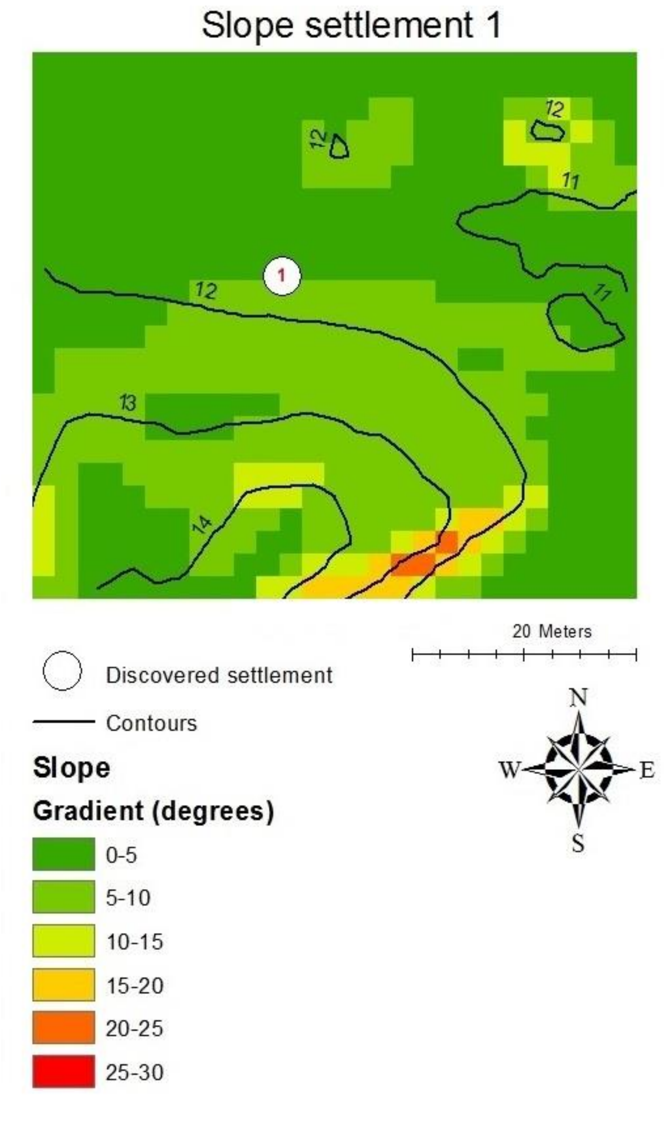


Figure 9. Slope for settlement 1

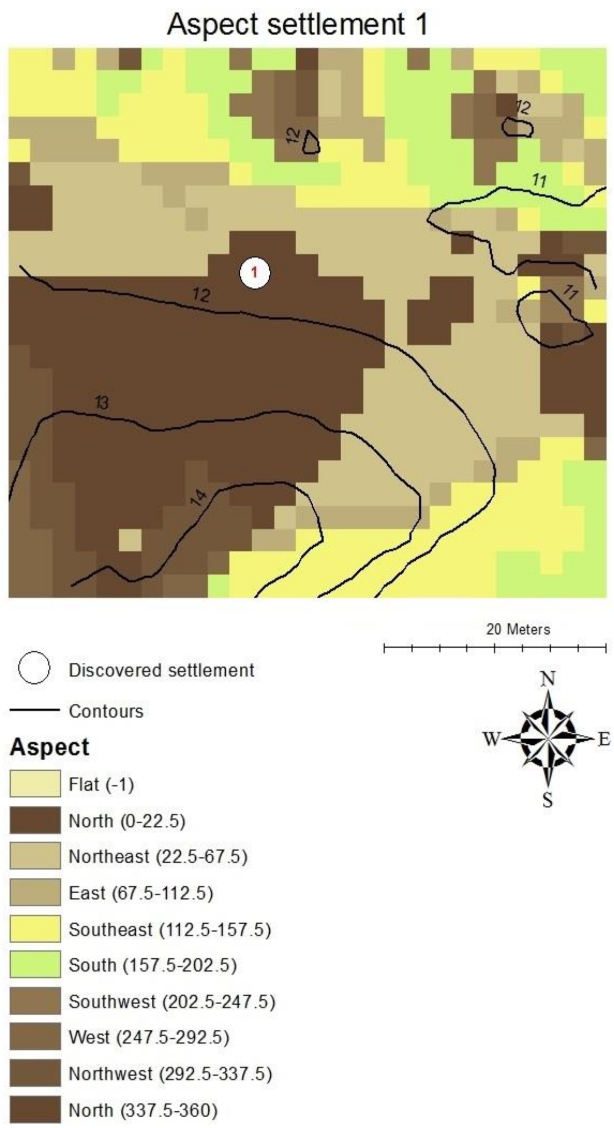


Figure 10. Aspect for settlement 1

Figures 9 and 10 depict the slope and aspect for settlement 1 respectively. The elevation data is also shown here as contours. The wide contours and small gradients seen in figure 9 suggest that this is a relatively flat landscape with a gentle slope when looking at the gradient of the mean slope here, which is 4.96°.

The aspect shows that this settlement is located on a north facing slope which provides protection from prevailing winds. There are also some sections with south-southeast facing slopes which means that this settlement would also have access to some sunlight, and not just protected from winds.

This settlement does not portray any of the characteristics proposed in the fishing site location model shown in table 3. It is however, close to a major river, the Ronneby, which could have been a fishing spot.

3.2.2 Settlement 2

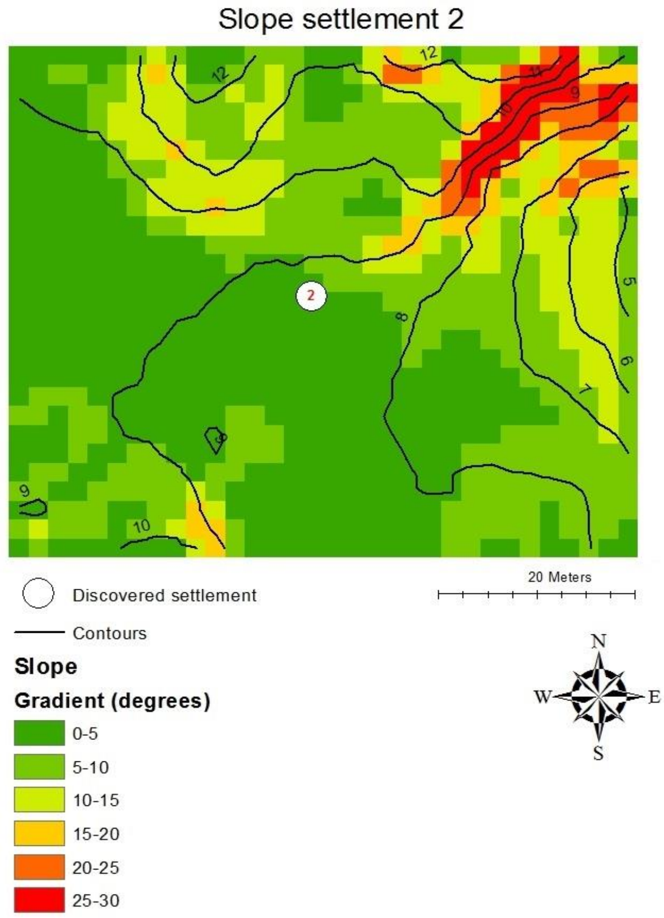


Figure 11. Slope for settlement 2

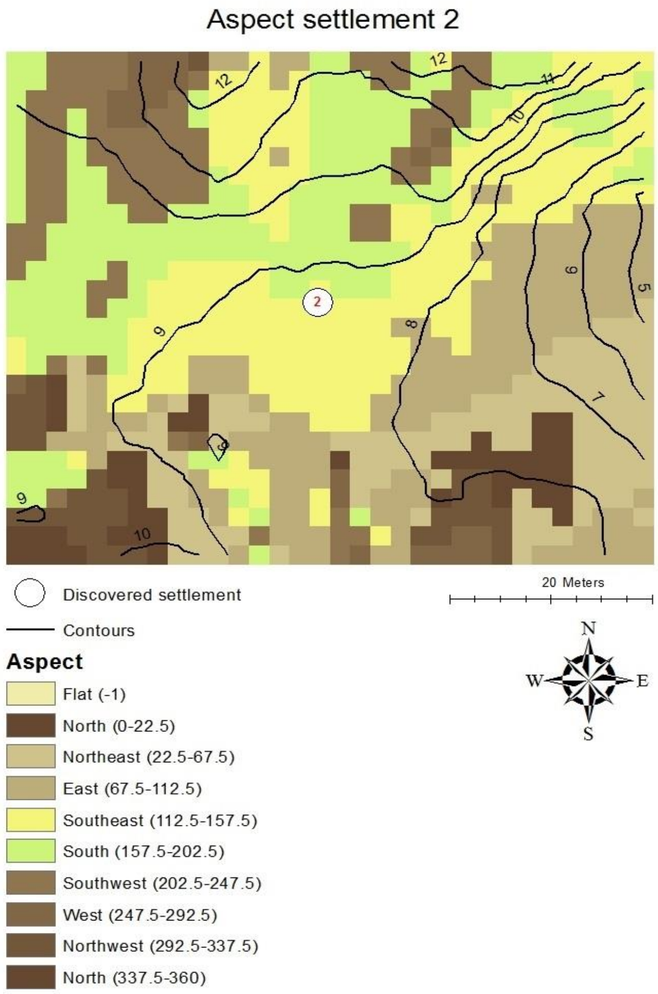


Figure 12. Aspect for settlement 2

The slopes in settlement 2 (figure 11) vary from steep slopes with gradients of 25° – 30° (the red sections) to gentler slopes with 0° – 5° gradients (the dark green sections). The contours in the sections with the steep slopes show an increase in elevation from 5 m to 12 m, supporting that this is indeed a steep slope. The top of this slope could potentially work as a close vantage point for the settlement, but the top of this slope at 12 m is not the peak of the whole hill, as can be seen in figure 7, which might suit better as a vantage point.

The slope directions that can be seen from the aspects (figure 12) show that this settlement is dominated by both south-southeast and east-northeast slope directions. The south and southeast slope directions allow access to sunlight, but there is little protection from the prevailing winds for this settlement.

Similarly to settlement 1 (figures 9 and 10) this settlement does not meet any of the characteristics mentioned in the fishing site location model, but it is also in close proximity to the Ronneby river.

