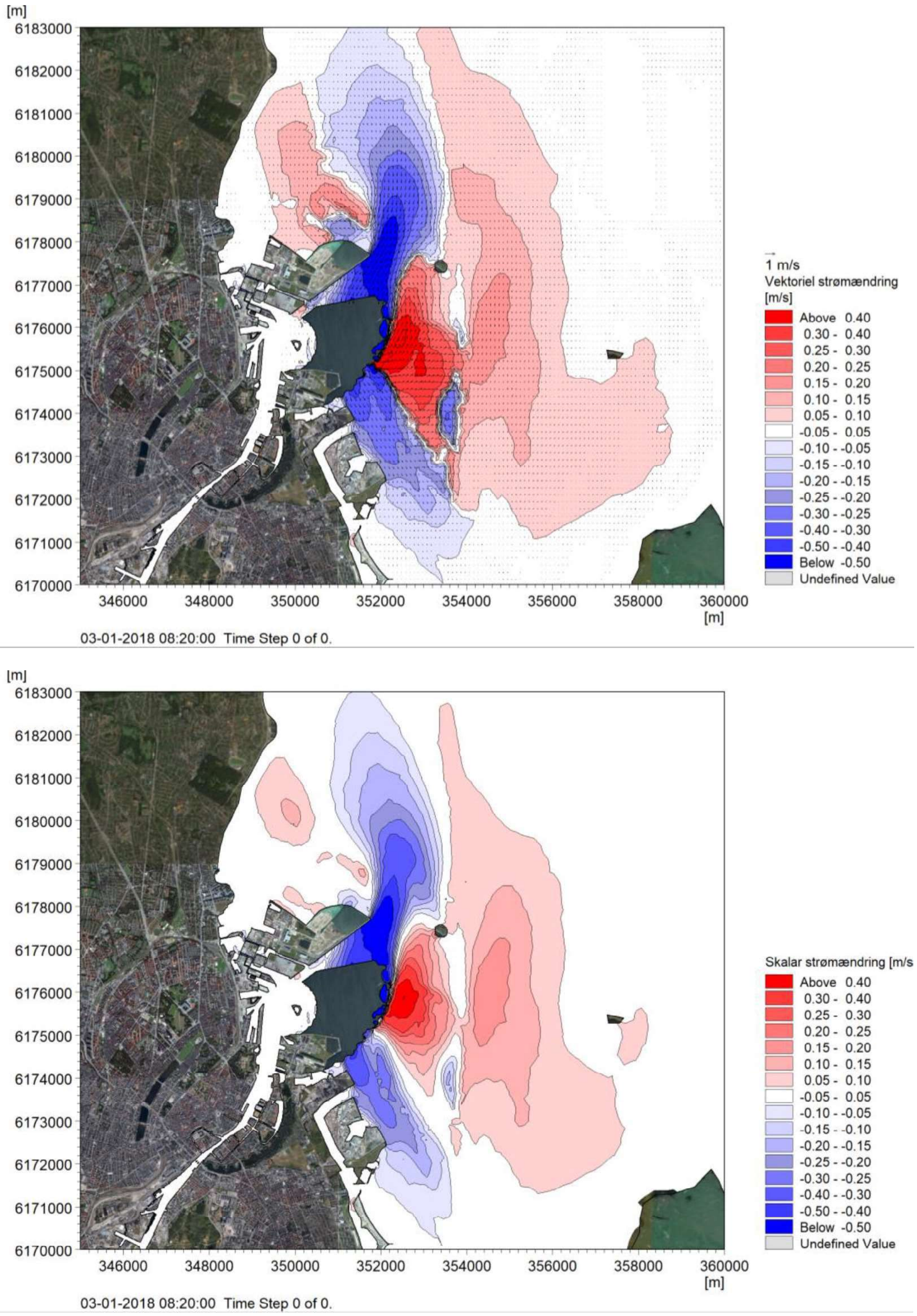

Figure 6-25 Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions of strong northbound current and reclamation with coastal landscape

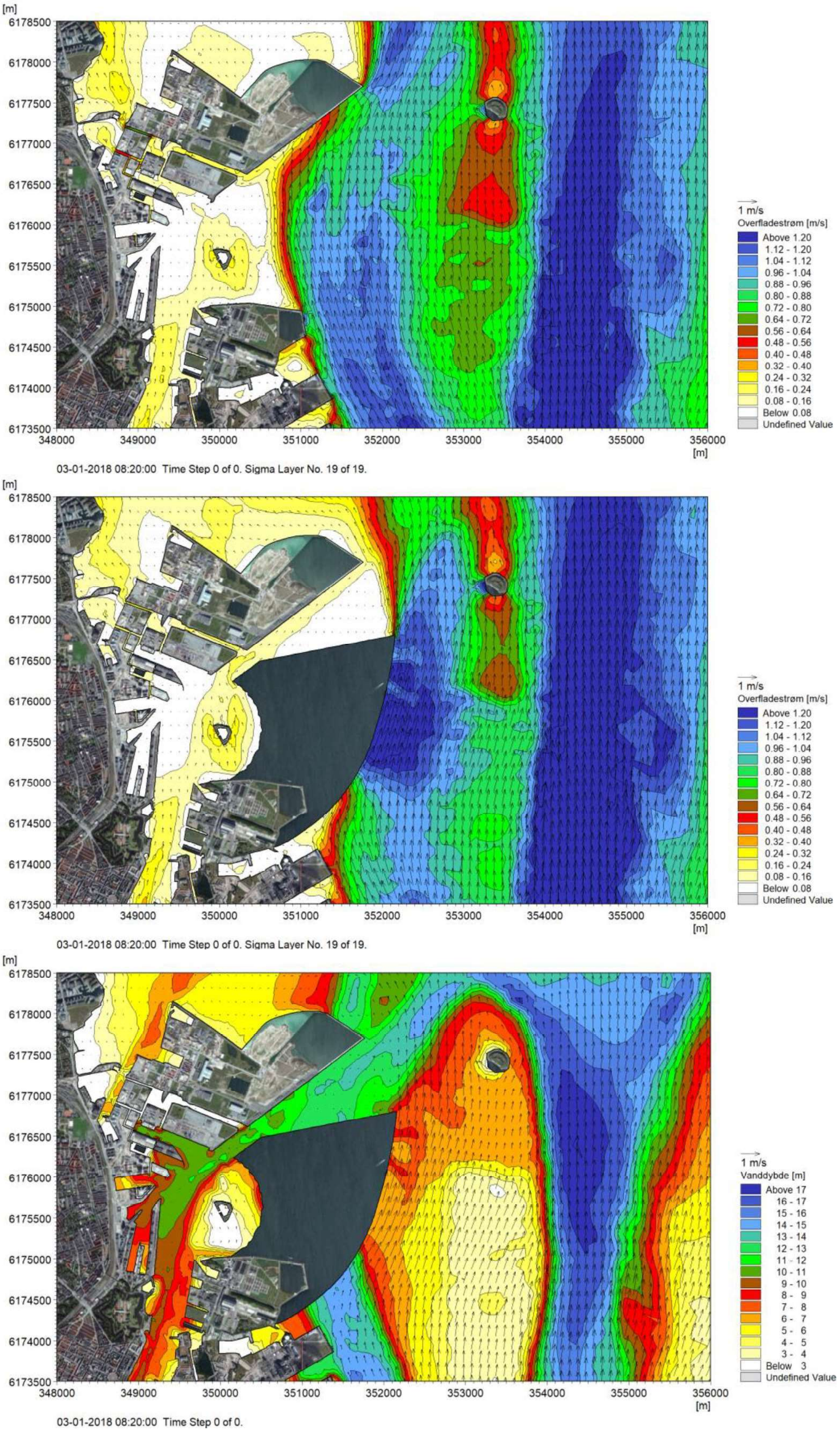

Figure 6-26 Surface velocity in conditions with strong northbound current on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.

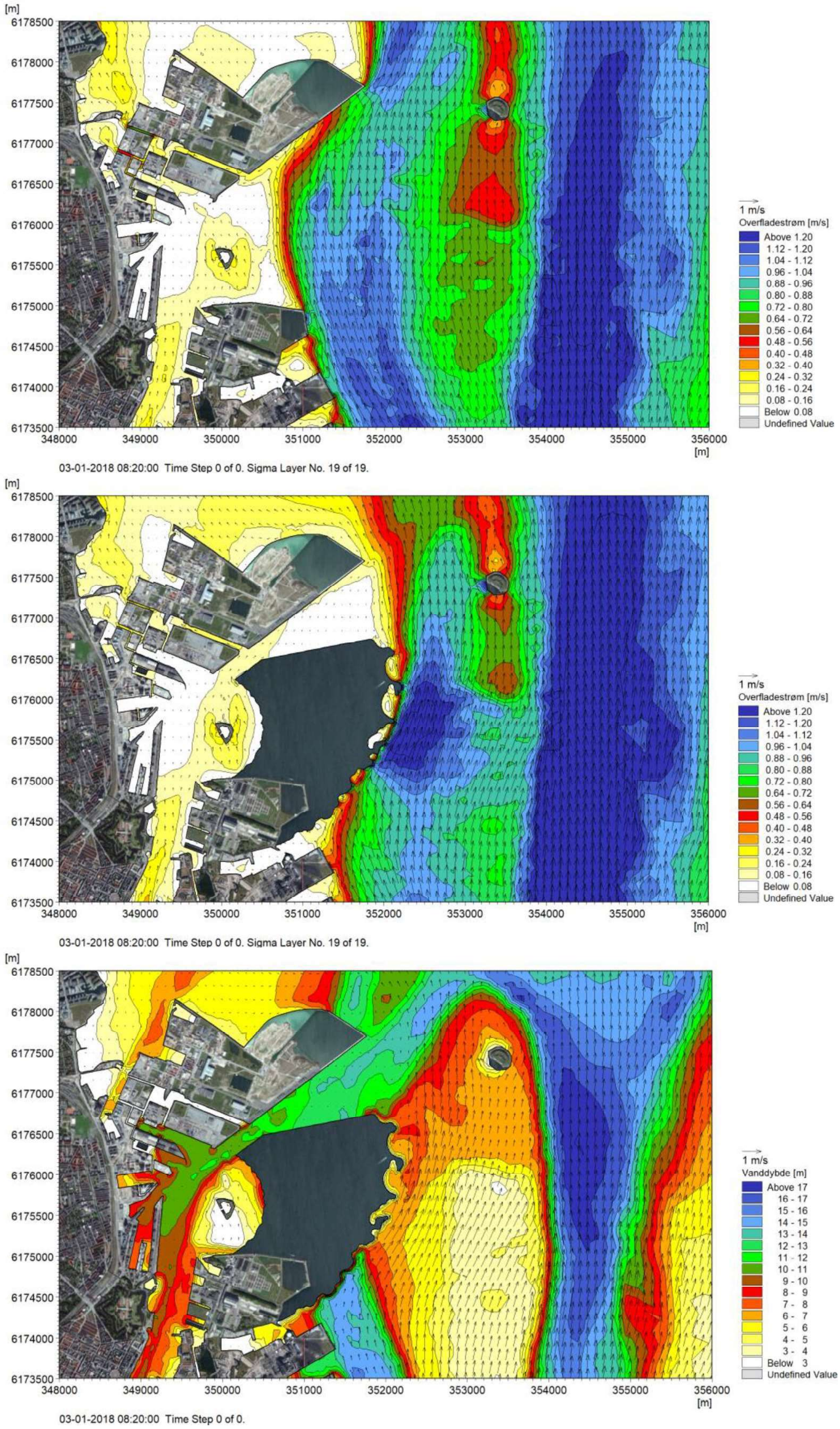

Figure 6-27 Surface velocity in conditions with strong northbound current on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.

In Figure 6-24 and Figure 6-25, current changes are calculated and shown as the vectorial change, which considers changes in the current direction and as a scalar change, taking into account only changes in the magnitude of the current. The plots are zoomed out to cover the entire impact area. It can be seen that changes in the depth-averaged current and current direction during this event impact an area with an extent of almost 10 x 14 km for the layout of a coastal landscape. The size of the impact area is slightly smaller for the layout without a coastal landscape. There is marked current damping in both layouts in Kongedybet and in the Kronløbet at the harbour mouth. In Svanemøllebugten (the area west of a line between the Nordhavn tip and Skovshoved), there is a slight current increase, which has an impact on the water exchange in the bay, which can be characterised as an area with a recirculating counter-current flow. In Hollænderdybet and its extension there is an increase of the depth-averaged current of between 5-19 cm/s over a stretch of about 12 km. The current damping in Kongedybet off Amager power station may impact the power station’s use of cooling water, as the water exchange will be reduced in general in this area.

For the same situation, with a northbound current, the surface velocities are shown in Figure 6-26 for the existing conditions and with a Lynetteholm reclamation without a coastal landscape, while Figure 6-27 shows the equivalent for a reclamation with a coastal landscape. The surface velocities are higher than the depth-average velocities, so the impact appears to be relatively larger. To better understand the current image, a plot of the water depths has been inserted again.

The changes in surface current are shown at the top of Figure 6-28 and Figure 6-29, calculated as the vector difference, considering changes in the direction of current and at the bottom of a scalar calculation, considering only the change in the current size. The image is analogous to the depth-averaged change, but the changes are more significant. It can be seen that there is a relatively significant change in the flows north of the Nordhavn-reclamation, which relates to Lynetteholm’s eastern perimeter controlling the direction of the flow so that unlike today it will flow more along the northern part of the Nordhavn-reclamation.

Figure 6-30 shows bottom velocities for the same northbound current situation for the existing conditions and with a Lynetteholm reclamation without a coastal landscape and correspondingly in Figure 6-31 with a coastal landscape. Due to bottom friction, the bottom velocities are lower than the depth-average velocities, so the impact appears relatively more minor. A plot of the water depths has been inserted again for the time in question to better understand the current image. Changes in the bottom current are shown in Figure 6-32 and Figure 6-33. It can be seen that, unlike the surface current, the bottom current dampens in the area north of the Nordhavn reclamation, indicating that there will be a change in vertical circulation (3D effects).