3.2.3 Settlement 3

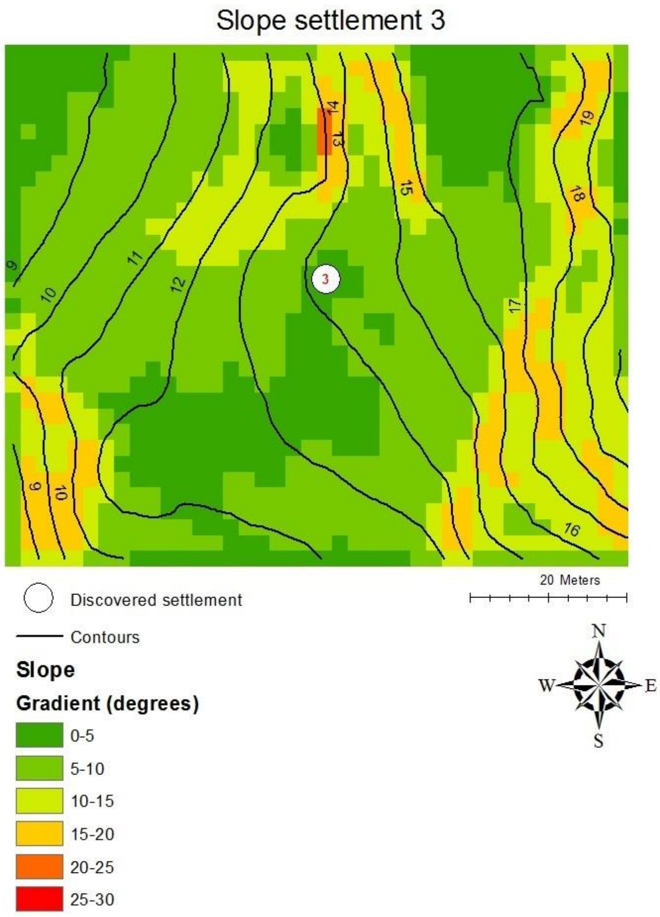


Figure 13. Slope for settlement 3

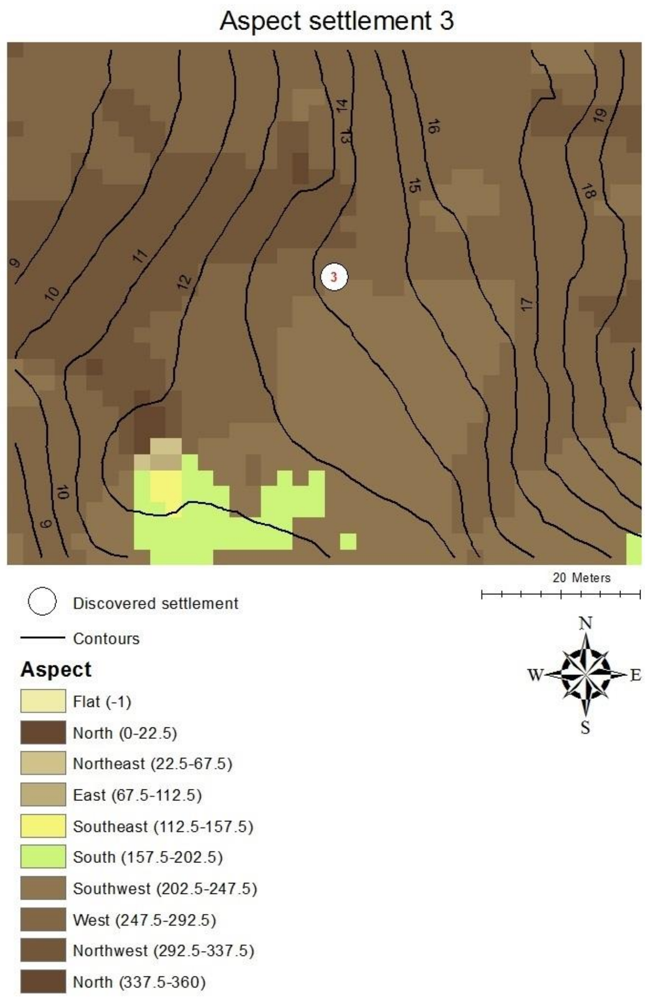


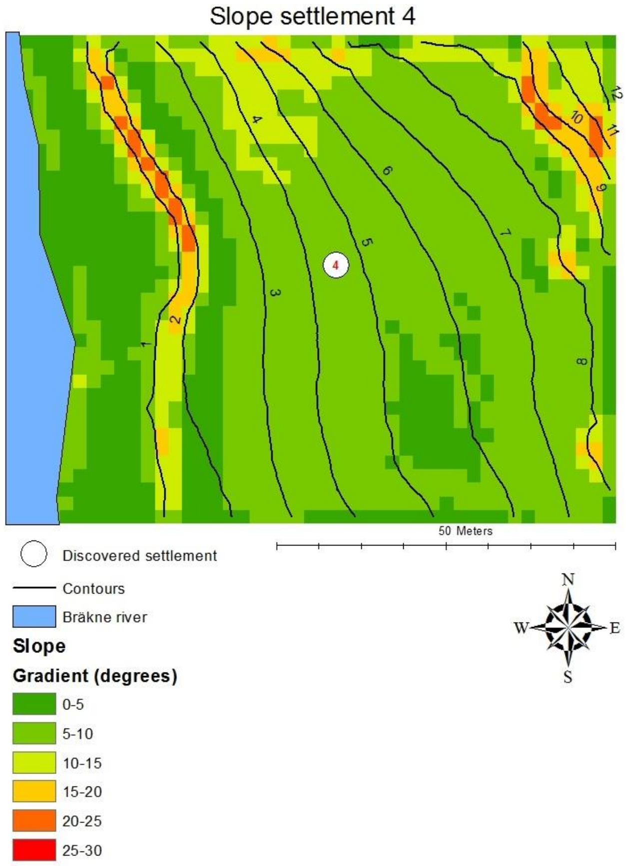
Figure 14. Aspect for settlement 3

The aspect shows that this settlement is located on a southwest-west facing slope (figure 14). This slope direction will not successfully protect the settlement from the prevailing winds, but it is a relatively sunny location. The mean gradient of this slope (figure 13) is 8.49° making this a somewhat gentle slope. This settlement is located on the slope of a small valley (which can be seen in figure 7) which could potentially have had a small creek, giving this settlement access to domestic water.

This settlement is located about 450 m away from the Ronneby river, meaning that this settlement is located furthest away from it when compared to settlements 1 and 2, but it is still within walking distance. So, it is possible that even for this settlement the same river could have been used for access to fish.

In terms of potential vantage points, this settlement is closest to the top of the hill (located on the downslope just west of the peak) which can be seen in figure 7. This peak would be a good vantage point for the surrounding landscape.

3.2.4 Settlement 4



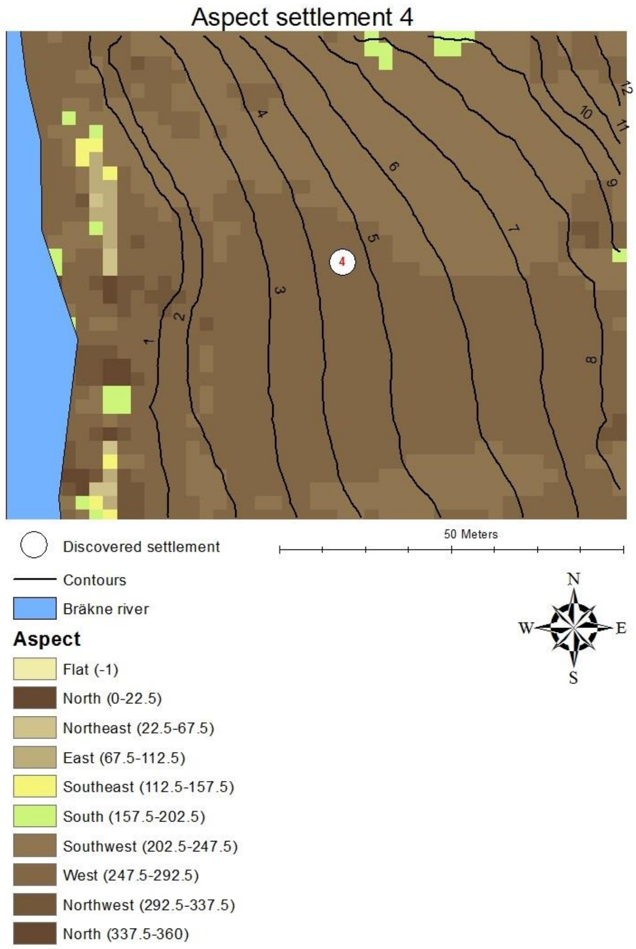


Figure 15. Slope for settlement 4

Figure 16. Aspect for settlement 4

Settlement 4 is located on a west facing slope right next to the Bräkne river. The gradient of this slope is mostly around 5° – 10° and the elevation rises from 0 m to 12 m (figure 15) which suggests that this settlement is not located on a flat landscape. Since the slope is west facing, there will be little protection from prevailing winds and not as much sunlight available as a south-southeast facing slope.

When looking at the surrounding area shown in figure 8, the top of the slope on which settlement 4 is located is not visible, but it is possible that this peak could be used as a vantage point.

Similarly to the other three settlements presented here, this settlement does not meet any of the characteristics presented in the fishing site location model in table 3. However, these four settlement sites are all further inland than the suggested Mesolithic settlement locations, which are presented next.

3.3 The submerged selected areas for identification of Mesolithic settlements

The locations that were selected for analyses of potential Mesolithic settlements can be seen in figure 17 where they have been outlined in red.

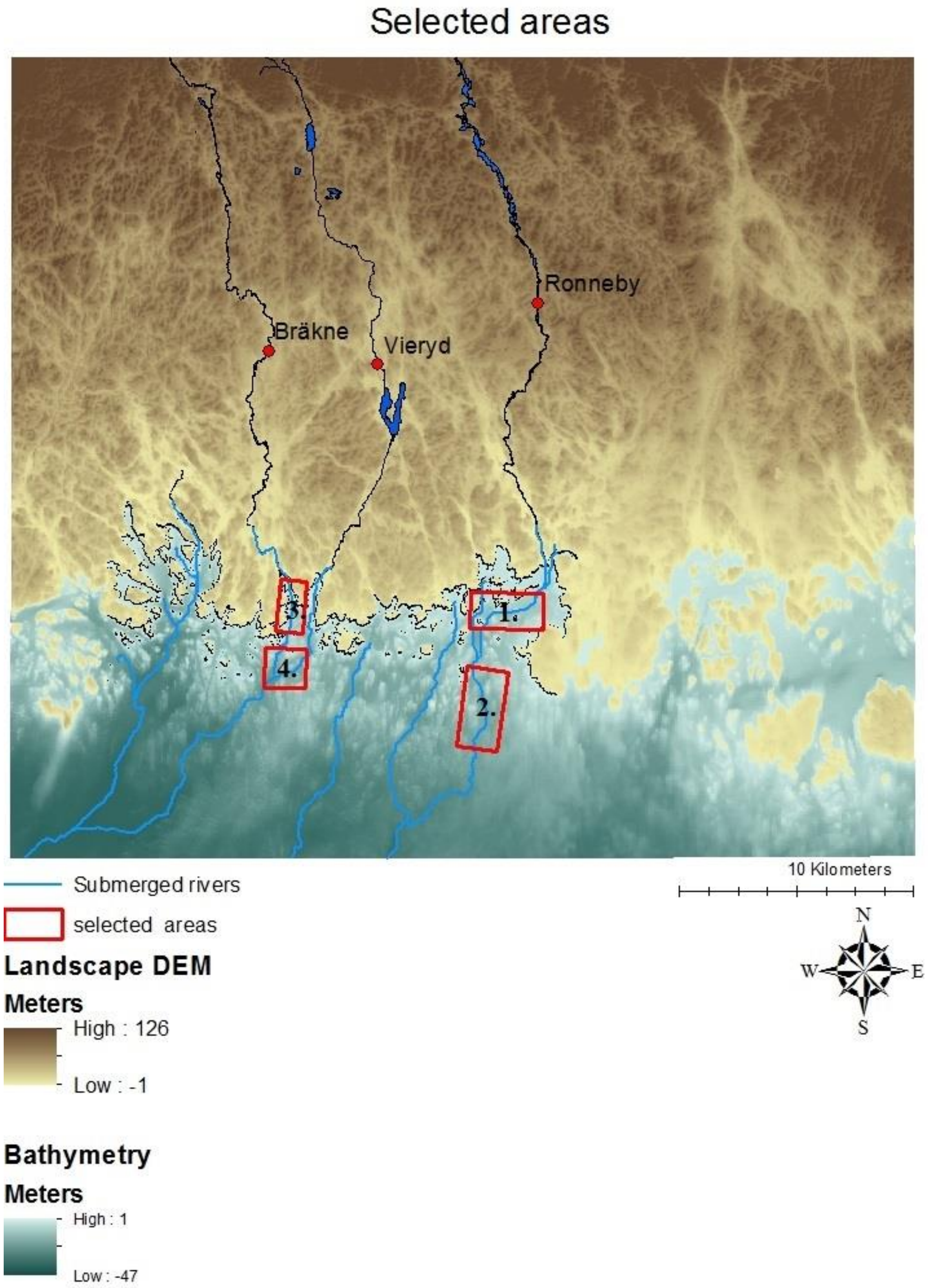


Figure 17. The selected areas for Mesolithic settlement analysis

3.3.1 Area 1

Area 1 is situated along the reconstructed river Ronneby close to today's coastline. Figure 18 shows the contours present here, which tell us the depth values. The red contour lines represent the depth values within the selected area. These values range from 0 m to around -12 m depth. The reconstructed submerged rivers can also be seen in this figure as light blue lines. As this is area 1, the main river that flows through here is the Ronneby river, which is the river to the right in figure 18. Another river can also be seen which further on joins Ronneby river, as can be seen in figure 17.

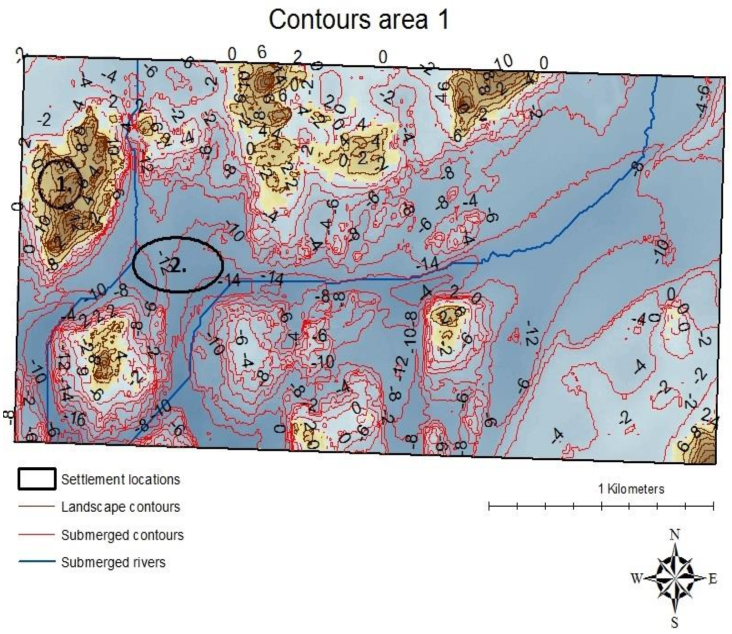


Figure 18. Contours for area 1. The red line symbolizes the contours. Suggested settlement locations are labeled 1 and 2

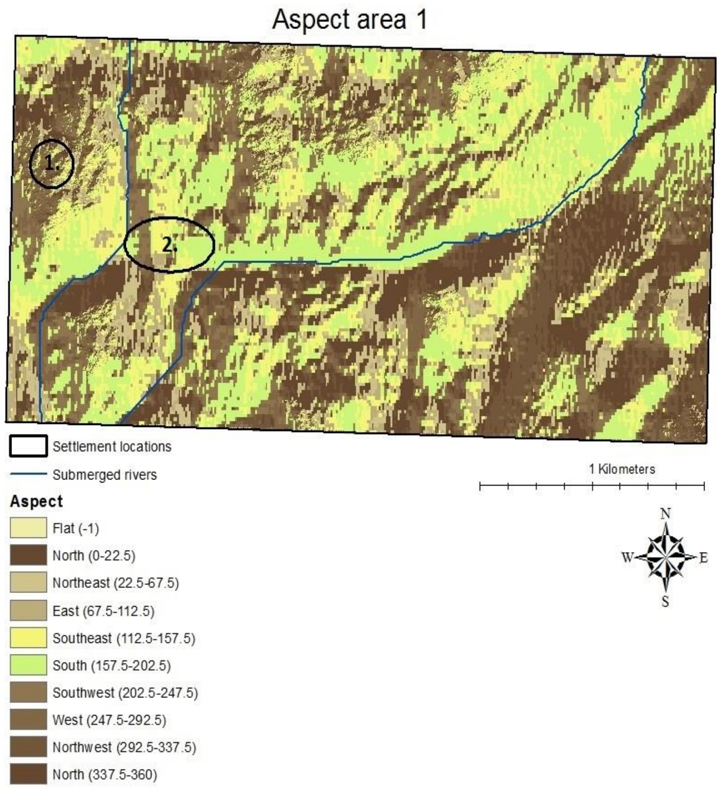


Figure 19. Aspect for area 1. Suggested settlement locations are labeled 1 and 2

Figure 19 next to the contours shows the aspect for area 1. The predominant aspects for this area are south and southeast facing slopes.

As for suggested settlement locations, these can also be seen in figures 18 and 19, which depict two potential locations for area 1, labelled 1 and 2.

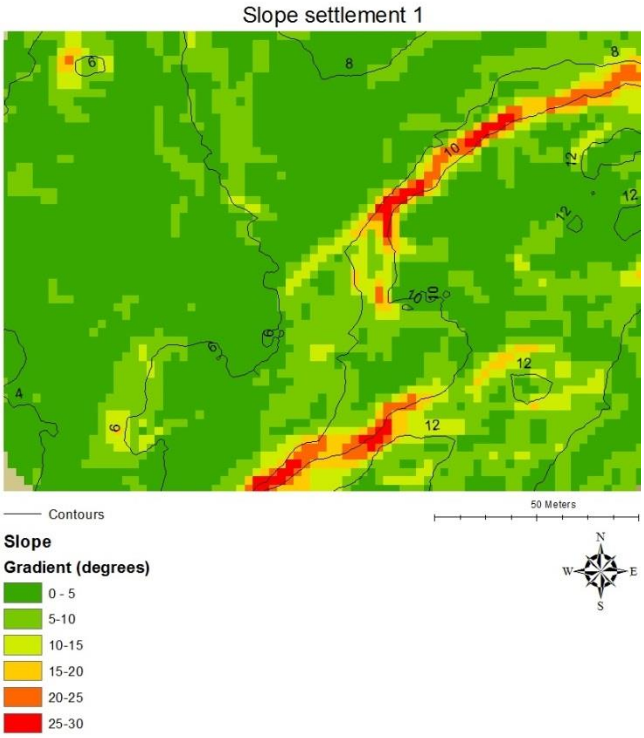


Figure 20. Slope for settlement location 1 in area 1

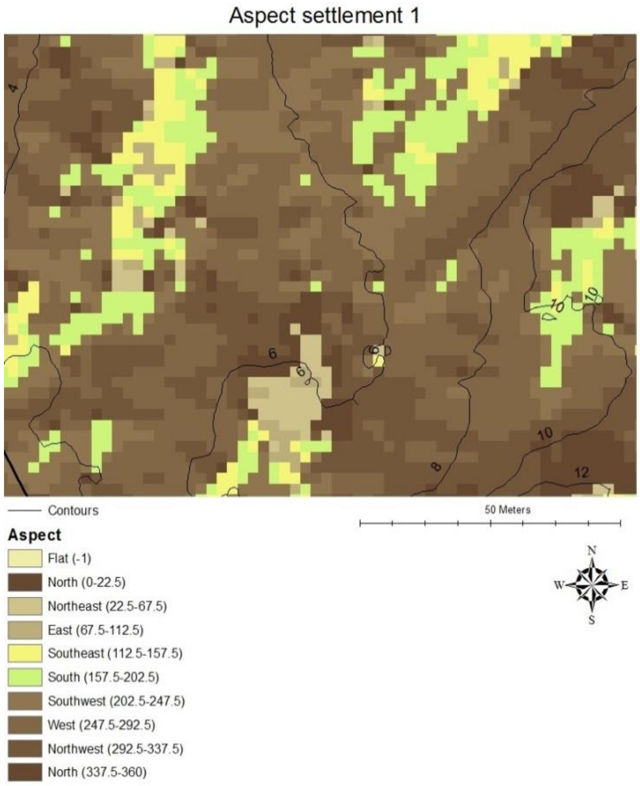


Figure 21. Aspect for settlement location 1 in area 1

Figures 20 and 21 visualize the slope and aspect in settlement location 1. The changing gradient does not suggest a particularly flat landscape, but the contour values do. The contours for the left half of settlement 1 are wide which suggest that the landscape here is somewhat flat. As for the aspect, this potential settlement is dominated by west and northwest facing slopes, with a few south-southeast facing slopes. The northwest facing slopes would provide slight protection from the prevailing winds from the south and southwest. The south-southeast facing slopes in this settlement will not be protected from the winds, but will instead allow more access to sunlight during the day.

The settlement 2 slope and aspect results for area 1 can be seen in figures 22 and 23. According to the gradients and the contours, this is a flat landscape since it is dominated by a 0 – 5° slope gradient. The aspect results show that most of this landscape is south-southeast facing, which is beneficial since it will receive large amounts of sunlight, more so than settlement 1 in this area.

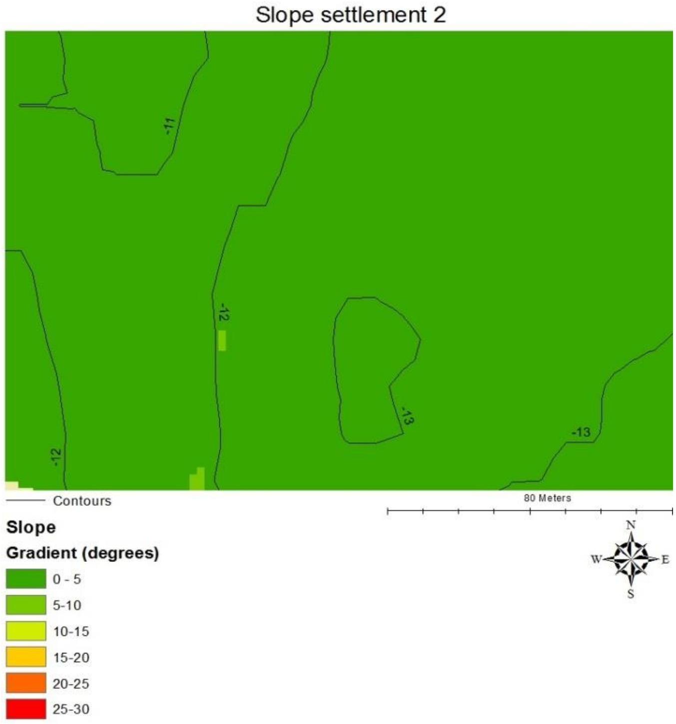


Figure 22. Slope for settlement location 2 in area 1

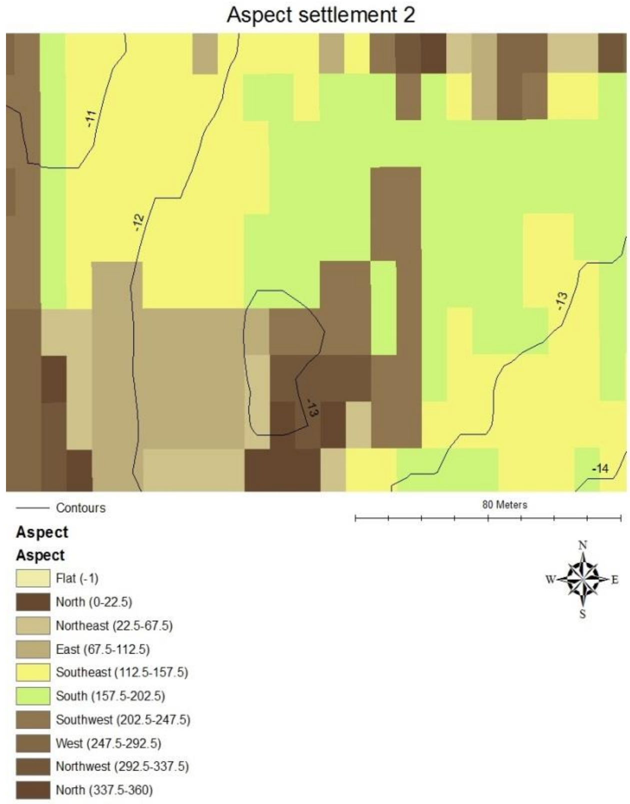


Figure 23. Aspect for settlement location 2 in area 1

3.3.2 Area 2

Area 2 is found slightly south of area 1, so further away from the coast. This area (figure 24) has overall lower elevations values when compared to area 1 which is slightly closet to the coastline. Here, the depth varies from around -4 to -20 m depth. The submerged river is the continuation of the Ronneby river, further downstream from area 1.

This area is divided up into 3 suggested settlement locations, which are labelled 1, 2 and 3 in figures 24 and 25.

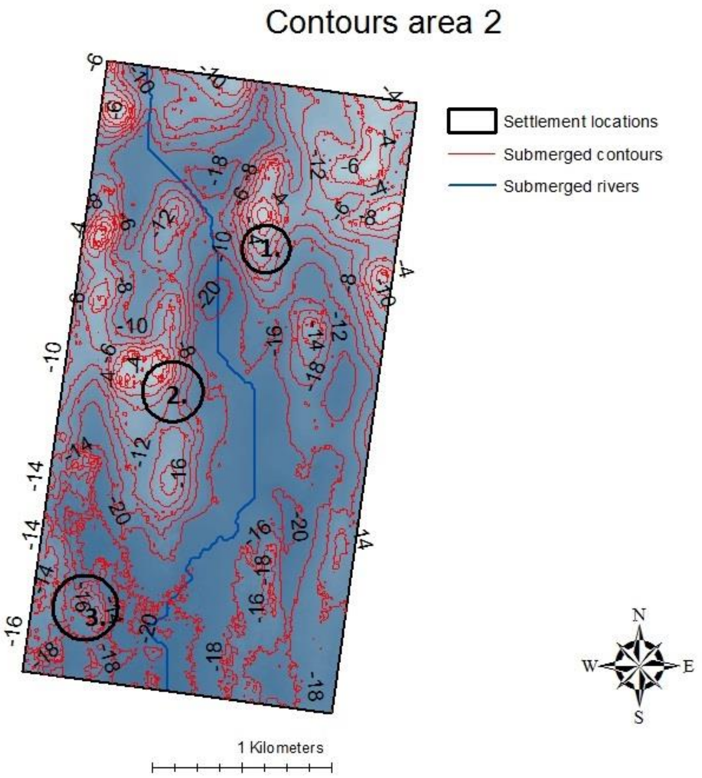


Figure 24. Contours for area 2. The red line symbolizes the contours. Suggested settlement locations are labeled 1, 2 and 3

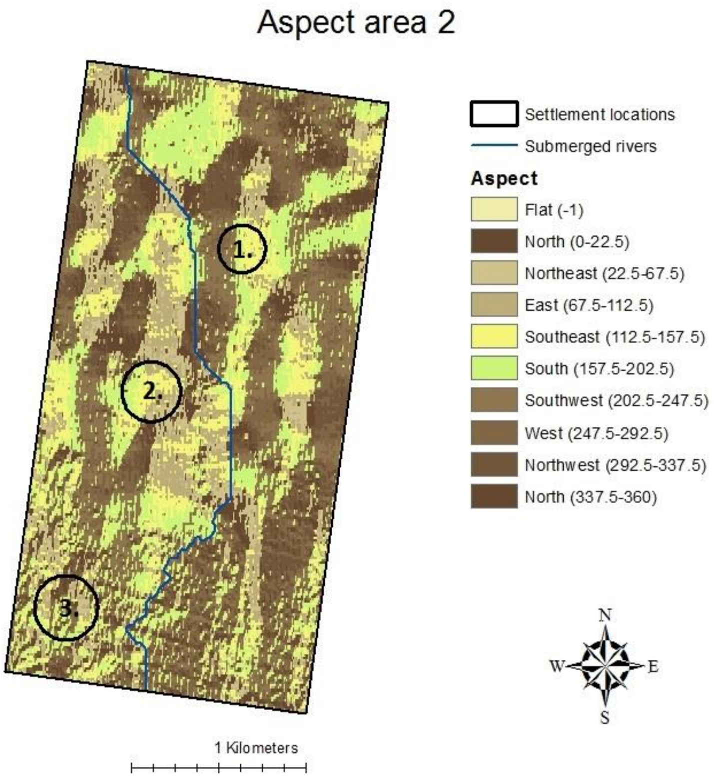


Figure 25. Aspect for area 2. Suggested settlement locations are labeled 1, 2 and 3

The slope and aspect for settlement 1 are depicted in figures 26 and 27 respectively. The elevations here change from -7 m to -12 m from left to right in the figures, and the gradient of this slope is between 0° and 5° which suggests a relatively flat landscape, corresponding to a beneficial characteristic presented in table 2.