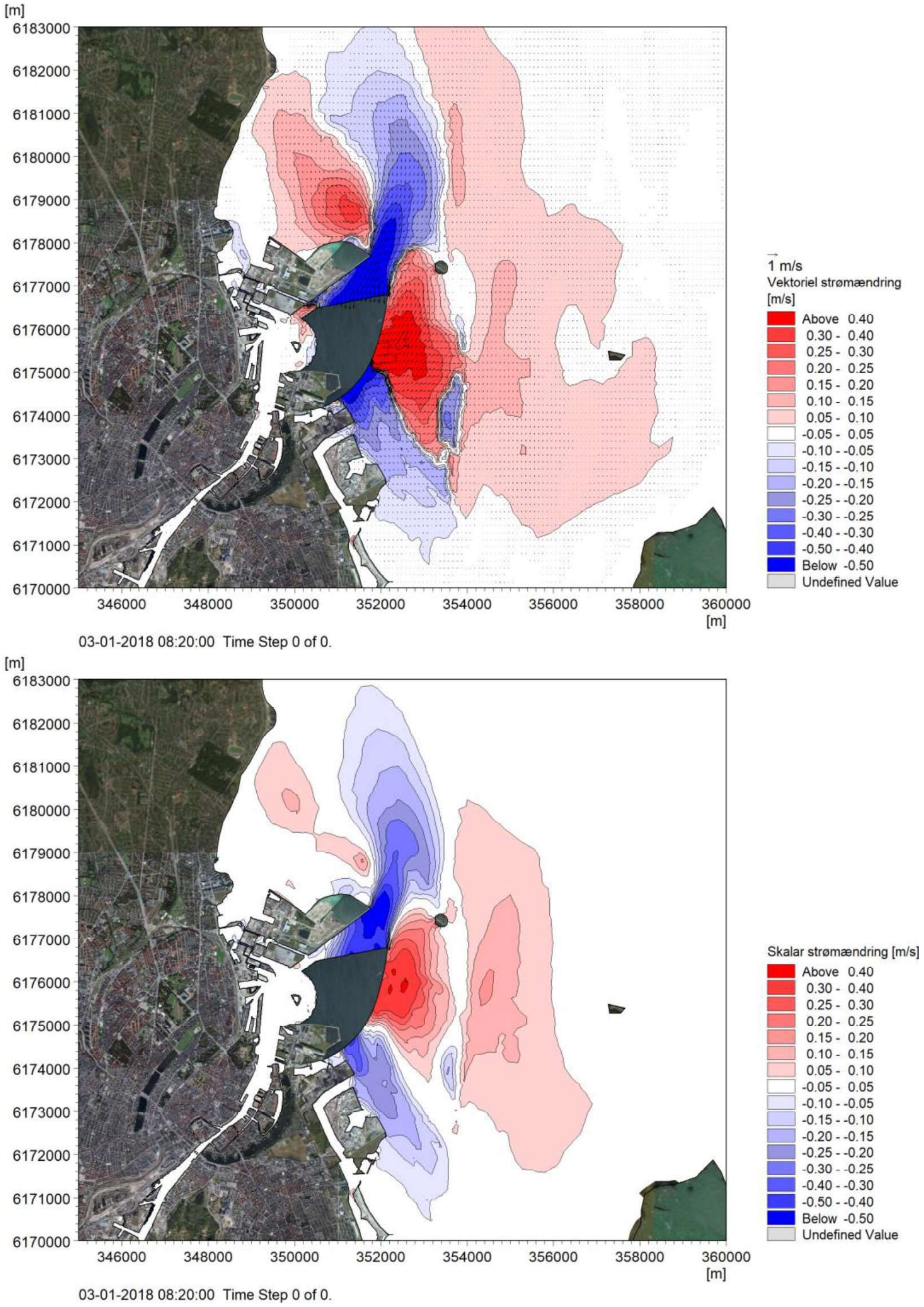

Figure 6-28 Vectorial (top) and scalar (bottom) calculated change of surface current for conditions with strong northbound current and Lynetteholm expansion without coastal landscape.

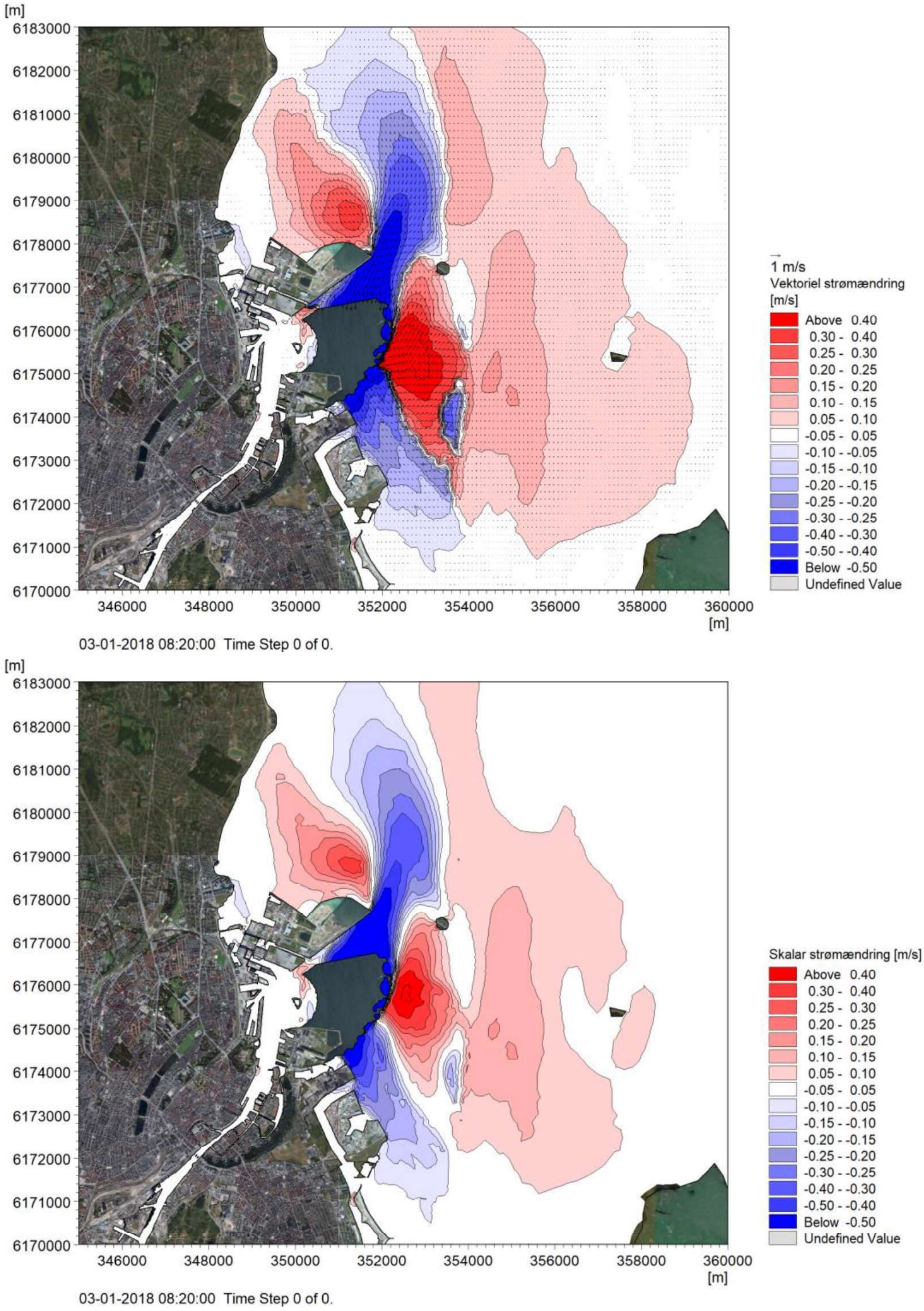

Figure 6-29 Victorial (top) and scalar (bottom) calculated change of surface current for conditions with strong northbound current and Lynetteholm expansion with coastal landscape.

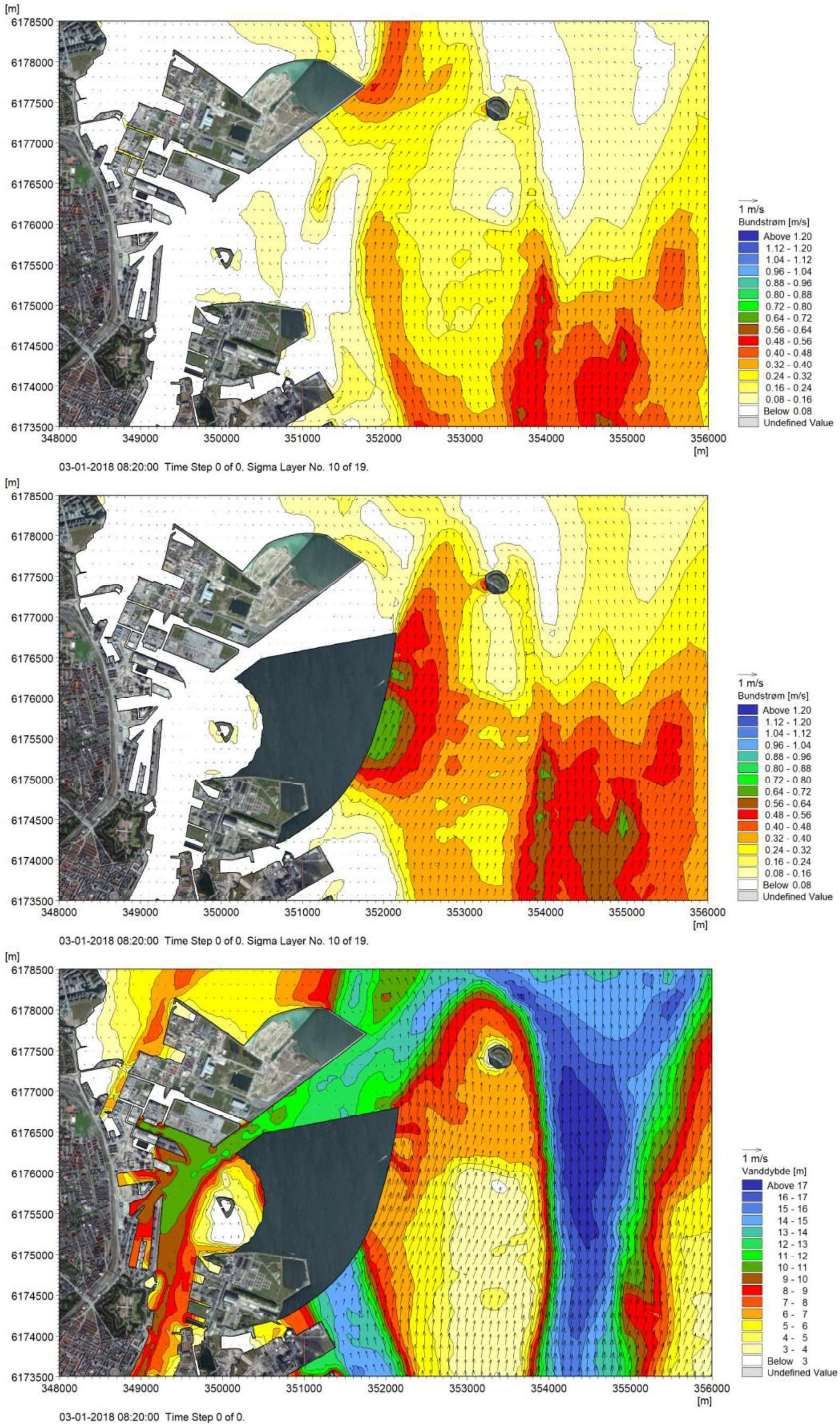

Figure 6-30 Bottom velocity in conditions with strong northbound current on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.

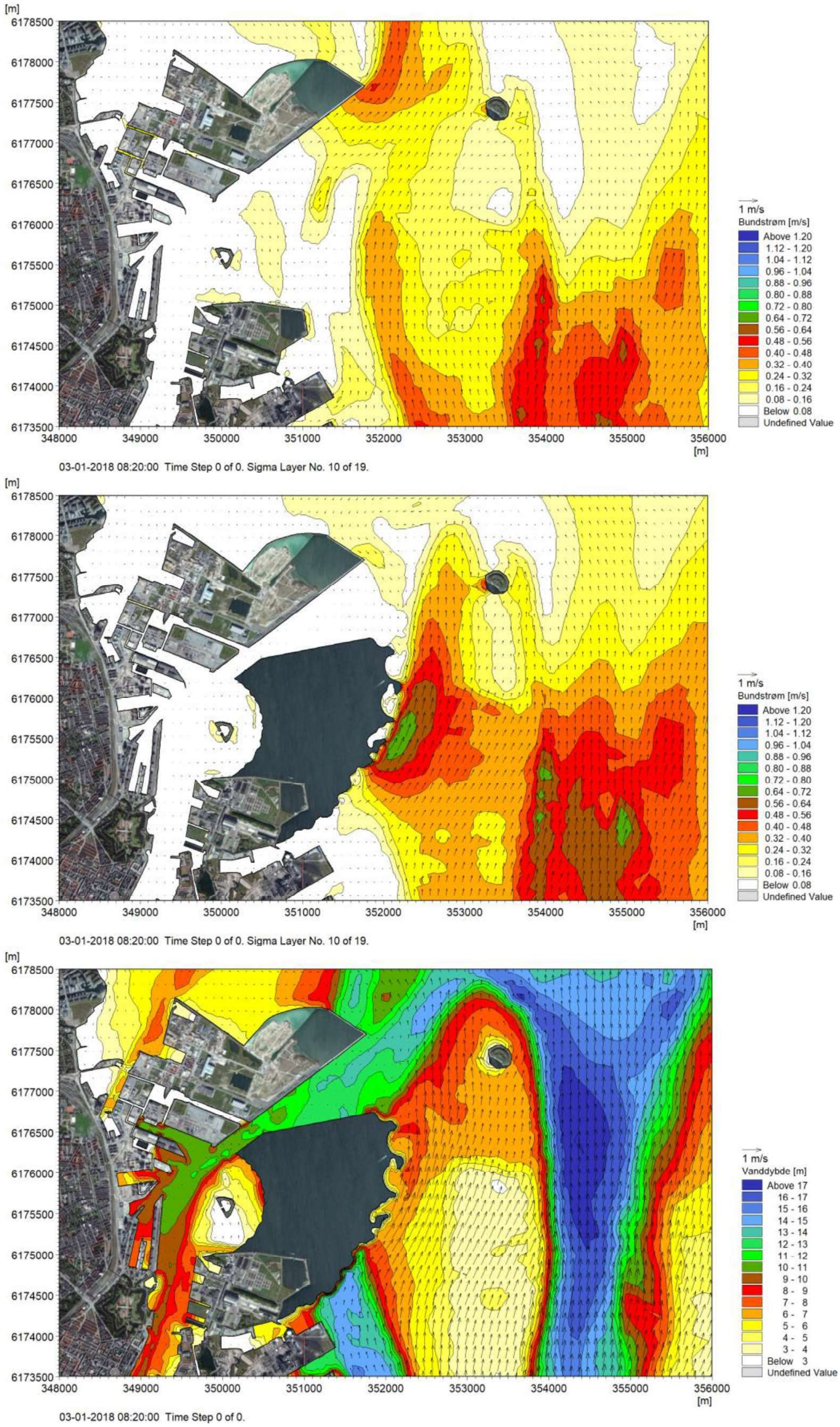

Figure 6-31 Bottom velocity in conditions with strong northbound current on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.

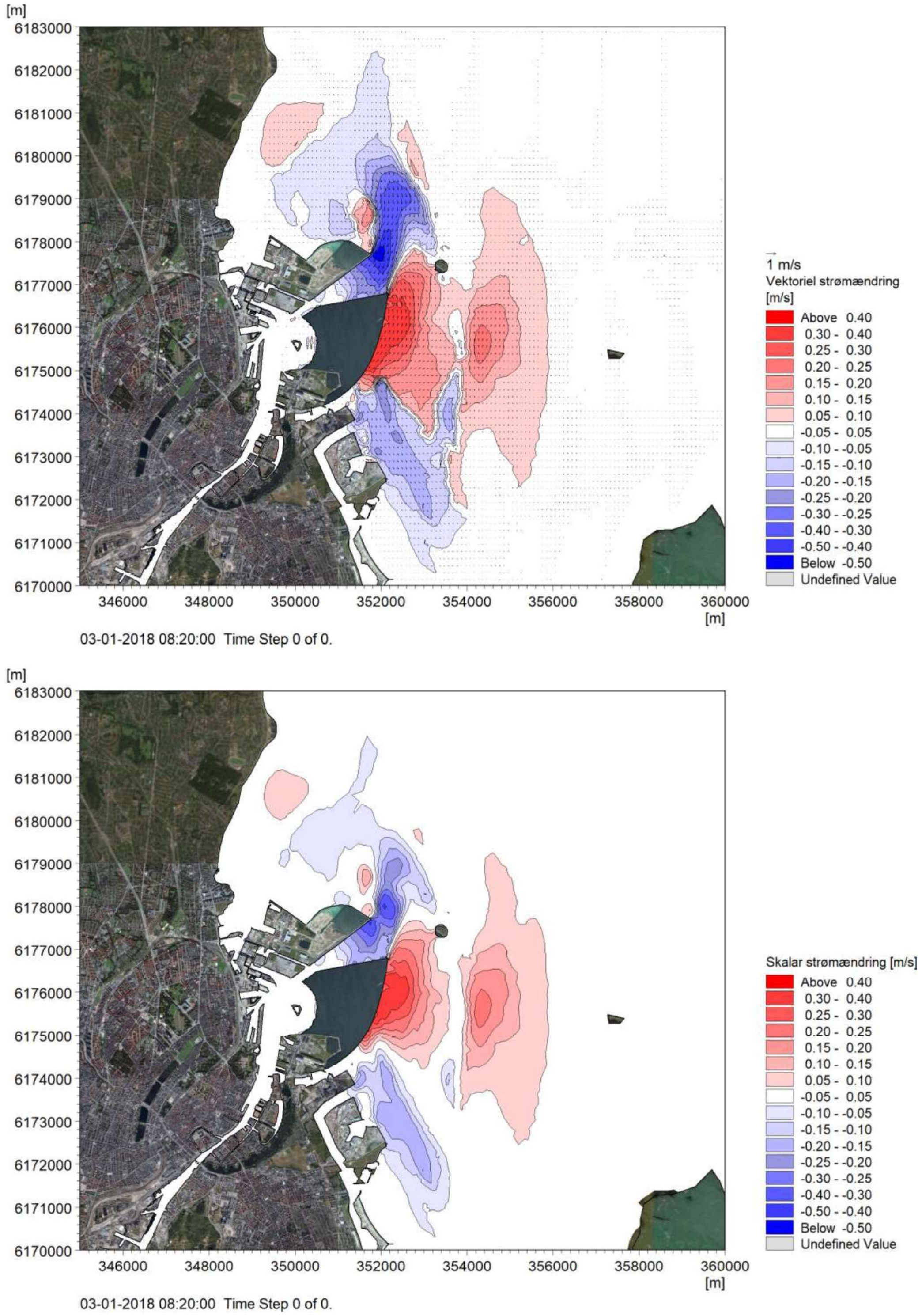

Figure 6-32 Vector (top) and scalar (bottom) calculated change of bottom current for conditions with strong northbound current and Lynetteholm reclamation without coastal landscape.

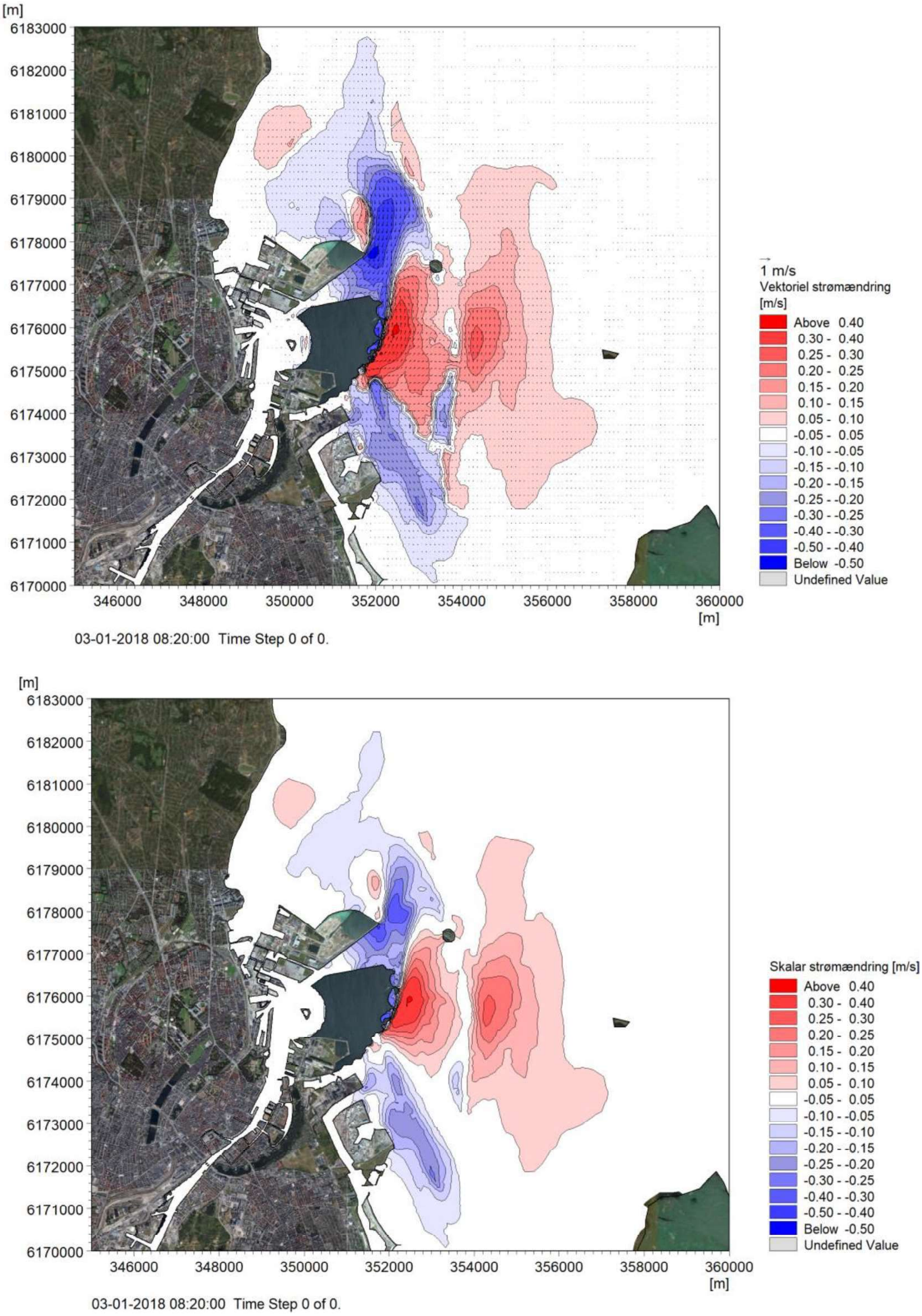

Figure 6-33 Vector (top) and scalar (bottom) calculated change of bottom current for conditions with strong northbound current and Lynetteholm reclamation with coastal landscape.

6.1.2.3 Depth-averaged current roses

The current fields shown in the previous section indicate that the local area where the current conditions may be affected is relatively large for some current situations. This section shows current roses in 14 extraction points distributed as shown in Figure 6-34.

The current roses give a depth-averaged picture of the current's directions, magnitude and duration, showing how it occurs in the given area. Comparing the current roses for the baseline and the two main proposals for the reclamation of Lynetteholm, respectively, presents an impression of the future current conditions and how much they will change in the given locations.

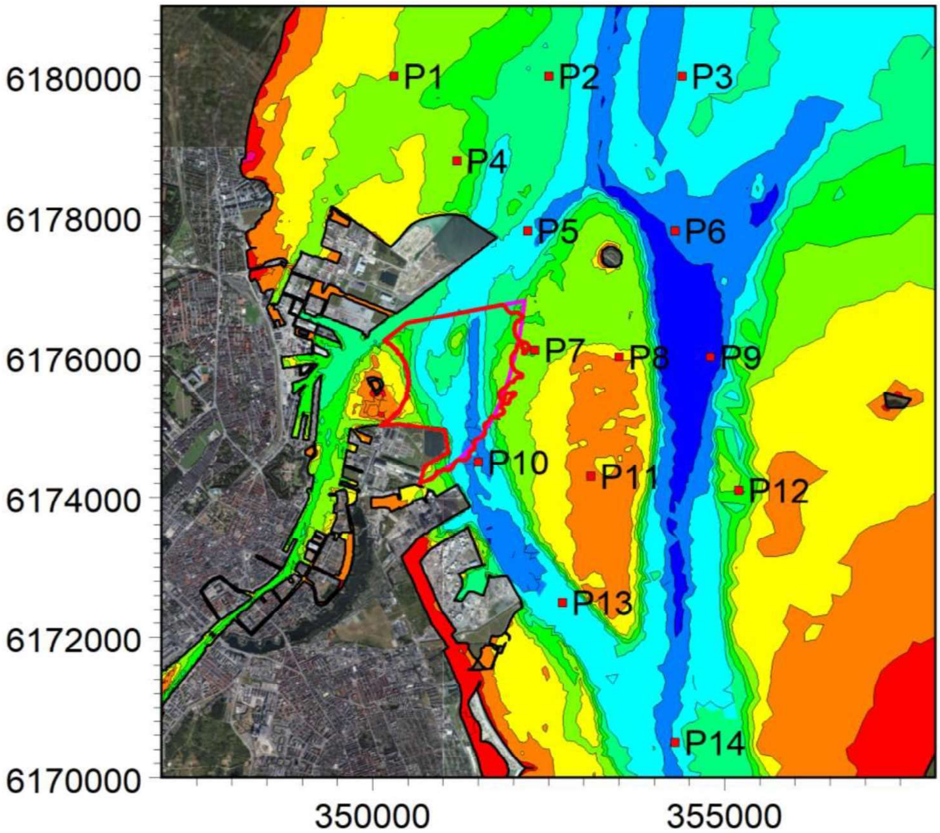

Figure 6-34 Current rose extraction points. Pink outline: Main proposal 1 - Lynetteholm bounded with a sheet pile wall and rubble mound protections. Red outline: Main proposal 2 - Lynetteholm with coastal landscape.

The current roses P1-P4 are located in the area north of the Nordhavn reclamation and Middelgrunden and are shown in Figure 6-35 for the existing conditions and the two main proposals for the Lynetteholm reclamation. The current roses show the direction in which the current runs and its magnitude according to the specified colour. Furthermore, the radial length of a field indicates the part of a year (expressed in %) during which the current situation in question is estimated to occur. Points P1 and P4 are located inside the zone that forms a recirculating counter-current flow in the area between the tip of Nordhavn and Skovshoved. A counter-current flow is a partially secluded area where a flow circulation occurs, driven by the through-flow out into the open part of Øresund. It can be seen that the current in the two points today is dominated by south, southeast-bound currents. The Lynetteholm reclamation will weaken this dominance, as there will be more current situations with a north, northwest-directed flow. Lynetteholmen is therefore seen to have an improving effect on the water exchange in this area. At P2, the southbound current is slightly reinforced, while there will be a noticeable weakening at the northbound current. At point P3, the effect is primarily a turn of the current of about 5 degrees counter-clockwise, for both southbound and northbound current, resulting from an increased flow through the Hollænderdybet.