The aspect results show that this slope is mostly south-southeast facing which means that this settlement would receive plenty of sunlight during the day, and matches one of the beneficial characteristics from table 2.

When looking at the location for settlement 1 in figure 24, the contours suggest that the settlement is located slightly south of a potential vantage point. There is a raise in elevation from -10 m to -4 m on the hill which settlement 1 is situated on.

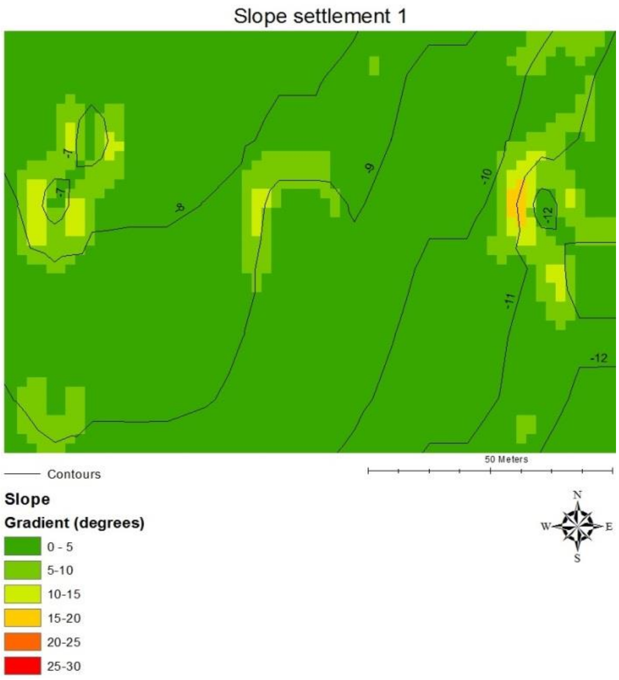


Figure 26. Slope for settlement location 1 in area 2

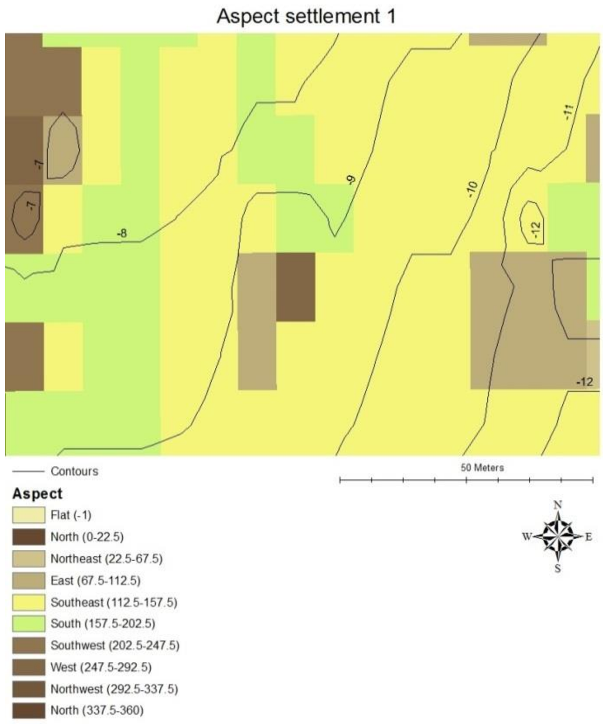


Figure 27. Aspect for settlement location 1 in area 2

The slopes in settlement 2 which can be seen in figure 28 follow the same pattern as settlement 1 (figure 26) and change from -7 m to -12 from left to right which can be counted as a gentle slope and a relatively flat landscape. Again, the aspect results (figure 29) here are dominated by south-southeast facing slopes which would allow for most access to sunlight during the day. However, since there are no north facing slopes, this settlement would have almost no protection against the prevailing winds from the south and southwest.

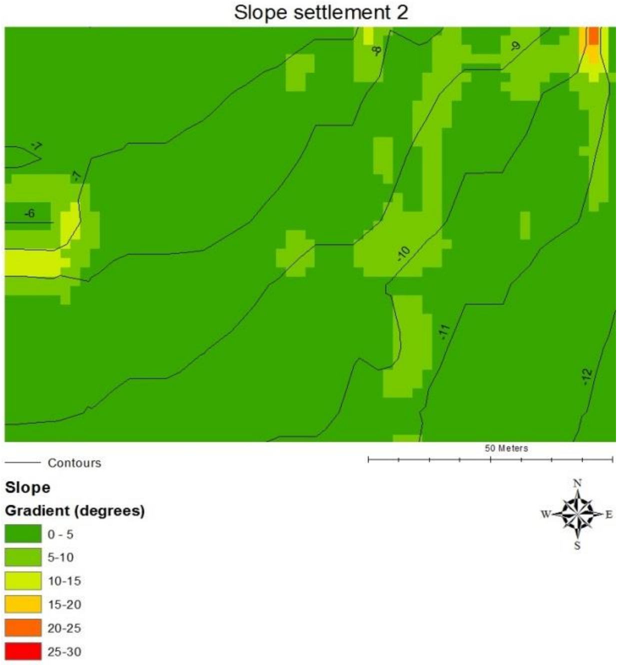


Figure 28. Slope for settlement location 2 in area 2

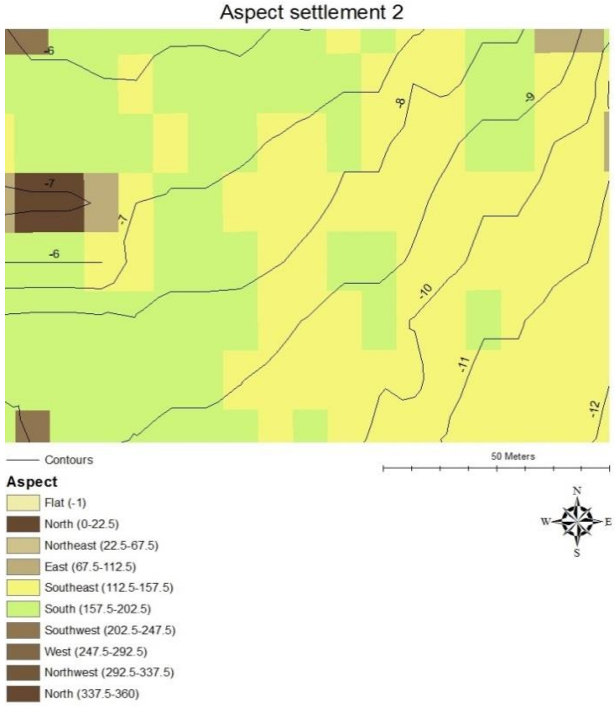


Figure 29. Aspect for settlement location 2 in area 2

Similarly to settlement 1 in this area, settlement 2 is also located on the slope of a raised area. The elevations here rise from -16 m to -4 m, and the peak could provide a vantage point for the surrounding landscape used by the settlement.

Settlement 3 can be seen in figures 30 and 31. In contrast to settlements 1 and 2 in area 2, this settlement has a somewhat gentler slope according to the contours which change from -17 m to -15 m, which can be seen in figure 30. This suggests that this settlement is in a flat landscape.

The aspect here is primarily a mixture of south, southeast and west facing slopes, with small east and northeast facing slopes. All these slope directions will affect the settlement by both providing protection from the prevailing wind from the northeast facing slopes, and providing access to sunlight from the south and southeast facing slopes.

Figure 30. Slope for settlement location 3 in area 2

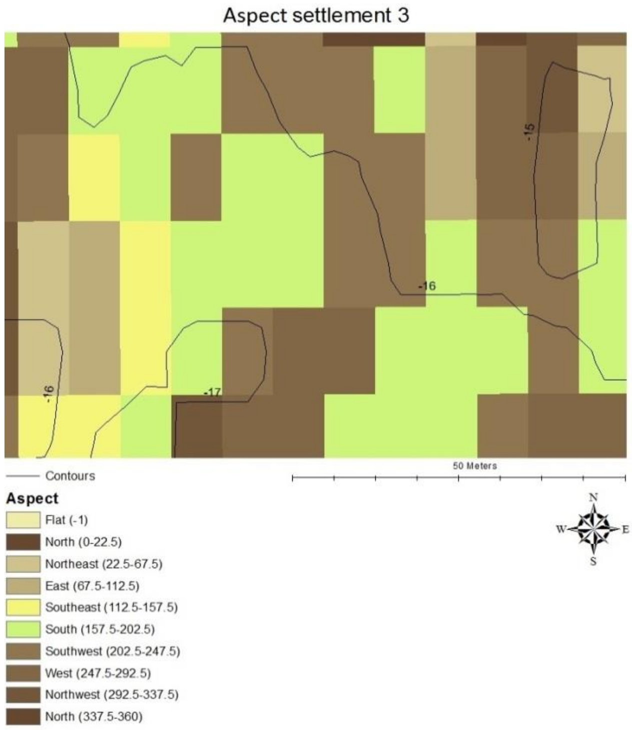


Figure 31. Aspect for settlement location 3 in area 2

3.3.3 Area 3

The contours for area 3 are depicted in figure 32 and range from 0 m to -12 m depth. Similarly to area 1, area 3 is situated close to the coast. Two submerged rivers are visible in the figure, Bräkne (left) and Vieryd (right), but only the Bräkne river runs through the box which represents the selected area.

Figure 33 shows the aspect for this area which varies a lot throughout this landscape. The dominating aspect directions are south, southwest and northeast.

The suggested settlements for this area are labelled 1 and 2. Both of these locations are situated close to the Bräkne river.

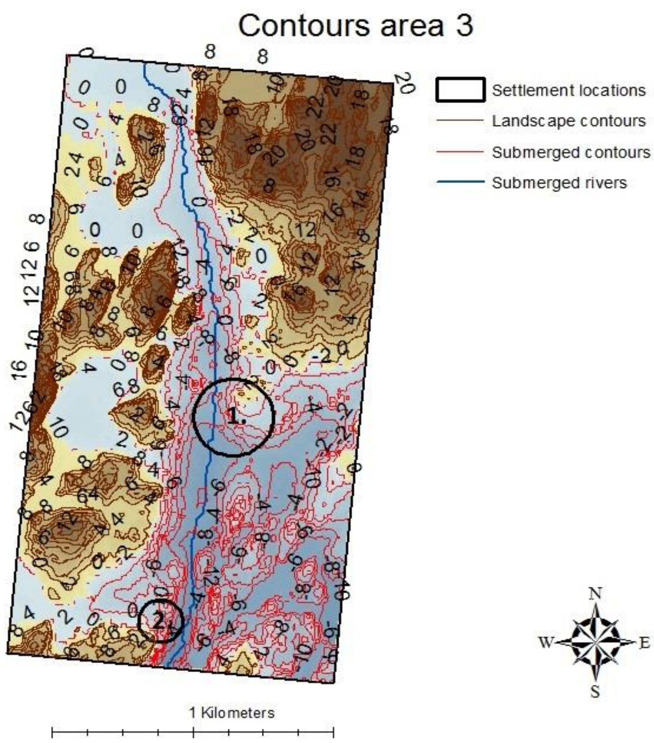


Figure 32. Contours for area 3. The red line symbolizes the contours. Suggested settlement locations are labeled 1 and 2

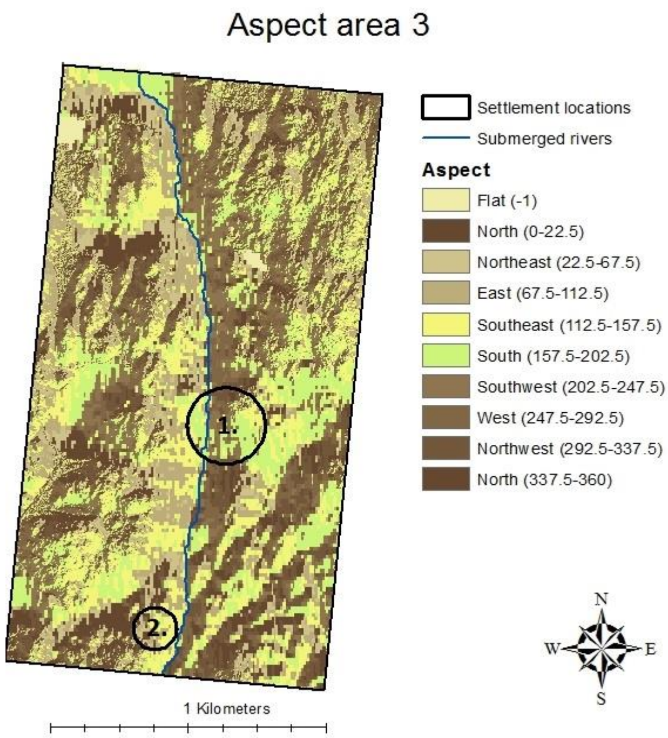


Figure 33. Aspect for area 3. Suggested settlement locations are labeled 1 and 2

In terms of slope and aspect for settlement 1 in area 3, these are shown in figures 34 and 35. This suggested settlement is also right next to the Bräkne river reconstruction which would allow access to fishing sites. The area immediately right of this river is flat, but slightly further to the right a steeper slope is introduced (figure 34). Overall though, this area has gentle slopes with both south and southwest facing slopes which can be seen from the aspect results in figure 35. The south facing slope is beneficial for this settlement as it suggests that there would be access to sunlight during the day.