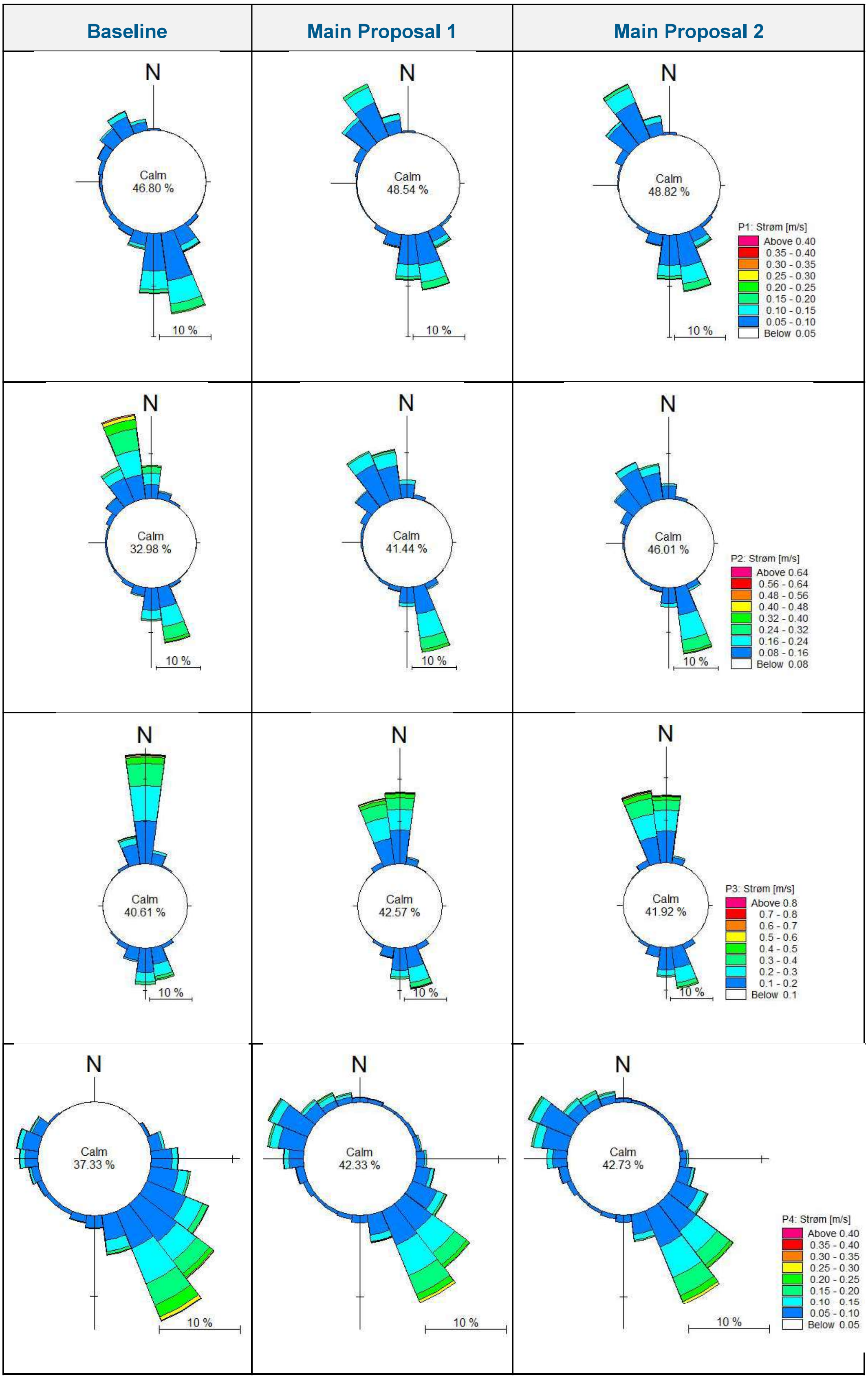

Figure 6-35 Current roses displaying the depth-averaged current velocities, directions, and occurrence in points P1-P4. Left side: Baseline, centre: Main proposal 1 and right side: Main proposal 2.

Points P5, P6 and P9 are located in Kronløbet and Hollænderdybet, respectively. The associated current roses are shown in Figure 6-36. The current in Kronløbet (P5) changes significantly with the construction of Lynetteholm. The flow through Kongedybet will be blocked, so today's powerful northbound currents will disappear and be replaced by much weaker currents. Approach by ships to the north side of the container terminal Nordhavns-reclamation will therefore be easier, as the area will no longer be exposed to strong cross-currents. In contrast, the mixing conditions at the Nordhavn tip, where surplus water is currently discharged from the Nordhavn-reclamation, will weaken. Likewise, the current directions are seen to turn at about 30 degrees counter-clockwise. In points P6 and P9 in Hollænderdybet, the changes are relatively limited. The primary effect is a weak current increase, which can most easily be seen because the period of calm current conditions becomes slightly shorter after the establishment of Lynetteholm. This also shows that the impact of Main Proposal 2 is slightly larger than in Main Proposal 1.

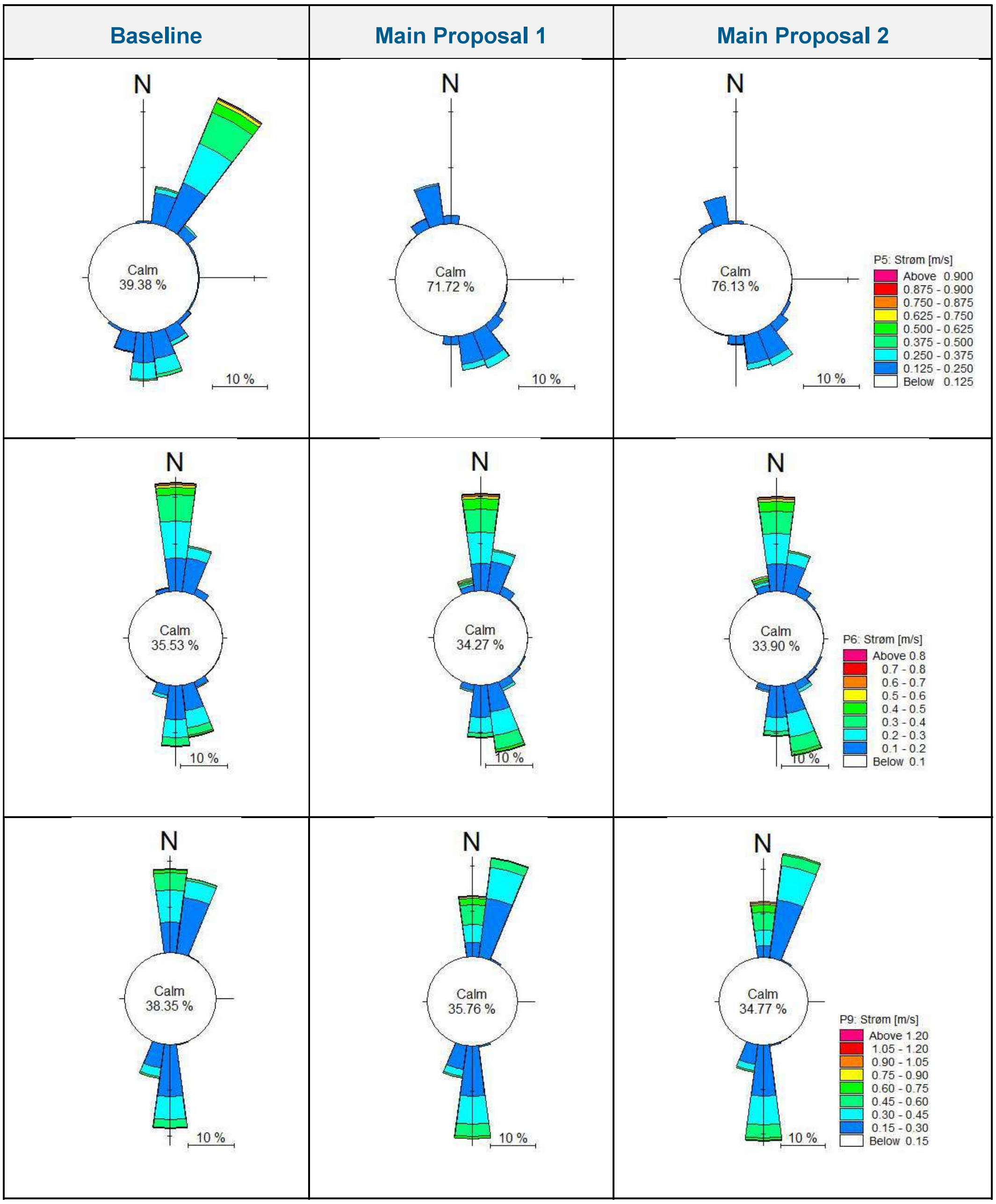

Figure 6-36 Current roses displaying current velocities, directions and occurrence in points P5, P6 and P9. Left side: Baseline, centre: Main proposal 1 and right side: Main proposal 2.

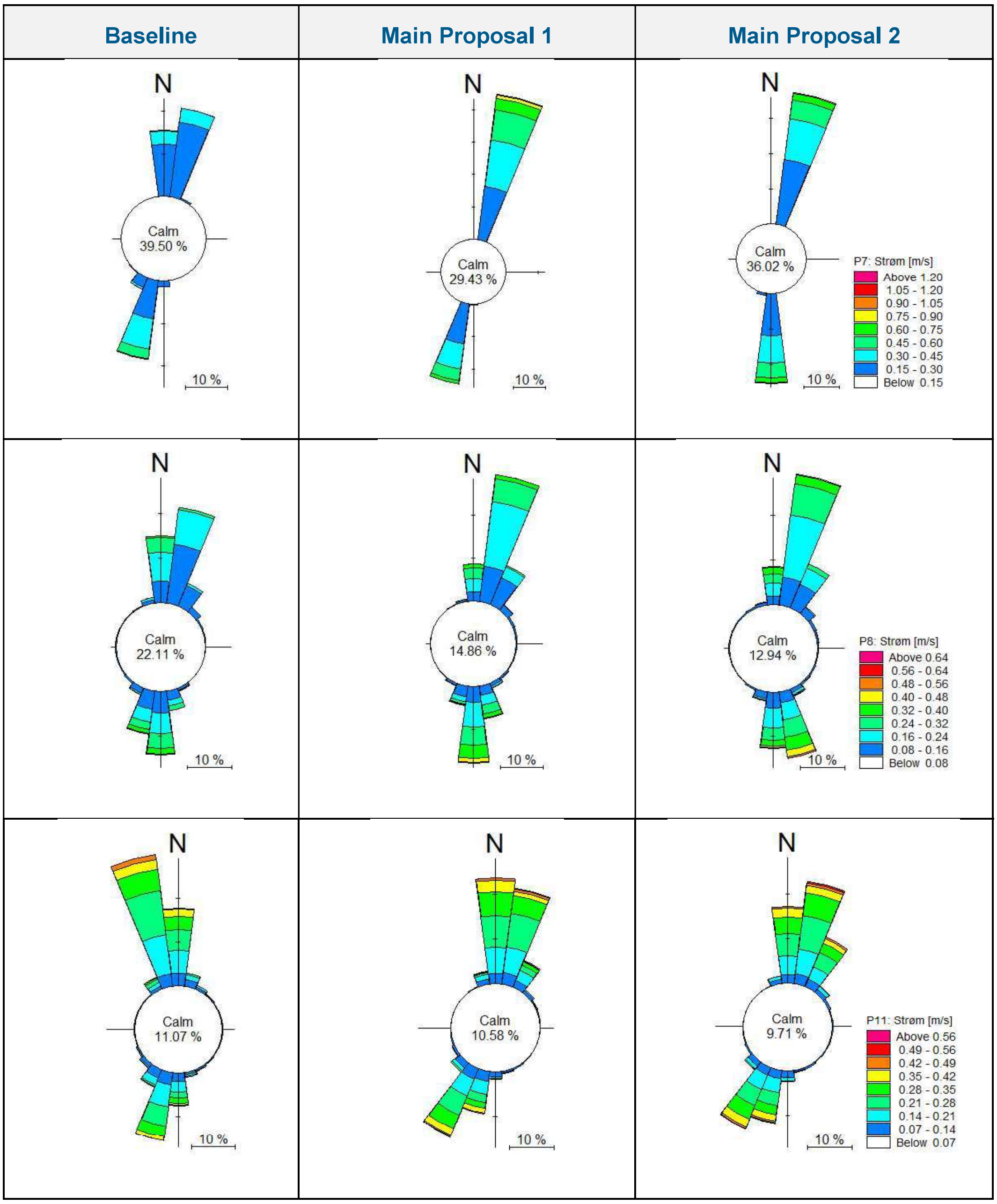

Figure 6-37 Current roses displaying current velocities, directions and occurrence in points P7, P8 and P11. Left side: Baseline, centre: Main proposal 1 and right side: Main proposal 2.

Points P7, P8 and P11 are located on Middelgrunden east of Lynetteholm. The associated current roses are shown in Figure 6-37. The point P7 is located just east of Lynetteholm, and since the water can no longer flow through Kongedybet, part of it is instead directed along the eastern periphery. Point P7, therefore, experiences a significant current increase, not least in situations with a northbound current. The northbound current directions are relatively unchanged, while the southbound currents turn about 15 degrees counter-clockwise in the Main Proposal 2. In Main Proposal 1, they do not change. Point P8 is located at a somewhat greater distance to Lynetteholm, but also here is an amplification of the current. The current directions are rotated slightly clockwise at the northbound current direction and at about 15 degrees counter-clockwise for Main Proposal 2 at a southbound current direction. Point P11 is located on Middelgrunden further south. Here is also a weak current amplification, but the biggest changes relate to a turning of the current of about 15 degrees clockwise at both north and southbound currents. The turning of the current relates to the closure of Kongedybet, which will direct more water between the Hollænderdybet and Kongedybet across the southern part of the Middelgrunden. Please note that the current scale is adapted to the current conditions at the individual points, as the primary purpose is to illustrate the impact in the individual point and not across the points.

P10 and P13 are located in Kongedybet. The former is located close to Lynetteholm and near Amager Power Station. It can be seen that the current weakens significantly in the area as a result of the Lynetteholm reclamation. The water exchange will therefore be reduced and may impact Amager Power Station's use of cooling water. In point P13, located in the southern part of Kongedybet, the northwest and southeast currents are weakening, while the main current directions remain unaffected.

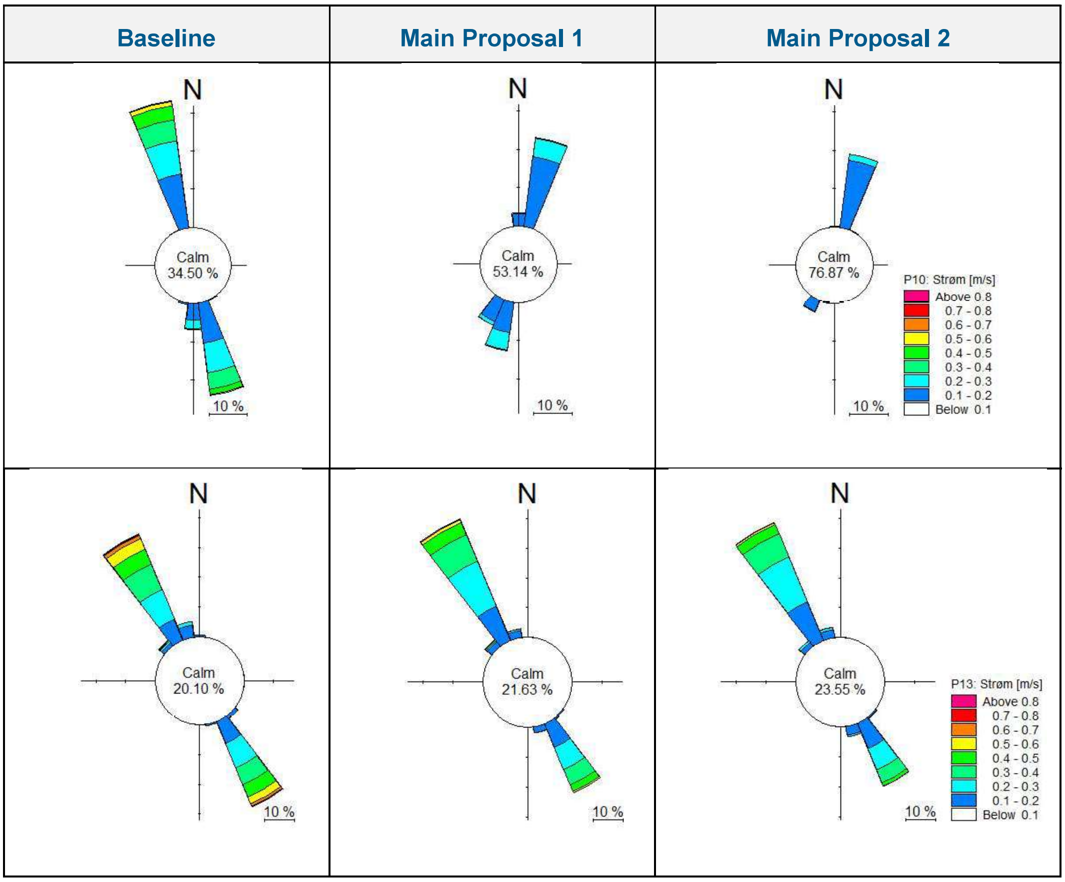

Figure 6-38 Current roses displaying current velocities, directions and occurrence in points P10 and P13. Left side: Baseline, centre: Main proposal 1 and right side: Main proposal 2.

Current roses belonging to points P12 and P14 are shown in Figure 6-39. The point P12 is located on the transition between Hollænderdybet and Saltholm Flak. Here is a current increase due to the closure of Kongedybet, which will lead to more water through Hollænderdybet. The northbound currents are rotated approximately 7 degrees clockwise. Point P14 is located south of Svælget (the confluence) at the entrance to Drogden. Here is a very modest current increase but no impact on the current directions.

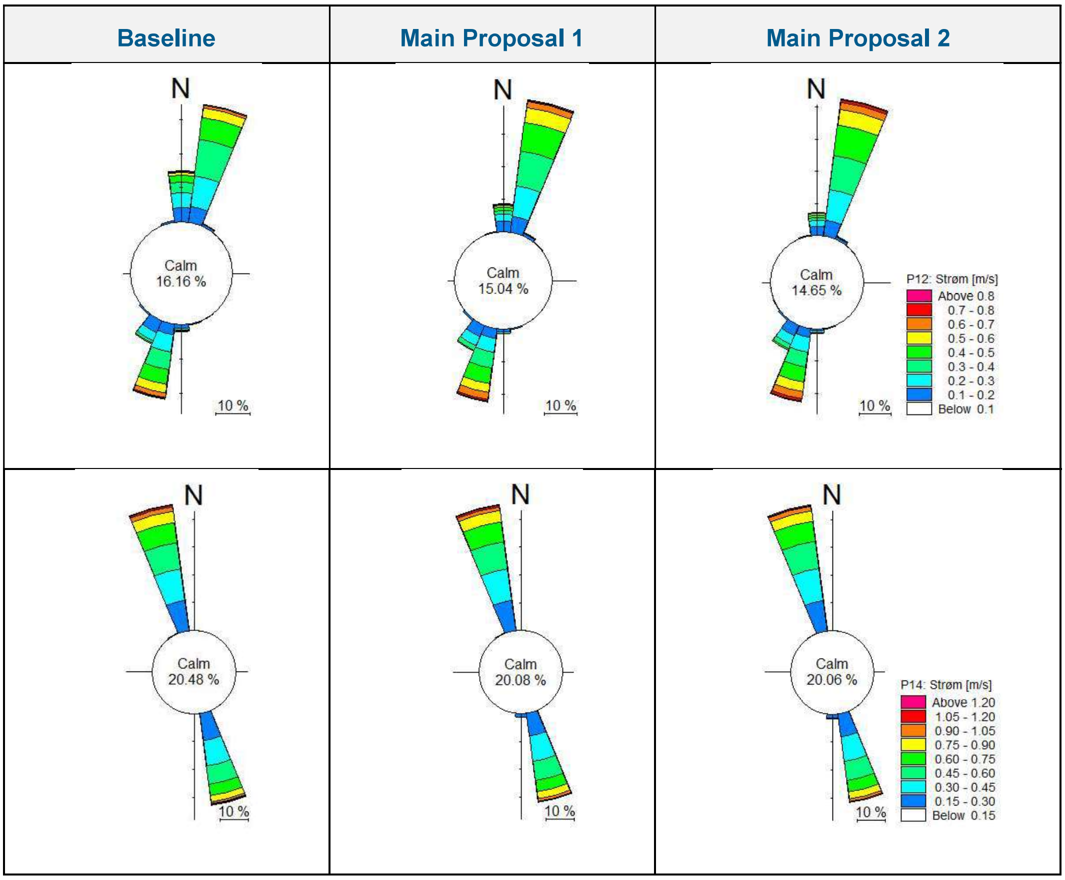

Figure 6-39 Current roses showing current velocities, directions and occurrence in points P12 and P14. Left side: Baseline, centre: Main proposal 1 and right side: Main proposal 2.

6.1.2.4 Impact on current conditions in the funnel between Lynetteholm and Nordhavn

The depth-averaged current plots can easily give the impression that the current is weak in the funnel between Lynetteholm and Nordhavn as well as in Havneløbet (the inner harbour). However, this is not entirely true since there often is a layered bidirectional flow in the outer part. To illustrate the importance of three-dimensional current effects and their impact on the project, the depth-averaged current and surface and bottom current have been extracted in the three points P1-P3 indicated in Figure 6-40. The map shows the bathymetry in the area and the outline of the two main proposals for the Lynetteholm reclamation. The pink contour shows the outline of Main Proposal 1, while the red contour shows Main Proposal 2. In places of overlap, the red contour is used.

Point P1 is located in Kronløbet in the inner part of the funnel. Current roses are shown in Figure 6-41 for baseline and the two main proposals. It can be seen that the depth-averaged current is significantly weakened after a reclamation, but that surface current and bottom current are reinforced compared to the baseline. The primary reason for this is effects from density-driven currents and opposite directed flow at the surface and bottom. In the baseline situation P1 is located outside the protected part of the harbour (i.e. in Øresund), where density gradients are smoothed out and 3D effects less significant.

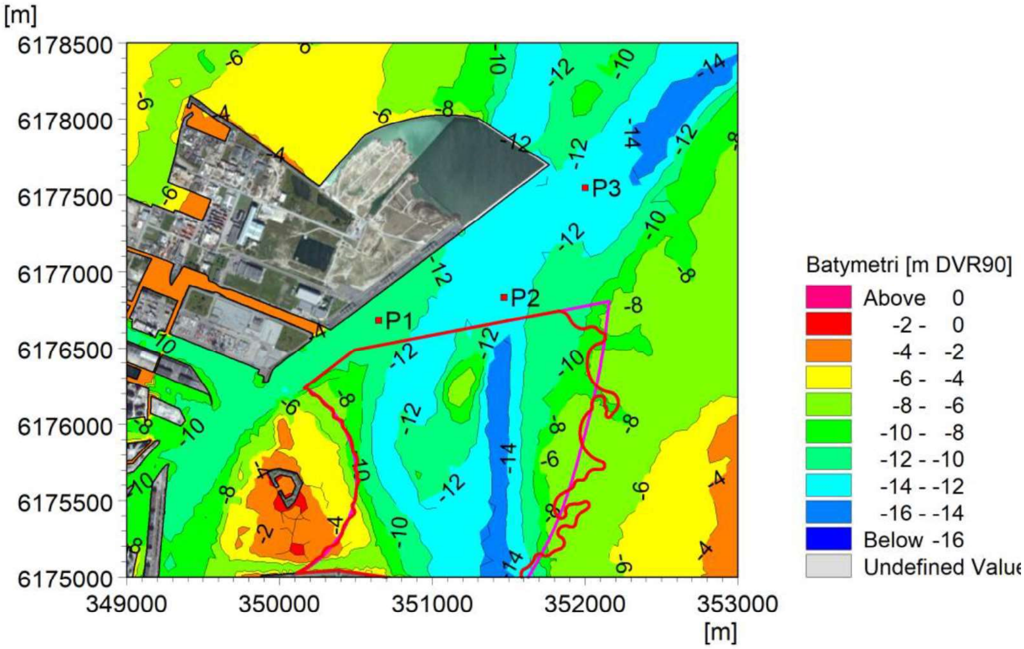

Figure 6-40 Current extraction points P1-P3.

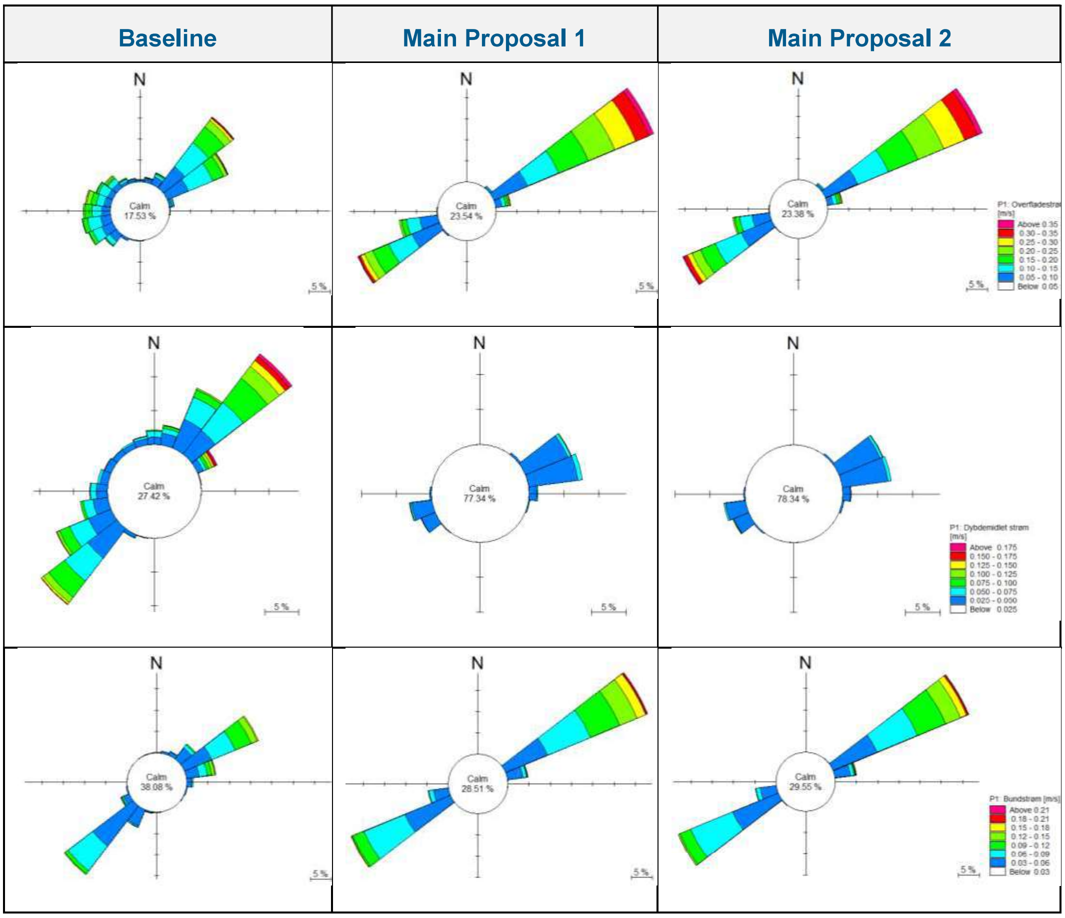

Figure 6-41 Current roses in P1 for baseline and the two main proposals. Top: surface current, middle: depth-averaged current and bottom: bottom current.

Point P2 is located in the transition between Kronløbet and Kongedybet. Current roses belonging to this point are shown in Figure 6-42. For baseline conditions, there is almost always northbound current at the surface, while the bottom current and the depth-averaged current can go both in a north-easterly and a south-westerly direction. With the construction of Lynetteholm, the current through Kongedybet will be cut off. Therefore, the current velocities will decrease considerably, and the main current directions will change to run parallel to the reclamation. P2 is located in the broader part of the funnel, where the flow cross-section is significantly larger than at P1. The current velocities are, therefore, somewhat smaller than at P1. The strongest bottom currents occur in the flow directed towards havneløbet (the inner harbour) but occur less frequently than flow directed away from havneløbet.

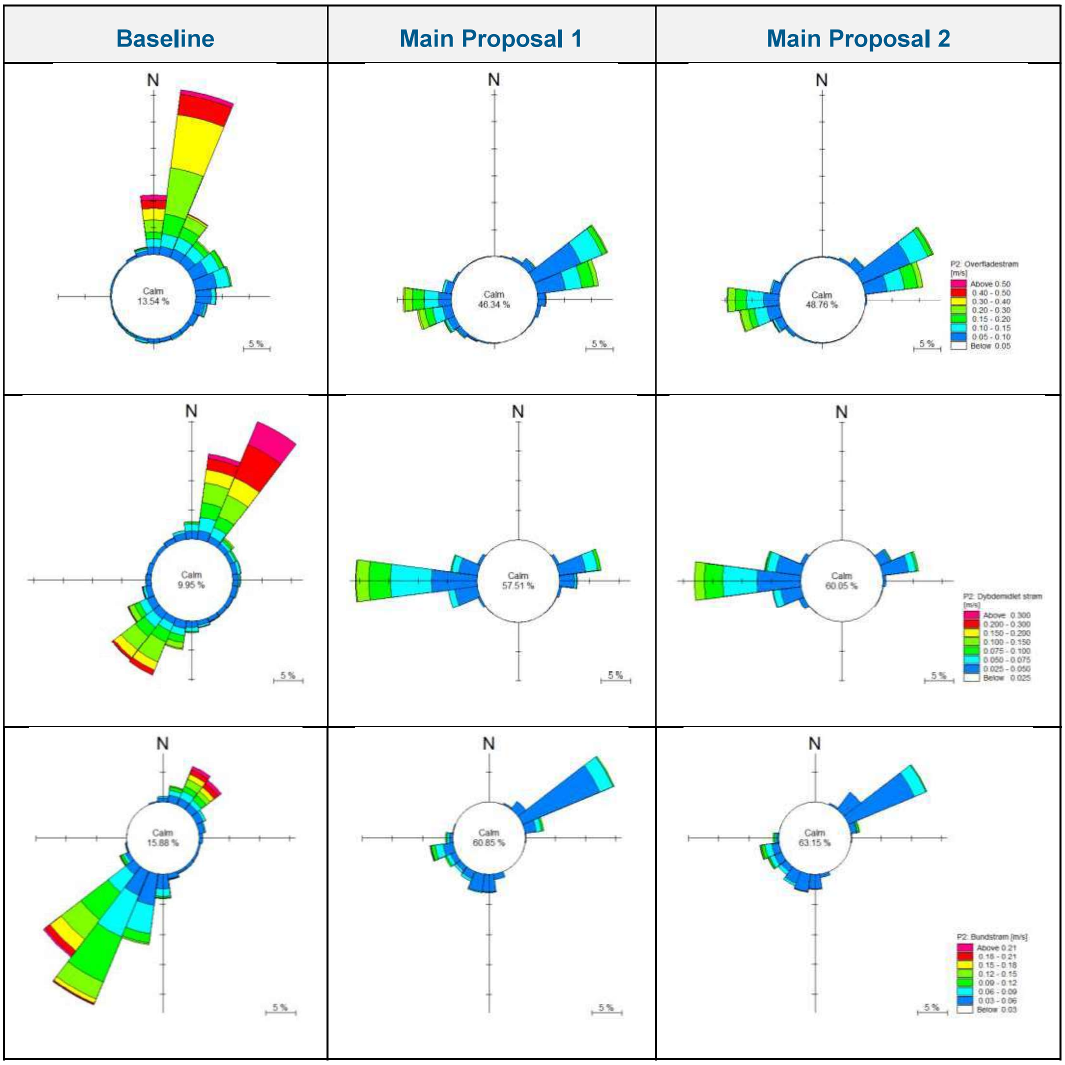

Figure 6-42 Current roses in P2 for baseline and the two main proposals. Top: surface current, middle: depth-averaged current and bottom: bottom current.