As for potential vantage points, this settlement location is situated in a rather flat landscape, so there are no ideal places close by for a vantage point. In the northeast corner of figure 34 there is a steep slope (14.91° – 46.9°) where the elevation rises from -9 m to -3 m. This might work as a potential vantage point, but the increase in elevation is not that high so it might not be high enough to scope out the surrounding landscape.

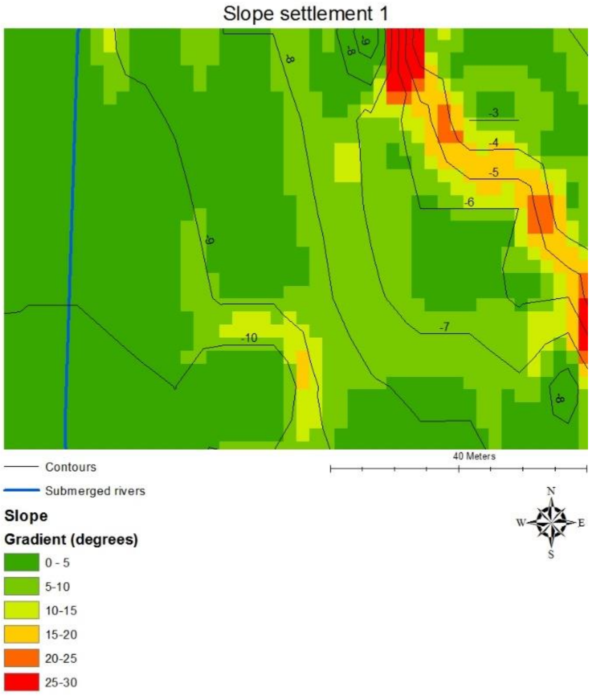


Figure 34. Slope for settlement location 1 in area 3

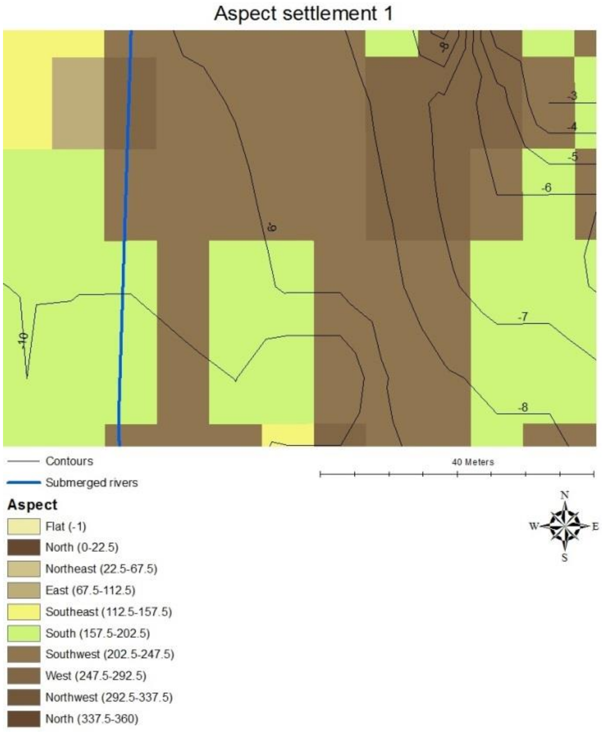


Figure 35. Aspect for settlement location 1 in area 3

Settlement 2 in this area is located on a somewhat steep slope which changes from -7 m to -14 m from left to right in figures 36 and 37. The slopes present in this settlement (figure 36) are the steepest compared to all the other settlements in the other areas. From comparing figure 36 to figure 32 which shows the landscape that surrounds this settlement, it is possible to see that this settlement is located on a slope that rises from -14 m to about 6 m. This increasing elevation could provide close proximity to a potential vantage point.

The aspect (figure 37) depicts that this slope is east-southeast facing, which is beneficial since it will receive plenty of sunlight, but a drawback is that this settlement is not protected from the prevailing winds.

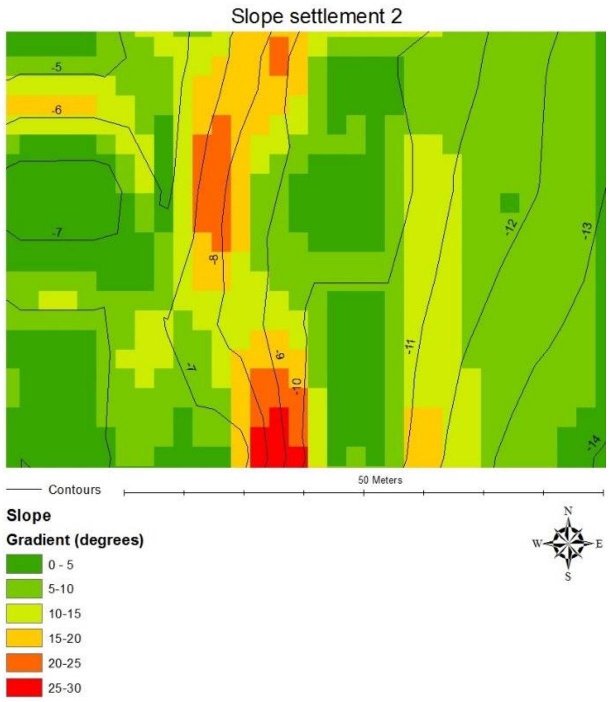


Figure 36. Slope for settlement location 2 in area 3

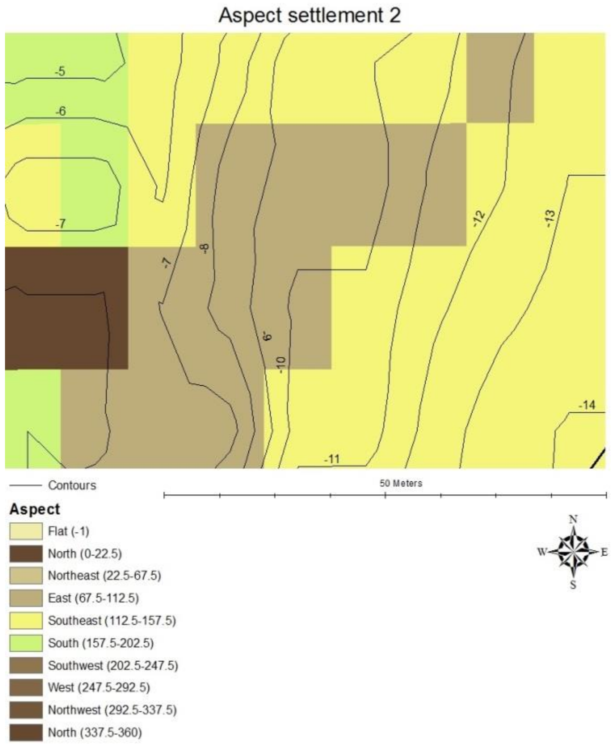


Figure 37. Aspect for settlement location 2 in area 3

3.3.4 Area 4

For area 4, the contours and aspect are shown in figures 38 and 39. This is the second area which is located slightly further out from the coast, similar to area 2. The ranges in depth vary from 0 m to -24 m, which is the largest depth variance out of all the areas. The confluence between Bräkne and Vieryd rivers is located here, but this would have already been submerged during Mesolithic times.

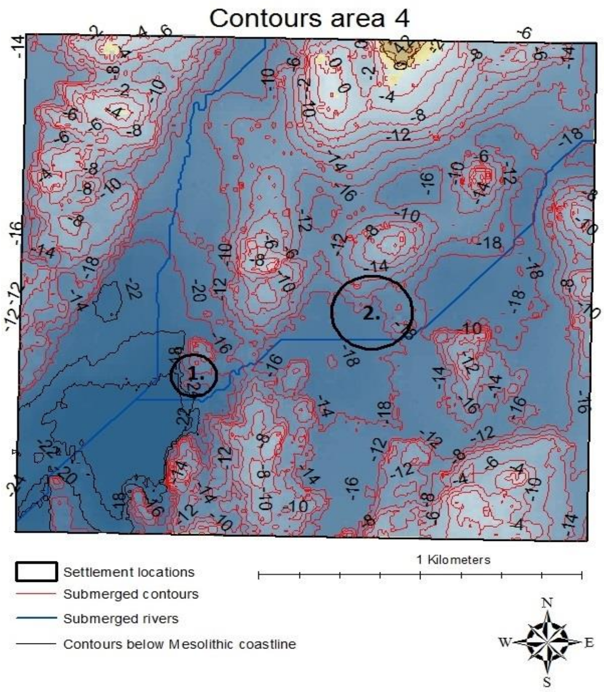


Figure 38. Contours for area 4. The red line symbolizes the contours. Suggested settlement locations are labeled 1 and 2

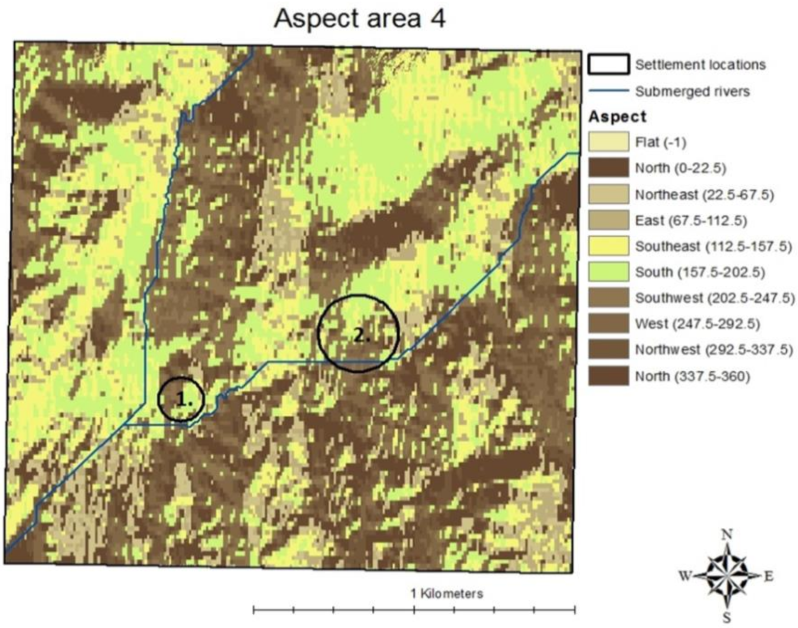
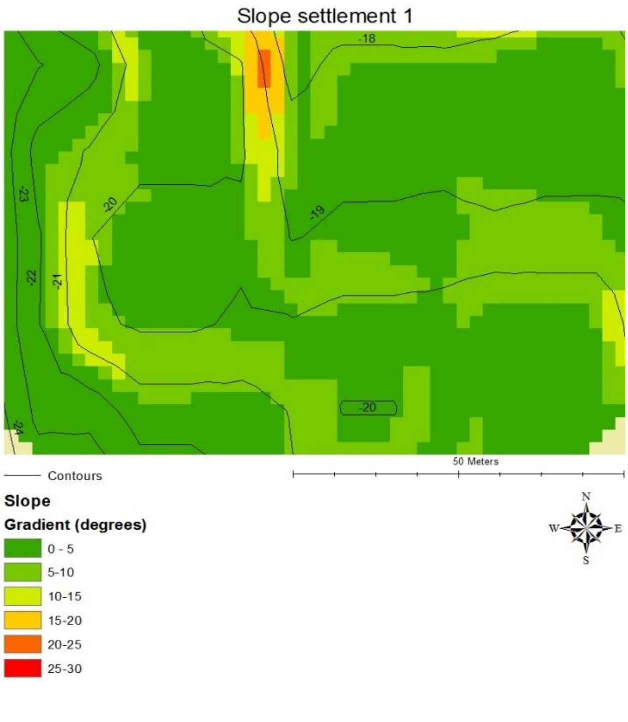


Figure 39. Aspect for area 4. settlement locations are labeled 1 and 2

The main slope direction for this area which can be seen in figure 39 is south-southeast (green and light-blue aspect respectively) which has a V-shaped form within which the reconstructed rivers somewhat follow.