Point P3 is located in the outer part of the funnel. The corresponding current roses are shown in Figure 6-43. In the baseline situation, the current in this area is quite strong. The main directions of the bottom current primarily follow the direction of Kronløbet (north-northeast, south-west), while the main directions of the surface current are directed towards the north-east and south. With the construction of Lynetteholm, the surface current and the depth-averaged current are rotated so that they are directed across the funnel and along the eastern perimeter of the reclamation. The direction of the bottom current is less well defined. It is usually oriented either to the north-northeast or south-southwest, but the strongest bottom currents occur when the flow is directed across the funnel.

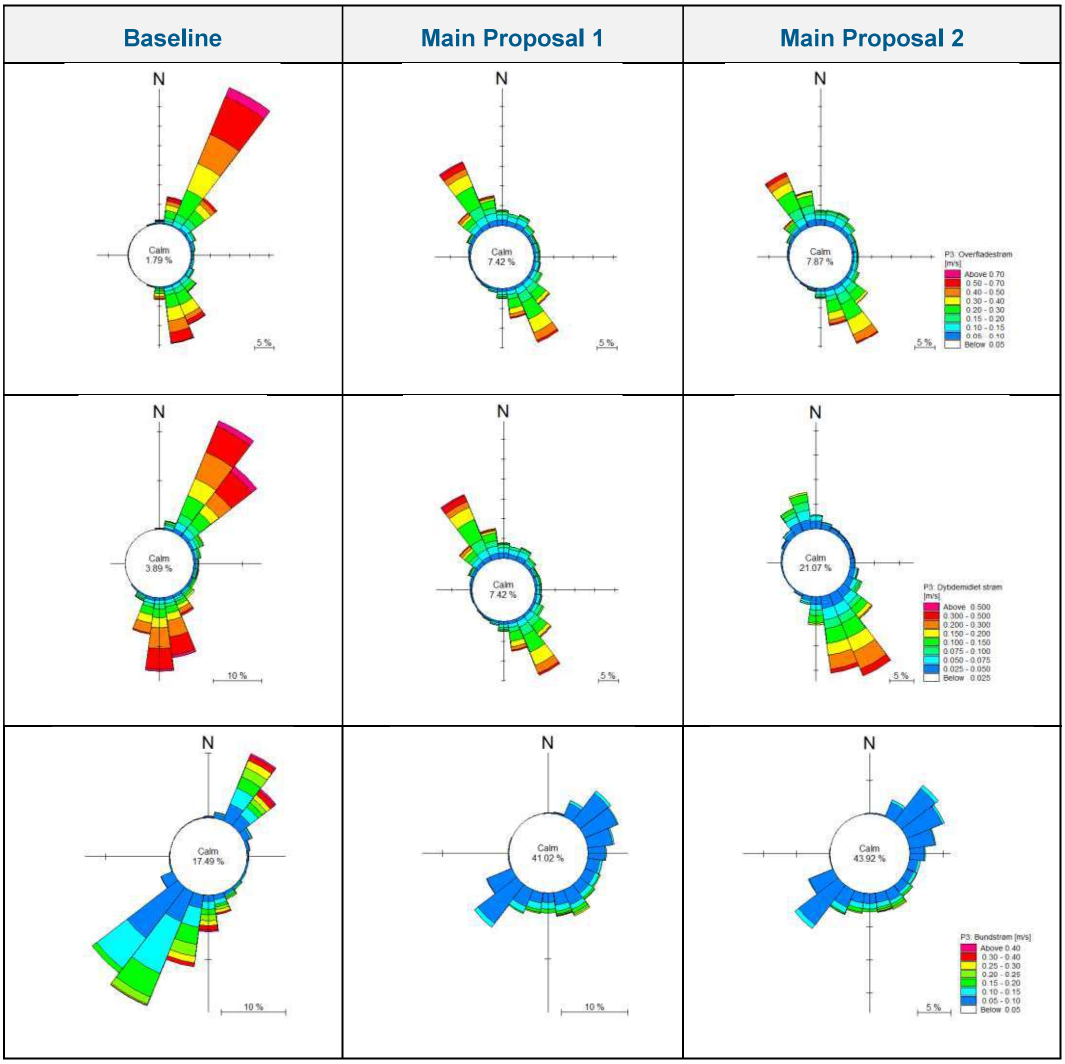

Figure 6-43 Current roses in P3 for baseline and the two main proposals. Top: surface current, middle: depth agent current and bottom: bottom current.

6.1.2.5 Impact of gross-flow

The extreme current situations described in sections 6.1.2.1 and 6.1.2.2 only appear at long intervals and therefore do not present a clear picture of the extent of the area experiencing a more permanent impact. To identify the primary impacted area, analyses based on the gross flow and the impact of the project on it have been carried out. Based on the modelled current speeds in 2018, the annual mean of the depth-averaged current velocity is calculated for baseline and the two main proposals for a Lynetteholm reclamation. Since the calculation does not consider the direction of the current, this is referred to as the gross flow.

The annual gross flow is a good measure of the impact which the area experiences over a whole year. Figure 6-44 shows the calculated gross flows for baseline condition, while Figure 6-45 and Figure 6-46 show calculated gross flows for each of the two main proposals. Both proposals show a marked weakening of the gross flow in Kronløbet and in Kongedybet south of Lynetteholm. East of Lynetteholm is a reinforcement of the gross flow across Middelgrunden.

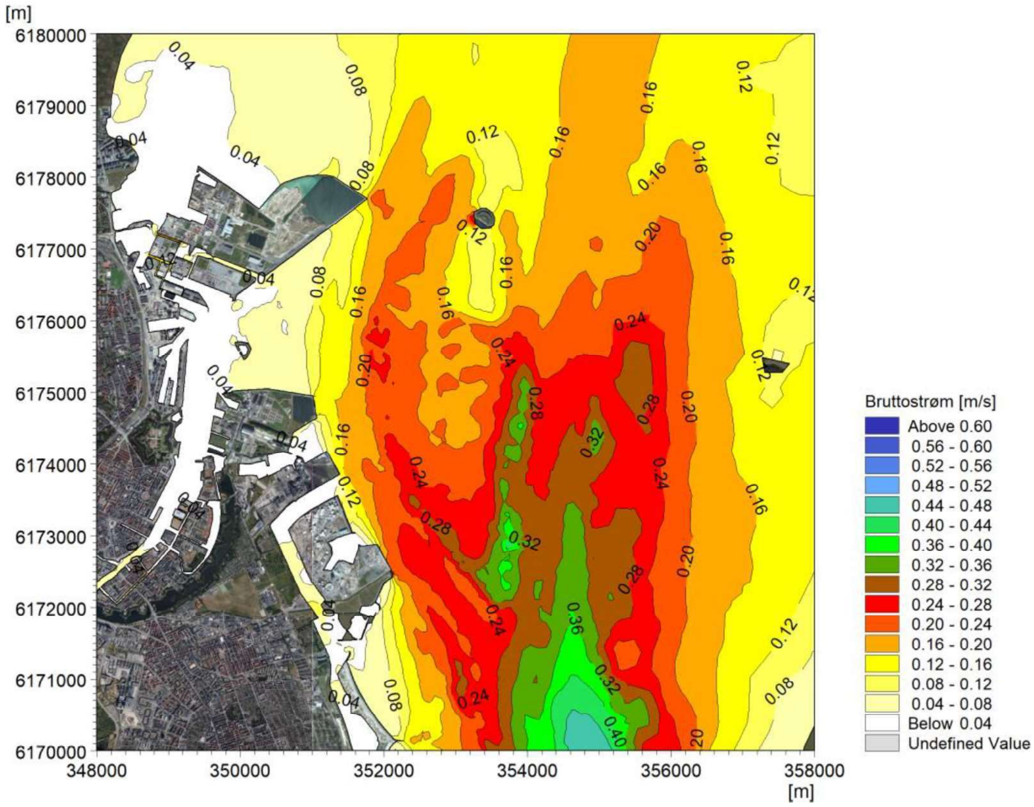

Figure 6-44 Annual average of the depth-averaged gross current with baseline conditions.

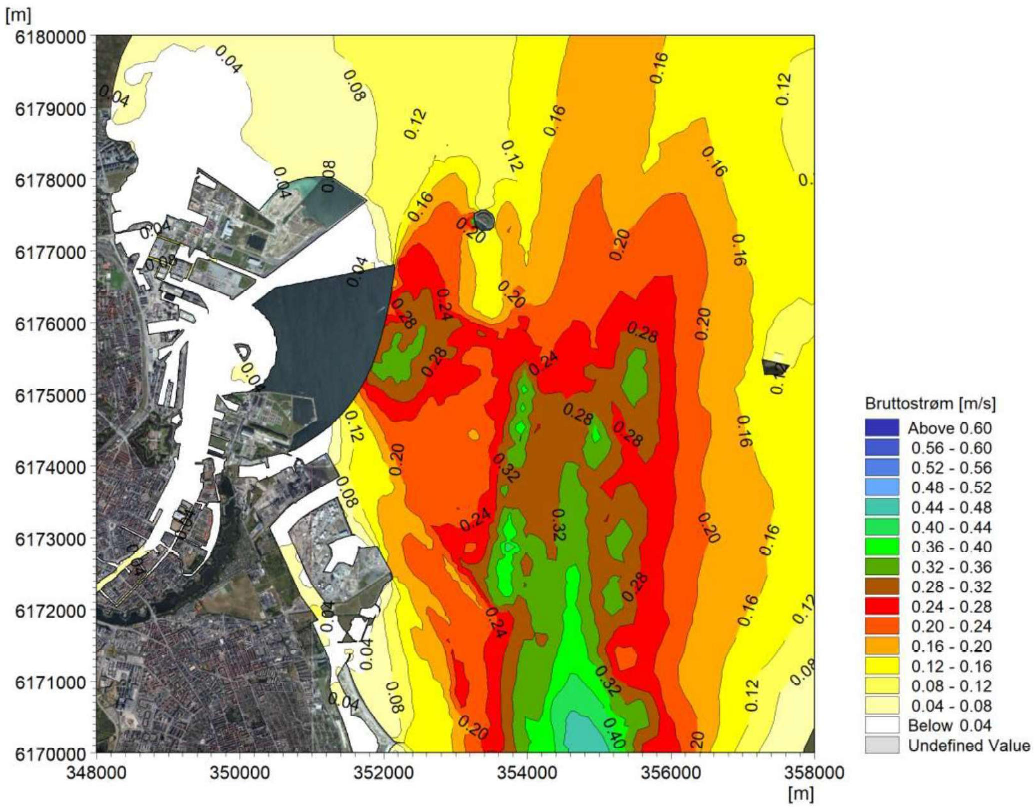

Figure 6-45 Annual average of the depth-averaged gross current with Main Proposal 1 reclamation.

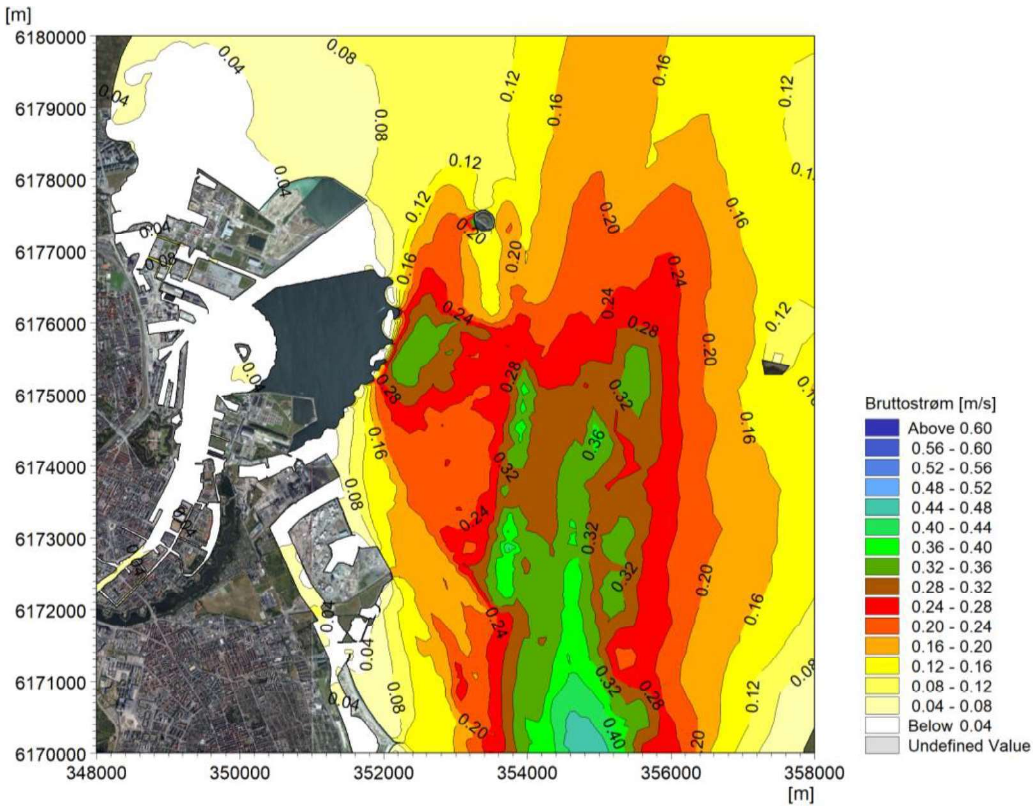

Figure 6-46 Annual average of the depth-averaged gross current with Main Proposal 2 reclamation.