The suggested settlement for location 1 in area 4 is located slightly northeast of the submerged (in Mesolithic times) river confluence between the Bräkne and Vieryd rivers. The slope for this area, which can be seen in figure 40, is mostly between 0° - 5° and 5°-10°, which is mirrored in the changing elevation values. This slope is mostly south facing, but some parts (top left corner in figure 41) are west and northwest facing. The south facing sections of this settlement are beneficial since they would have access to sunlight, and the northwest facing slopes would provide some protection from the prevailing winds, making this both a sunny and somewhat protected settlement location.

Also, this settlement is one of the only two settlements that matches one of the fishing site location characteristics since it is at the mouth of two large rivers, both the Bräkne and the Ronneby rivers.



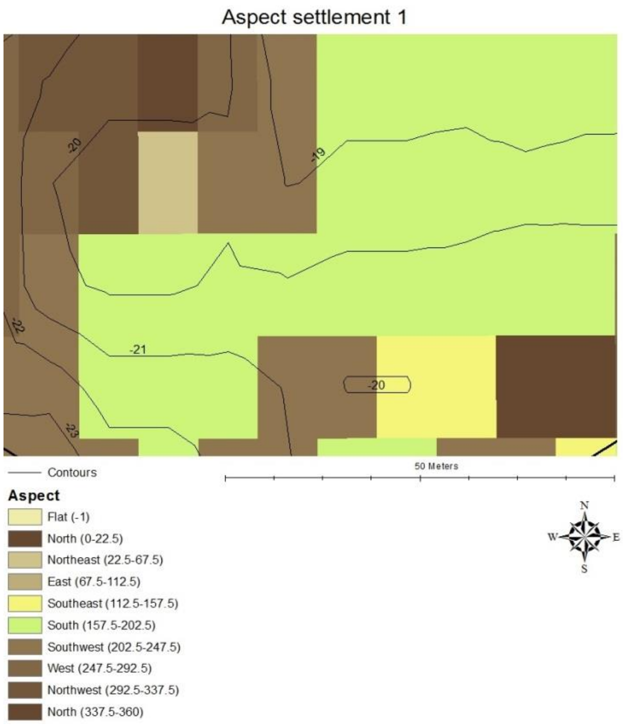
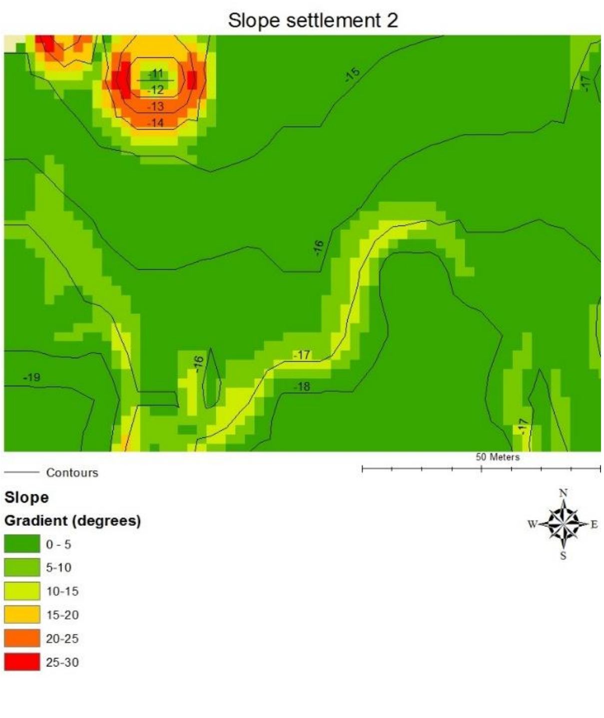


Figure 40. Slope for settlement location 1 in area 4

Figure 41. Aspect for settlement location 1 in area 4

Lastly, the slope and aspect for settlement 2 in area 4 are shown in figures 42 and 43. The central section of this suggested settlement is flat, but in the region immediately south, the steepness of the slope increases from 0° – 5° to 10° – 15° as can be seen in figure 42. To the north, there is a circular peak that rapidly increases in elevation from -15 m to -11 m at its peak which would be an excellent vantage point since the rest of the landscape is relatively flat.



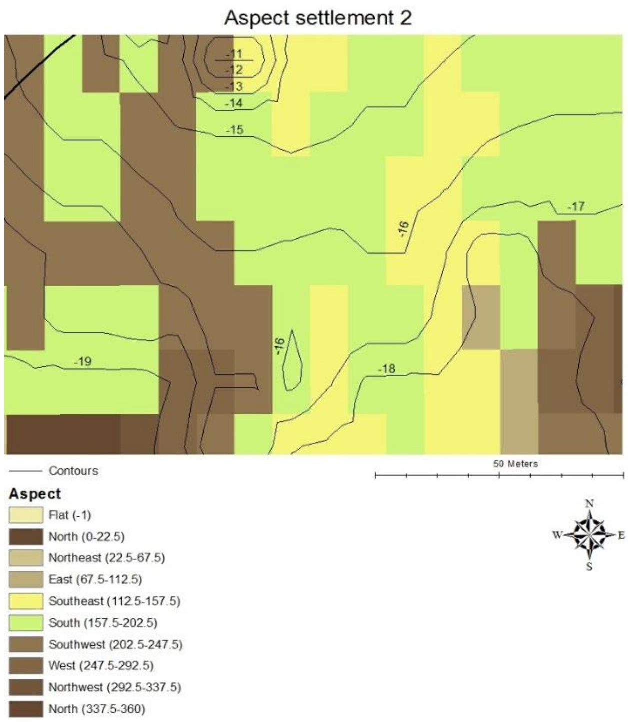


Figure 42. Slope for settlement location 2 in area 4

Figure 43. Aspect for settlement location 2 in area 4

The -18 m elevation seen to the south of this settlement is part of a larger circle of the same elevation (visible in figure 38), which is intersected by the Vieryd river. This has the potential of being a lake since the water from the river could fill up this section of lower elevation. This suggests that similarly to settlement 1, settlement 2 also potentially meets the same fishing site location model characteristic since it is located at the mouth of a stream of river, which is the mouth of the Vieryd river into the potential lake.

The aspect in this area, which can be seen in figure 43, is dominantly south-southeast facing, with a few slopes facing southwest, as can be seen in figure 43. These slopes would allow access to plenty of sunlight, which is beneficial for the settlement.

3.4 The aspect and slope means of the Mesolithic settlements

Table 4 shortly summarises the main results for slope and aspect in the already identified Mesolithic settlements presented in section 3.2. For each of the four settlement locations, the mean aspect and slope were calculated using the zonal statistics function in ArcGIS. This was done so that it would be simple to compare the overall slopes and aspects of the known Mesolithic settlements to the suggested potential settlements.

In terms of slope gradients, settlement 3 has the steepest slopes at 8.49°, and the other three settlements range from 4.96° to 7.16°. In comparison to the mean slopes of the suggested Mesolithic settlements presented in table 5, the identified settlements have overall higher mean slope values.

Settlements 1, 2 and 4 all have overall south facing slopes (southeast, southeast and southwest at each settlement respectively) whereas settlement 3 has an overall west facing slope.

Table 5 shows the mean slope and aspect for the suggested Mesolithic settlements in areas 1 to 4. The steepest slope in this set of results is found in settlement 2, area 3 with a gradient of 8.6°.

All these suggested settlements have overall south facing slopes apart from settlement 2 in area 1 which has an overall east facing slope.

Table 4. The slope and aspect mean values for the four already identified Mesolithic settlements

Identified Mesolithic settlements		
Settlement number	**Characteristic**	**Mean**
1	Slope	4.96°
N. of cells = 700	Aspect	129.83 SE
2	Slope	7.16°
N. of cells = 864	Aspect	146.84 SE
3	Slope	8.49°
N. of cells = 1,320	Aspect	260.21 W
4	Slope	6.83°
N. of cells = 1,620	Aspect	243.769 SW

Table 5. The slope and aspect mean values for the 9 Mesolithic settlements that have been suggested for the areas 1 - 4

Suggested Mesolithic settlements			
Area	**Settlement number**	**Characteristic**	**Mean**
1	1	Slope	5.23°
	N. of cells = 3,762	Aspect	242.6 SW
	2	Slope	0.73°
	N. of cells = 5,070	Aspect	70.86 E
2	1	Slope	3.24°
	N. of cells = 2,832	Aspect	142.69 SE
	2	Slope	3.35°
	N. of cells =3,630	Aspect	149.01 SE
	3	Slope	2.91°
	N. of cells = 1,824	Aspect	173.33 S
3	1	Slope	5.26°
	N. of cells = 1,110	Aspect	213.45 SW
	2	Slope	8.6°
	N. of cells = 896	Aspect	126.13 SW
4	1	Slope	4.35°
	N.of cells = 1,184	Aspect	176.98 S
	2	Slope	3.99°
	N. of cells = 2,142	Aspect	152.12 SE

4. Discussion

4.1 The selected Mesolithic settlements already identified in the study area

4.1.1 Settlement 1

Settlement 1 is situated west of the Ronneby river on a small terrace at 12 m height after a slight slope. The mean slope gradient for this area is 4.96° which is relatively flat in comparison to the other three identified settlements. When comparing this to the beneficial characteristics for a Mesolithic settlement shown in table 2, this settlement meets the criteria of a somewhat flat landscape and that there are some patches of south and southeast facing slopes which would result in sun exposure. This settlement does not however, meet any of the fishing site location model characteristics, making it more difficult to discern what characteristics this settlement portrays.

So, settlement 1 matches two out of the three beneficial characteristics, and meets none of the fishing site location model characteristics. However, there are only two settlements that actually meet one of the fishing site location model characteristics (the suggested settlement 1 and 2 in area 4) so it is questionable as to how useful this model is for this particular study.

4.1.2 Settlement 2

Settlement 2 is located slightly south of settlement 1 (the first three settlements can all be seen in figure 7), just a few hundred meters west of the Ronneby river. It was suggested in Pettersson and Wikell (2004) that Mesolithic dwellings would be located within walking distance of the coastline so that when it was time to hold a hunting expedition for fish, it would not be too far to the closest fishing area. Maybe the same can be thought when looking at major rivers such as the Ronneby river which is within easy walking distance of all the four already identified settlements since rivers are also a great source of fish.

When looking at the slope, the mean value is 7.16°, which suggests that this landscape is not flat. Similarly to settlement 1, there is what looks like a small terrace at around 8 – 9 m, but in the northeast of figure 11 there is a steep slope with elevations rapidly changing from 5 m to 12 m.

However, in terms of aspect, this settlement does meet the beneficial characteristic. About half of the settlement is south and southeast facing, meaning that these areas will receive sun both in the morning and throughout most of the rest of the day. Most of the south section of this area is on an east-northeast facing slope which would provide more shade.

This settlement location meets the aspect characteristic, but not the other two characteristics so it is debatable if these were taken into consideration when setting up dwellings. This makes it slightly more difficult to decide if these are valid characteristics to take into consideration when trying to find Mesolithic settlements. It might be useful to consider additional landscape and archaeological characteristics such as locations of other resources used by Mesolithic people.

4.1.3 Settlement 3

Settlement 3 is also present in figure 7 and is located further away from the Ronneby river, to the west of settlements 1 and 2. This settlement location has the highest slope gradient at 8.49°, which suggests that this is not a flat landscape. This is supported by the contour values that rise by 11 m from left to right in figure 13. This slope is changing gradually from west to northwest and north sloping, which means that this is not the best location choice in terms or receiving most amounts of sunlight. However, these slope directions will provide protection from the prevailing winds coming from the south and southwest. In accordance to the beneficial characteristics presented in table 2, the only potential ones visible here is that it is located close to a vantage point and that it is protected from prevailing winds. The top of the slope is about 50-70 m northeast of the settlement, suggesting that the vantage point could be located here. So there are two strong reasons behind the possible location of settlement 3.

4.1.4 Settlement 4

Settlement 4 is located right next to the Bräkne river (figure 15) on a northwest facing slope with a gradient of 6.83°, still not a particularly flat landscape. So, this settlement provides some protection from the prevailing winds and easy access to fishing opportunities since it is located right next to the Bräkne river.

None of the four settlement locations discussed here have had dominantly flat landscape. Whereas this may be a beneficial characteristic, it does not seem to have been seriously considered for these four settlements. From this, it is clear to see that none of the four settlements suggested here actually meet all the beneficial characteristics, but they do give some insight to a few of the reasons for the location choices.

Of course, a more detailed analysis which includes more than just four identified settlements is needed before definite conclusions can be drawn about this.

4.2 The submerged selected areas and their suggested Mesolithic settlements

4.2.1 Area 1

Settlement 1 is situated at about 6 m height, with the elevation rising to 10 m in the east which increases the mean slope of the area, even though it is relatively flat. This rising elevation to the east of this settlement might be a good vantage point to scout the surrounding low areas. Also, southeast (yellow) and south (green) facing slopes are the slope directions that receive morning sun and most sun during the day which is supported by the mean aspect of this location (table 5), which is southwest facing. It is possible that a settlement could have been located on these slopes just below a potential vantage point. If there was a settlement located on this slope, it would be very close to the river which can be seen on the left-hand-side in this figure. This river could potentially provide food in the form of fish. It does not however meet the characteristics of the fishing site location model, but this does not mean that there was no fishing in the area. The mean slope is a gradient of 5.23°, supporting that this is a somewhat flat landscape. However, the close distance to both a vantage point and a main river are both beneficial. This settlement is most similar to the already identified settlement 4, which has a mean aspect of 6.83° and a mean aspect in a southwest direction. The slopes both imply that the landscape is on a slight slope, and that these settlements had little to no protection from the prevailing winds.

Settlement 2 is found in a relatively low (-11 to -13 m) area between two rivers. The river to the right is part of the Ronneby river which can be seen in figure 18. This low-lying area has a slope direction of south-southeast, meaning that it will receive a lot of sun throughout the day. The mean slope for this area is 0.73°, which means that this is definitely a flat settlement location. On the other hand, it is not close to any location that could be a potential vantage point. So, this settlement is both flat and has a south-southeast slope direction, meeting two of the three beneficial characteristics. None of the already identified Mesolithic settlements have a landscape this flat, but the identified settlements 1 and 2 also have overall southeast facing slopes according to the mean results presented in table 4, which could suggest that this is an important characteristic that was taken into account during Mesolithic times.

4.2.2 Area 2

Settlement 1 is furthest upstream in this area, situated on a south-southeast facing slope which would allow access to maximum amounts of sunlight during the day. The elevations at this location vary from -7 m to -12 m which suggest that this is a somewhat flat landscape. So, this location has close access to a main river and a vantage point (just above the circle marked 1 in figure 24). When looking at the mean slope of this area, which is 3.24°, this result supports the contour results that the landscape is relatively flat. In comparison to the already identified settlements, settlement 1 in area 2 has a much lower mean slope, but has the same mean aspect (southeast direction) as identified settlements 1 and 2.

Even though this settlement in area 2 has a flat landscape, which is a beneficial characteristic according to Törnqvist (2012), other studies discuss the importance of both flat and steep landscapes when analysing settlement locations. Pettersson and Wikell (2004) discusses that the settlements close to the coastline could be found at varying elevations, and that if the surrounding landscape had steep elevations, settlements were often found at high elevations in eastern central-Sweden. If the surrounding landscape was more flat, then the settlements would be located at lower elevations. It is mentioned that this might have been due to the seasonal variations in sea level (Pettersson and Wikell 2004). This aspect would have probably also been considered in southern Sweden at the study site examined here, since there have been quite drastic changes in sea level during the development of the Baltic Sea which can be seen in figure 2 (Berglund and Sandgren 2010). Another point mentioned by Pettersson and Wikell (2004) is that the buildings associated with sea activity, such as fishing, could be located next to the coastline and the actual dwellings might be situated slightly further inland, but still close by. The reason for having a short distance between the two amenities is that it would have been impractical to have to walk unnecessarily long distances to reach the boats used during a hunting trip (Pettersson and Wikell 2004). This would be important to incorporate when identifying potential settlement locations for both areas 2 and 4, which are both close to the coastline. This could mean that settlement 3 in area 2 could be where the dwellings were located since it is close to the Mesolithic coastline (elevations below -20 m depth).

Settlement location 2 is just slightly further south, also on a south-southeast facing slope. The landscape here has the same small elevation variations as location 1 and also has a potential vantage point, just to the northwest of the circled location. The mean slope is also very similar with a gradient of 3.35° (in comparison to settlement 1 with a gradient of 3.24°) which can be called a pretty flat landscape. The slope directions would allow access to sunlight, which means that this location meets all three beneficial characteristics. None of the already identified settlements meet all of the characteristics.

Settlement location 3 in area 2 is one of the two settlements (the second one being settlement 1 in area 4) which is located closest to the Mesolithic coastline. However, it is not possible to see the actual coastline in the figures, which makes it difficult to implement the fishing site location model here. This settlement location has the second lowest mean slope with a gradient of 2.91° (the lowest being 0.73° at settlement location 2 in area 1) meaning that this is also a flat landscape. The mean aspect is south, but when looking at figure 31, it is possible to see south, southeast, west, east and northeast facing slopes. The dominant aspect is south, as shown by the mean; however the combination of the other aspects suggests that this settlement location could have had access to both sunlight and protection from prevailing winds, making it quite ideal. This settlement is not really similar to any of the already identified settlements, implying that maybe more identified settlements should have been analysed than just the four presented in section 4.1.

4.2.3 Area 3

Settlement location 1 in this area is situated on a south-southwest facing slope (green and yellow respectively). The highest elevation here is 0 m, which falls to -10 m where the river is Bräkne river is located. Whereas this is not a flat location, with a mean slope gradient of 5.26°, its distance to the river and slope direction makes it suitable for a Mesolithic settlement. In terms of sunlight availability, since this location is on a southwest facing slope according to the mean aspect presented in table 5, it will receive decent amounts of sunlight during the day. However, just slightly east of the suggested location is a slope which tilts in the south-southeast direction which would allow access to more sunlight. The downside to this location is that there is little protection from prevailing winds.

Settlement location 2 is further downstream on an even steeper slope with a high elevation of 0 m and a low elevation of -14 m, again not particularly suitable when considering the hypotheses made by Törnqvist (2012) that a flat landscape was a beneficial characteristic for a Mesolithic settlement. On the other hand, the slope direction is south-east, which means this location will have access to morning sun, and it is right next to a large river. This makes this particular location better suited for a settlement than the immediate surrounding landscape since much of it has a west-northwest slope direction which would limit the amount of sunlight received.

4.2.4 Area 4

The first settlement location in area 4 is found next to what would have been the coastline during the Mesolithic which is assumed to be depth data below -20 m in this study. As mentioned earlier, outflows from rivers were places where there would have been fishing opportunities, making it a good location for a settlement due to this food source (Wastenson and Selinge 1994).

Settlement location 1 in area 4 is situated very close to the Mesolithic coastline, closer in fact than location 3 from area 2. This could mean that location 1 was where the buildings associated with fishing were located, and that the settlement with the dwellings could be located further inland (Pettersson and Wikell 2004). In Mesolithic times, this location would have been the closest to the current coastline. Due to this, it is one of the two settlements discussed in this study that meets one of the fishing site location model characteristics since it is at the mouth of a larger stream or river. This settlement is in fact close to the mouths of two large rivers, both the Bräkne and the Vieryd rivers. The fact that only two settlements whatsoever in this study meet one of the four characteristics proposed by Fischer (1995), and that this settlement location is the one closest to where the Mesolithic coastline would have been situated, suggests that this model is only valid for locations closer to the coastline. This implies that this particular model is maybe not perfectly suited for studies such as this one, or that to have made better use of this model, more sites right next to the Mesolithic coastline should have been suggested and analysed. So the main beneficial characteristics about this location are that it is close to both the Ronneby and the Vieryd river mouths, and the open sea, which would have provided fishing opportunities.

Settlement location 2 in this area has a relatively flat slope gradient of 3.99°. The central section of this settlement seen in figure 42 makes up the flat landscape, and the slopes are present mainly to the south of this. To the north of the flat central landscape there is a small circular peak which rises from -15 m to -11 m sharply with a slope gradient of 20° - 25°. As the rest of the landscape at this settlement location is of a lower elevation, this peak would act as an excellent vantage point.

The slope in the south section of this settlement location sinks from -16 m to -18 m and when looking at this section in figure 38, this -18 m elevation makes a circle with all its sides sloping in towards it. A reconstructed section of the Vieryd river runs through this lower landscape. This suggests that the -18 m circle could potentially be a lake. If this is the case, then this settlement location would also meet the fourth fishing site location model characteristic ‘at the mouth of a larger stream or river’.

5. Conclusions

The land based Mesolithic settlement sites that had already been identified were analysed for the hypothesised beneficial characteristics. They did not in fact portray many of these beneficial characteristics. They all had slope gradients over 4.96°, results which do not suggest a particularly level landscape. It was also difficult to implement the fishing site location model characteristics on these settlements as they are all located on land, away from the coast. However, the mean aspect results show that almost all these settlements (apart from settlement 3) were located on southeast or southwest facing slopes, which would have allowed access to sunlight.

The suggested potential Mesolithic settlements mostly portrayed relatively flat landscapes (apart from settlement 1 in area 1, and settlement 2 in area 3), and all had mean aspects facing either south, southeast or southwest directions, optimizing the amount of sunlight that the settlements could receive. This would however have left them with little protection from prevailing winds. Some of the settlement locations do indeed have a few north facing slopes, but probably not enough to actually create a decent amount of protection. Many of the settlements were also in close proximity to raised elevations that could have been potential vantage points, but this is difficult to prove without further research.

This report was met with a series of limitations that can all be improved with more time and further research. One limitation is that only the largest flows of water have been considered when analysing each settlement, both already identified and suggested. If more river networks had been included it would have been possible to identify small streams and creeks that might have been present at the settlement locations. This would have increased the validity of the fishing site location model.

Though this report presents valid arguments, further research would provide more conclusive results. One type of further research would be to analyse more previously identified settlements to better understand and identify their locations. This would improve and increase the amount of beneficial characteristics to look for when trying to suggest potential Mesolithic settlement locations.

Another way to improve this study would be if other analyses of the landscape or archaeology were included, creating more characteristics to look for when locating and identifying settlements. The comparative method used here would then have yielded stronger results. Also, the inclusion and analysis of preferred soil types could have been a useful aspect to consider when identifying suitable settlement locations.

Merging a landscape DEM and a bathymetry DEM is possible once a few minor alterations have been considered and applied. An important detail to take into consideration is that there can be no negative elevation values when trying to merge two DEMs. This was the case in this study, and as such, the elevation values presented in figure 5 with the merged DEMs have been offset by 47.8 m as this was the lowest negative value in the bathymetry layer meaning that this offset became the new 0 m level. The elevations in all the other figures utilize present day elevation values so that the offset would not affect the results. Another issue to consider is the cell sizes of the DEMs that are going to be merged. Ideally, the cell sizes of the two DEMs should be the same, but this is not always the case. If the cell sizes are different, then the DEM with the finer cell size is resampled on top of the DEM with the coarser cell size.

To conclude, it is possible to suggest potential settlement areas from a combination of archaeological and geological knowledge of an area, but unless the suggested area is surveyed through diving, there is no conclusive way to be certain that a settlement was located there. It is also possible to analyse already known characteristics of Mesolithic hunting practices, which aids in finding suggested potential settlement locations. Of course, more research will broaden the knowledge of how to better identify and locate Mesolithic settlements.