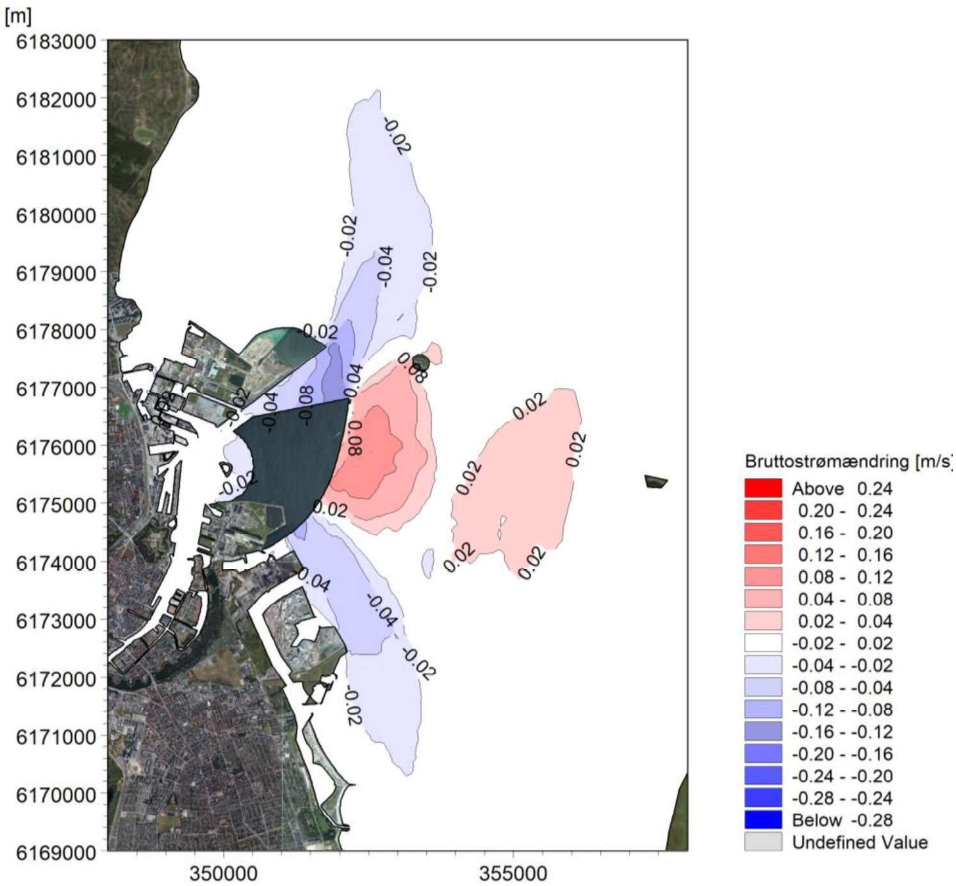

Figure 6-47 Main Proposal 1. Change of annual average of gross current (depth-average).

The primary impact area can be identified by a gross flow difference plot; such a plot illustrates where there will be increased and weakened dynamics, respectively. Figure 6-47 shows the changes in the gross current expected with the Main Proposal 1 reclamation. It can be seen that the gross flow is increased east of the reclamation across Middelgrunden and in Hollænderdybet in the area between Middelgrundsfortet and Flakfortet. The red areas indicate the primary area where a minor effect of erosion would usually be expected, while the blue colours are areas where eroded sediment could potentially be deposited due to the weakened dynamics of the area. Middelgrunden is a natural reef, where the Copenhagen limestone is close to the bed surface, and the sediment layers above have a modest thickness. The resulting current increase is therefore only expected to lead to a modest actual erosion. In Figure 6-48, the corresponding plot is shown for Main Proposal 2. The extent of the impacted area is slightly larger than for Main Proposal 1, but the current amplification also occurs here in areas where the Copenhagen limestone is close to the surface, and the extent of erosion will be limited.

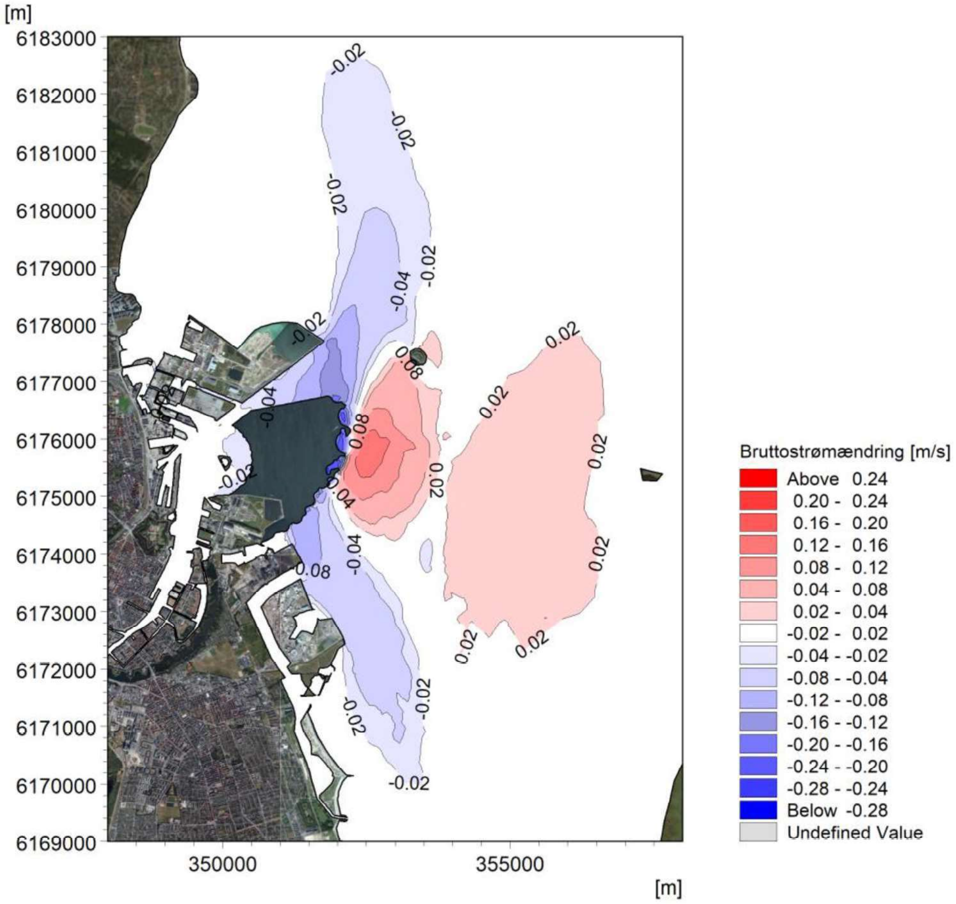

Figure 6-48 Main Proposal 2. Change of annual average of gross current (depth-average).

Based on the modelled year (2018), the maximum depth-averaged current velocity is identified and extracted. Therefore, the current velocities found do not represent the conditions at a specific time, as there may be time lags regarding when the highest current velocity occurs at a given location. The statistically calculated maximum current rates are shown in Figure 6-49 for baseline conditions and in Figure 6-50 and Figure 6-51 for the two main proposals, respectively. It can be seen that the current velocities exceed 1 m/s in the area just east of Lynetteholm but that the current velocities are somewhat lower than those that frequently occur in the Drogden trench further south. In Main Proposal 2, the current inside the protected bays is of modest strength so that bathing can take place shielded and safe. However, it is also apparent from the plots that moving outside the protected areas would involve significant risk.

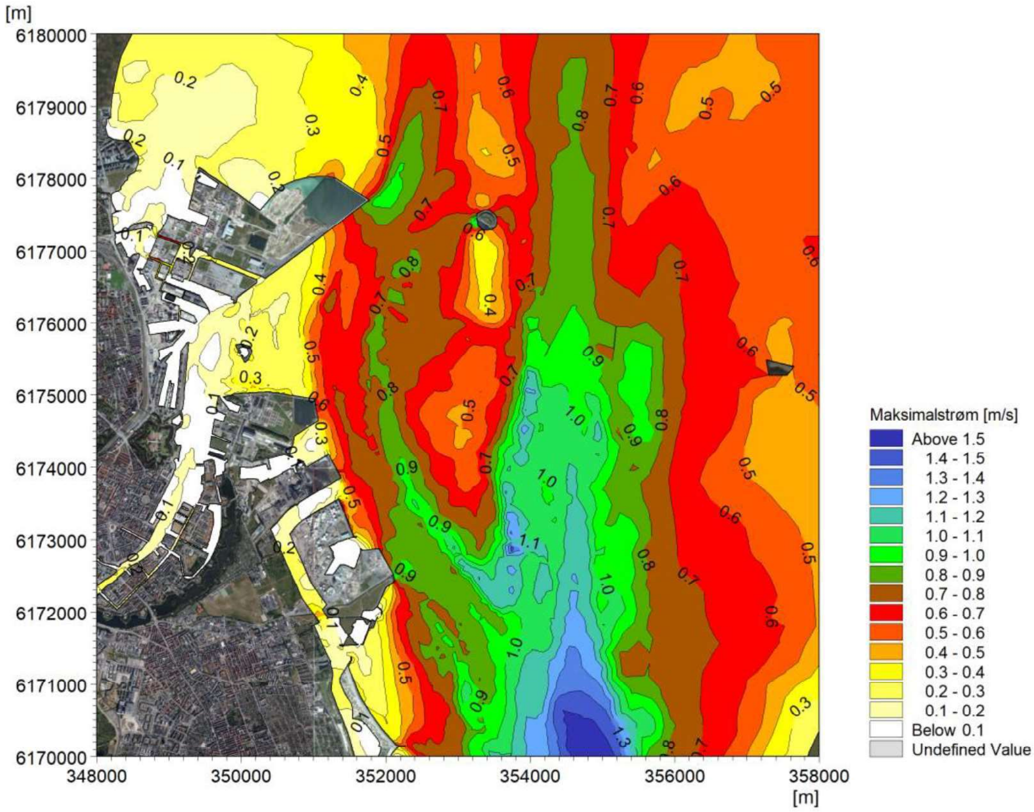

Figure 6-49 Maximum depth-averaged current year 2018 with baseline conditions.

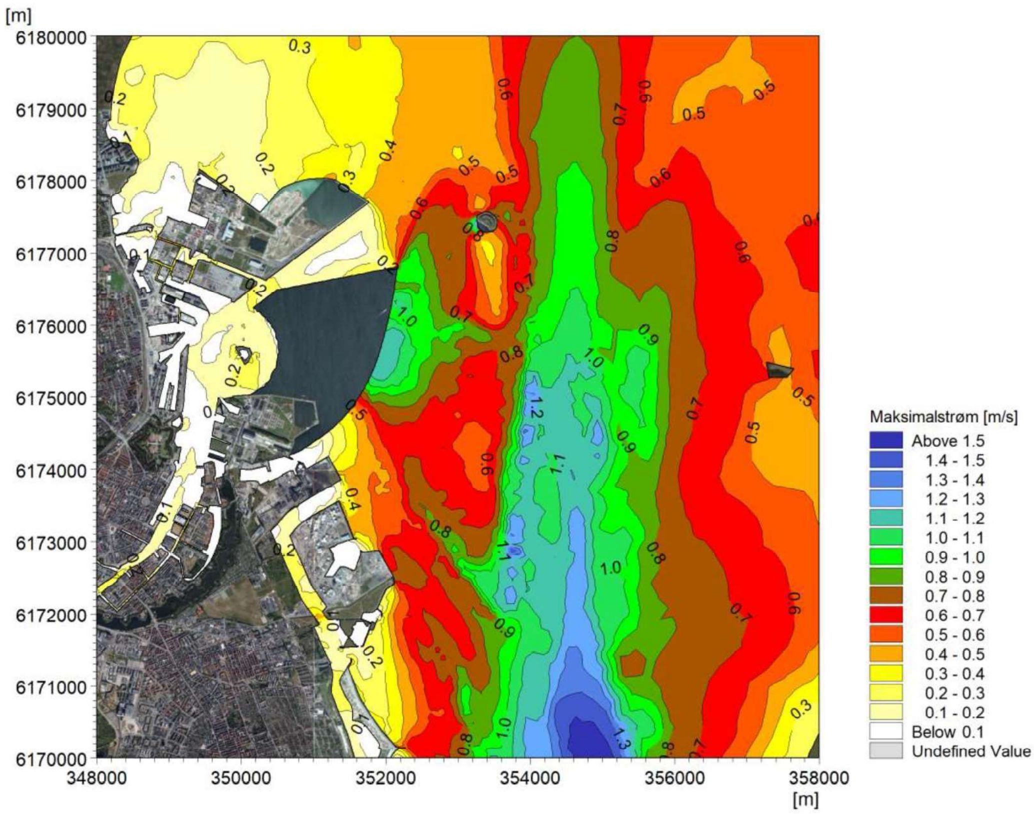

Figure 6-50 Maximum depth-averaged current year 2018 with Main Proposal 1 reclamation.