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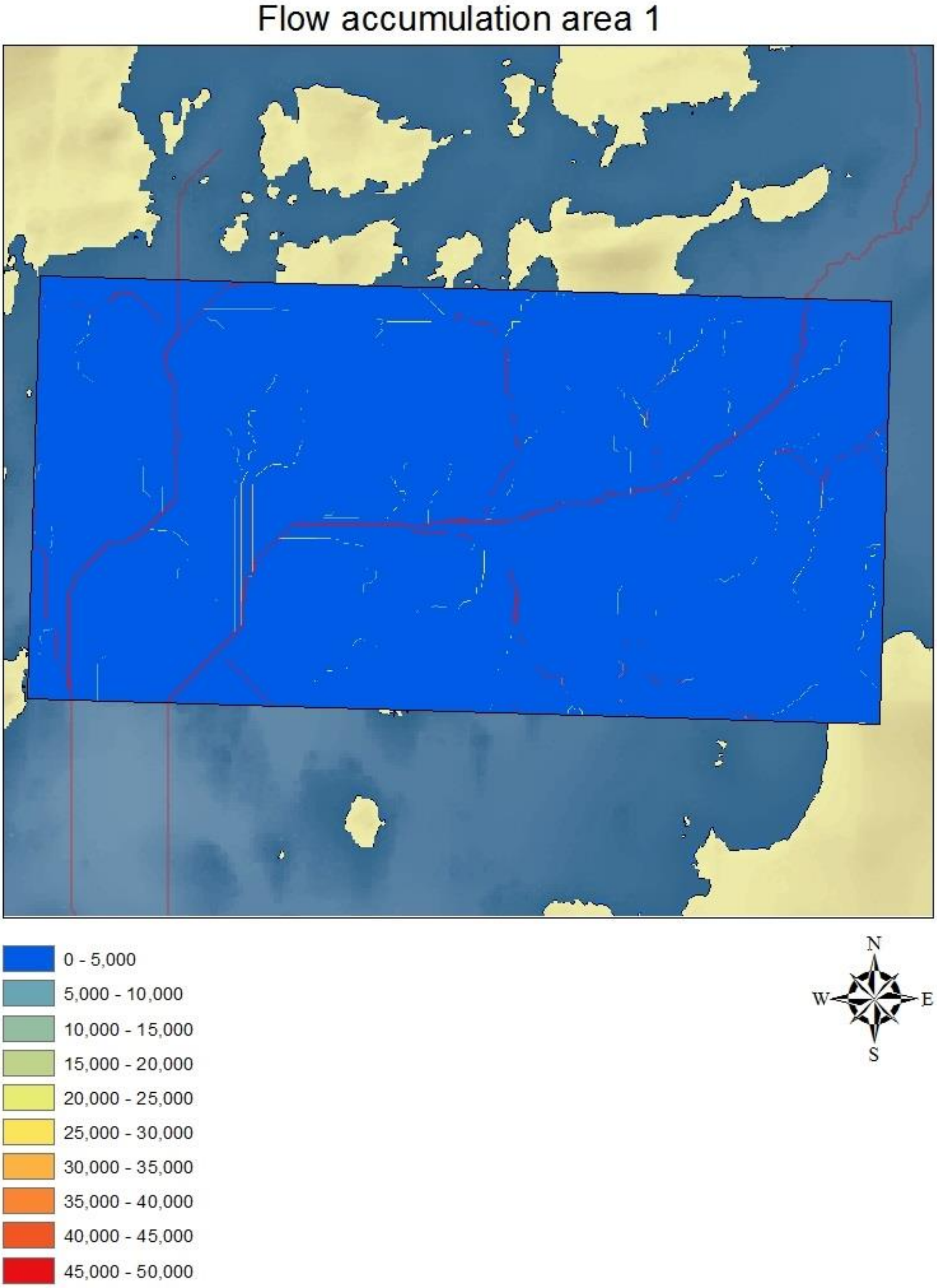
Appendix I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5,000 - 10,000
10,000 - 15,000
15,000 - 20,000
20,000 - 25,000
25,000 - 30,000
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40,000 - 45,000
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N
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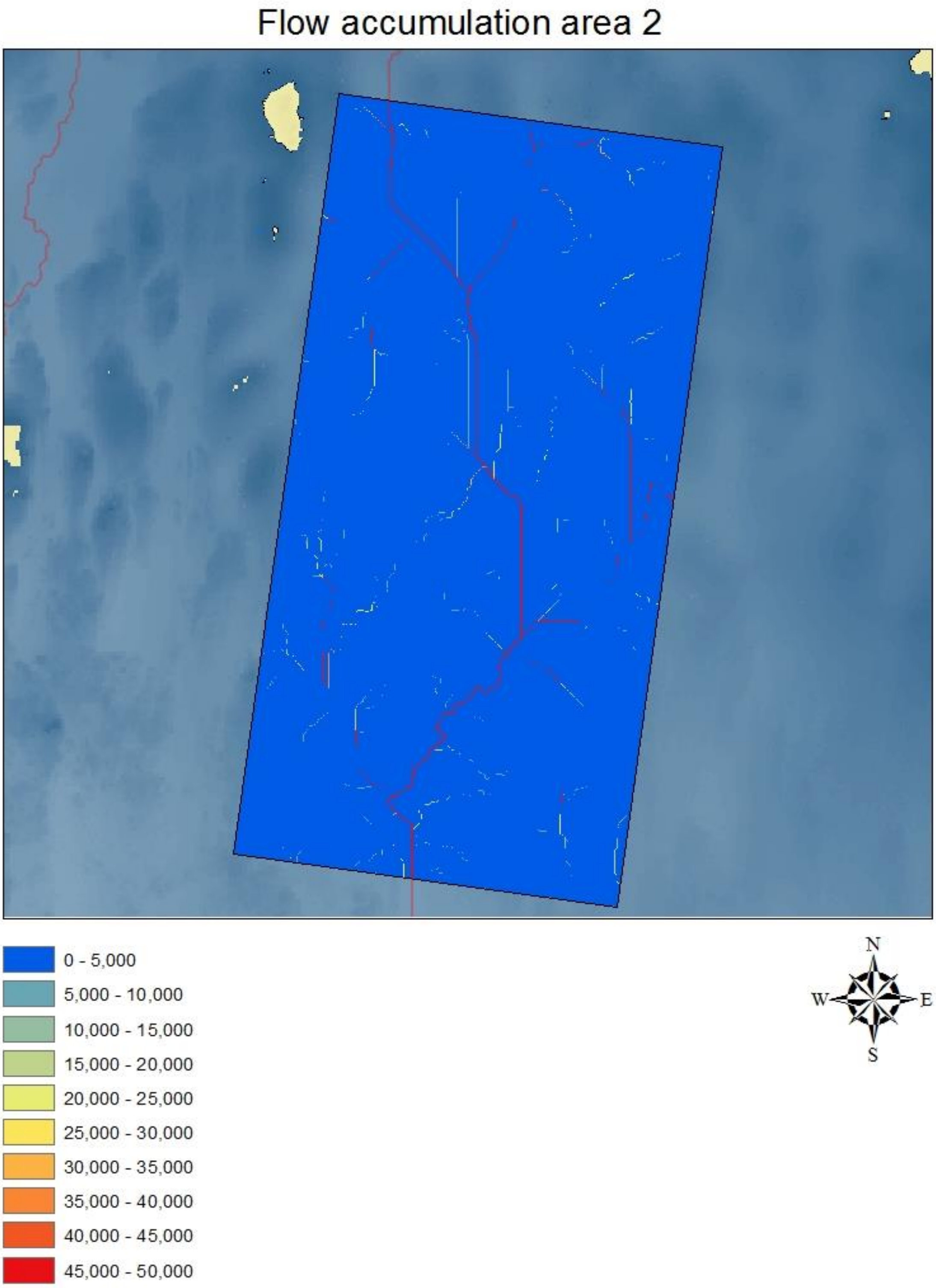
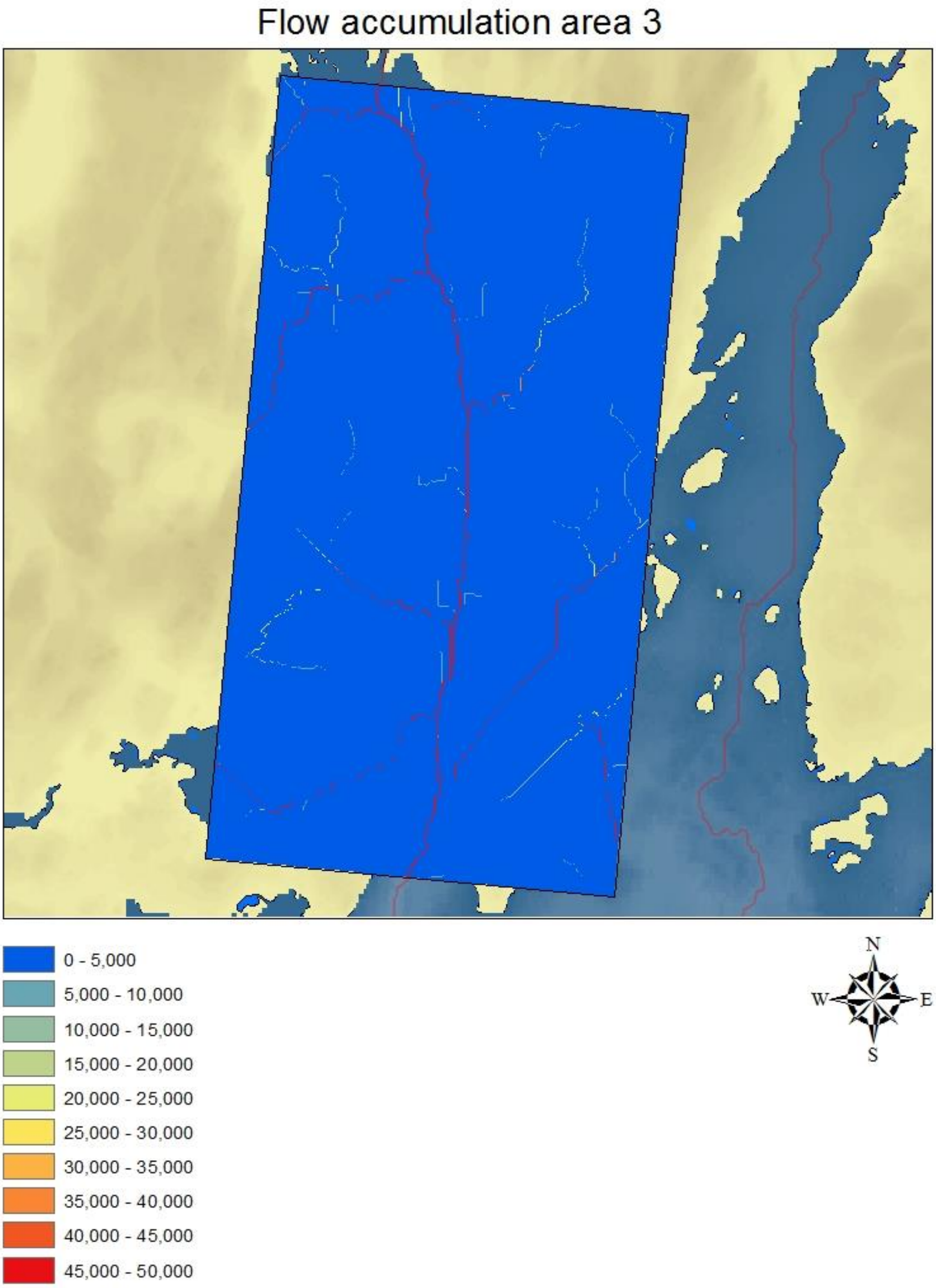
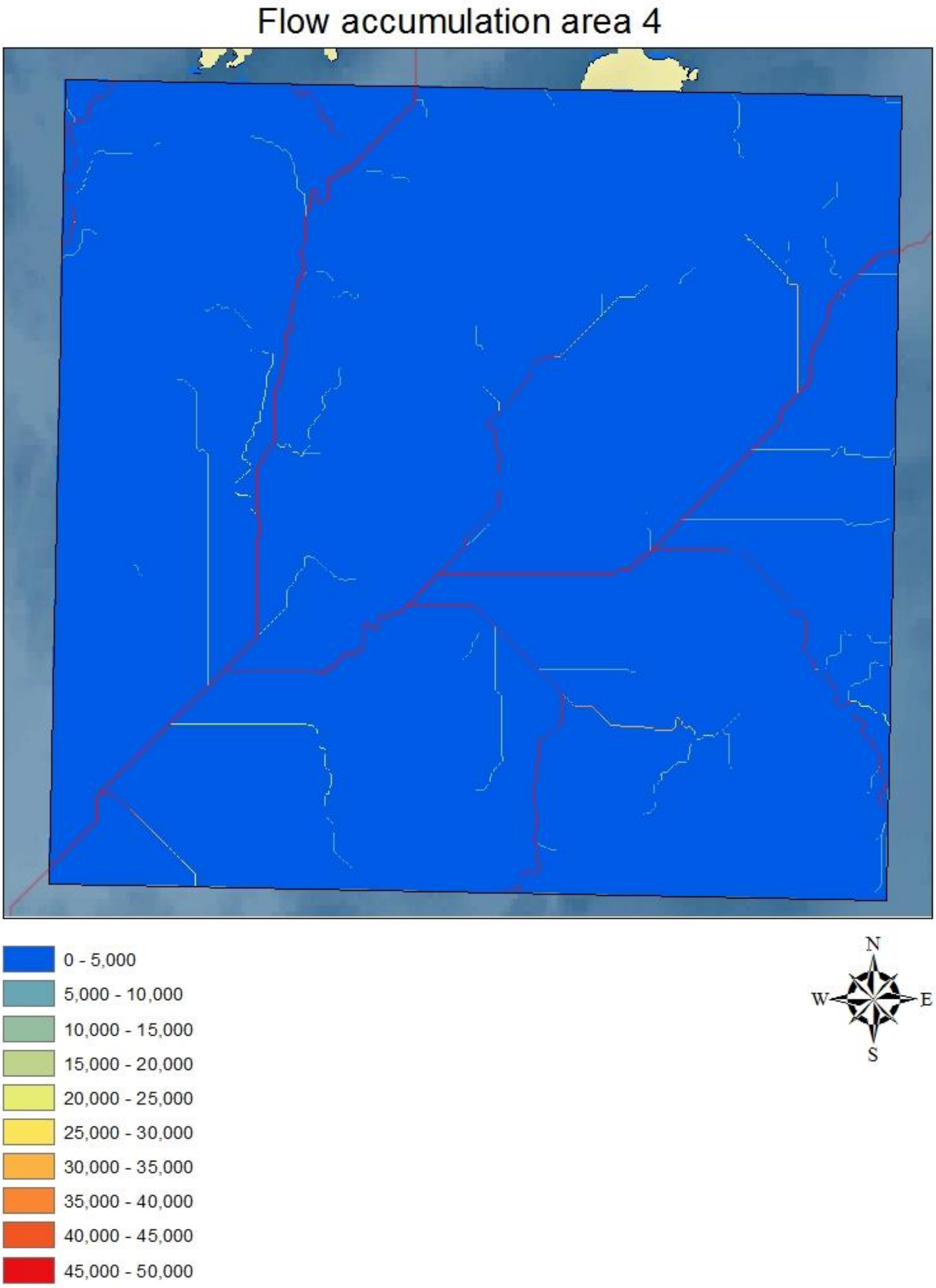
Appendix I (cont.)



Appendix I (cont.)



Appendix I (cont.)



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