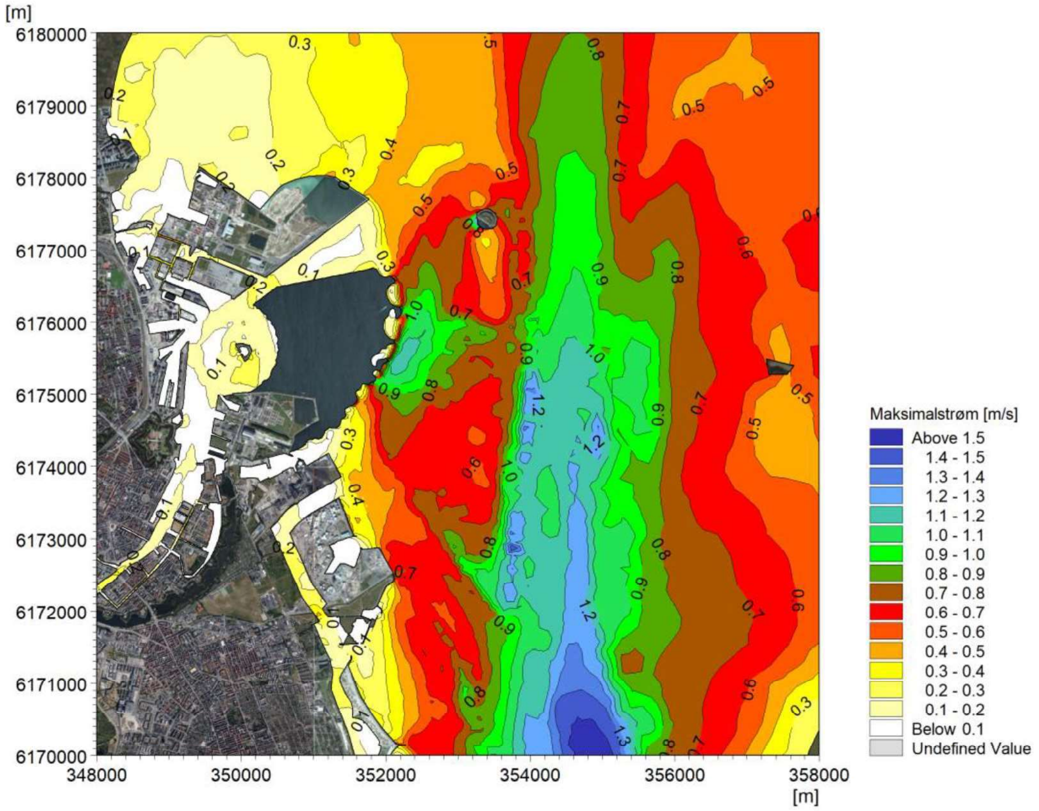

Figure 6-51 Maximum depth-averaged current year 2018 with Main Proposal 2 reclamation.

The changes in the depth-averaged maximum current are shown in Figure 6-52 for Main Proposal 1 and in Figure 6-53 for Main Proposal 2. The areas illustrated here can be seen as a secondary impact area where erosion in the red areas is occasionally likely. Similarly, the blue colours indicate areas where eroded sediment may be deposited. It can be seen that the impact area of Main Proposal 2 is slightly larger than Main Proposal 1.

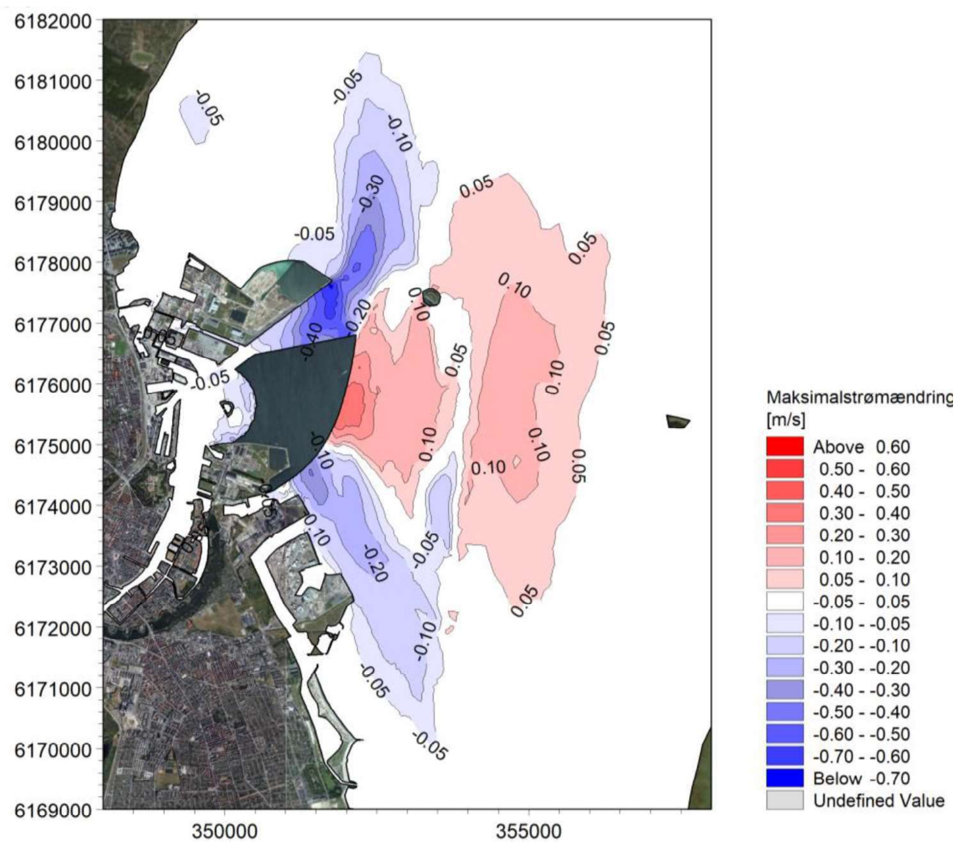

Figure 6-52 Main Proposal 1. Change of maximum depth-averaged current.

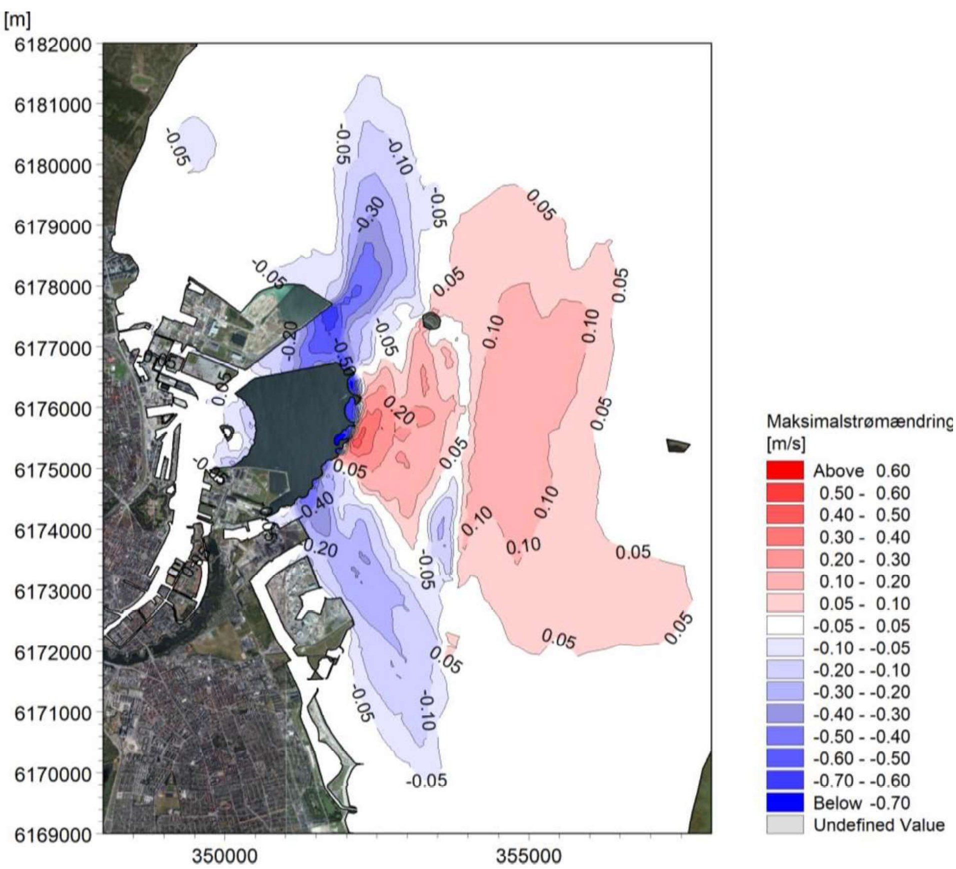

Figure 6-53 Main Proposal 2. Change of maximum depth-averaged current.

6.1.3 Assessment of changes in water temperature

The water exchange through the deeper channels in the Sound often brings warmer or colder water. Therefore, the closure of Kongedybet will have a local effect on the transport of water and "heat" in the area. Furthermore, the dynamics (water exchange) tend to attenuate in parts of the area, which will typically lead to a slightly stronger solar heating in the summer months and slightly more severe cooling in the winter season.

6.1.3.1 Annual average water temperature

The water temperature varies a lot over the year due to an annual variation. In areas where the water exchange is reduced, there will be a tendency for slightly more vigorous heating in the summer and marginally more cooling in winter. The two effects will level out when looking at a mean temperature, which is why the project's impact on the annual means will be relatively limited. Since the yearly variation of the water temperature can be approximated with a sine oscillation, the mean annual temperature will typically represent conditions similar to the spring and autumn months.

Figure 6-54 to Figure 6-56 show the calculated annual mean water temperature (depth-average) for the whole of 2018 for baseline conditions and the two main proposals. It can be seen that the variations in water temperature are relatively limited (ranging from 10.2-10.7 °C). The highest water temperatures are seen to occur in areas with lower water depths, while the coldest ones occur in areas with larger water depths. The warm area along the northern part of Saltholm is because the area is not always water covered and therefore are not averaged in the same way as the areas with constant water cover. The mean temperatures are found by statistical analysis and therefore do not reflect a snapshot.

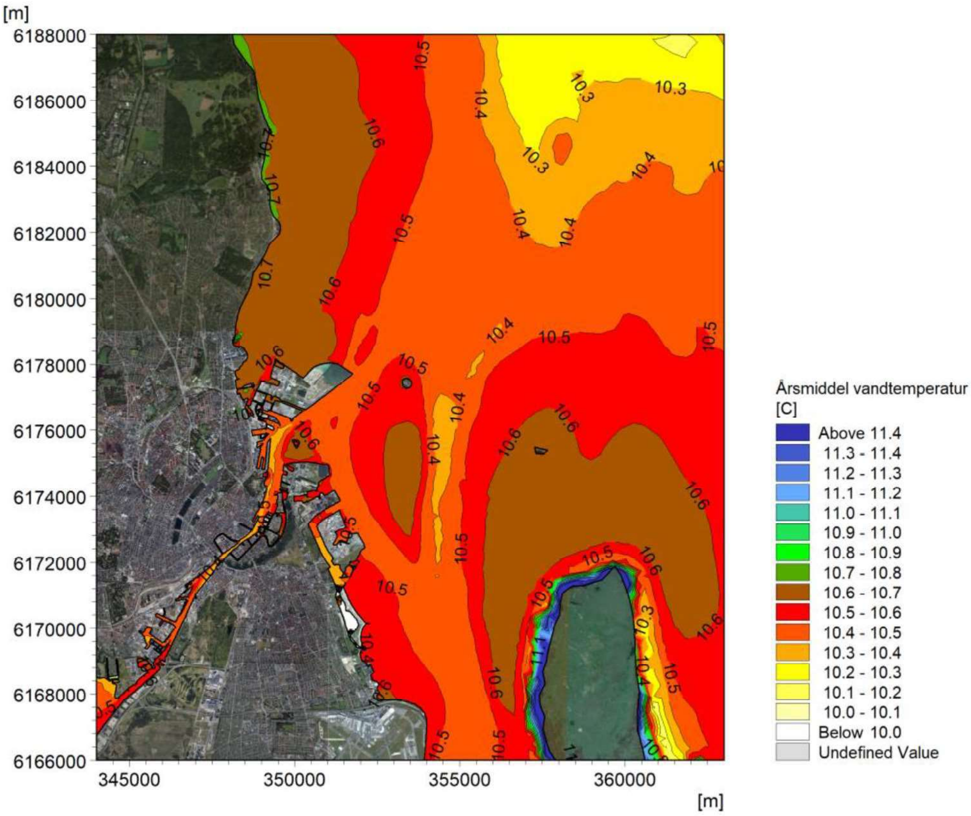

Figure 6-54 Annual average of depth-averaged water temperature for baseline conditions.

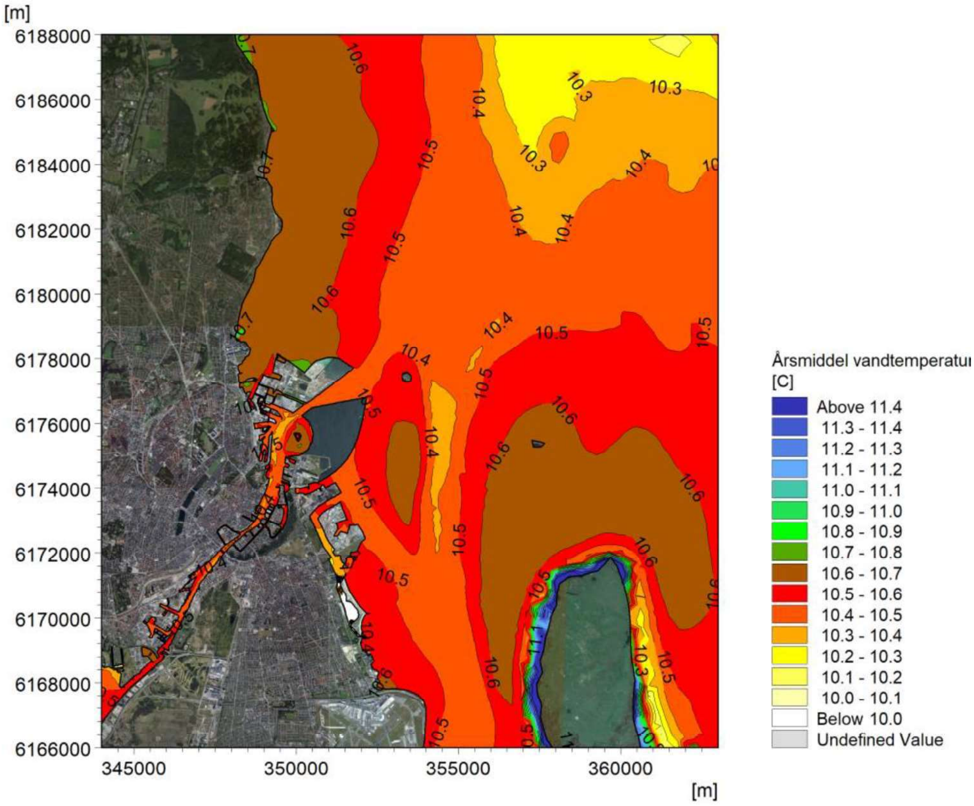

Figure 6-55 Annual average of the depth-averaged water temperature. Main Proposal 1 - without coastal landscape.

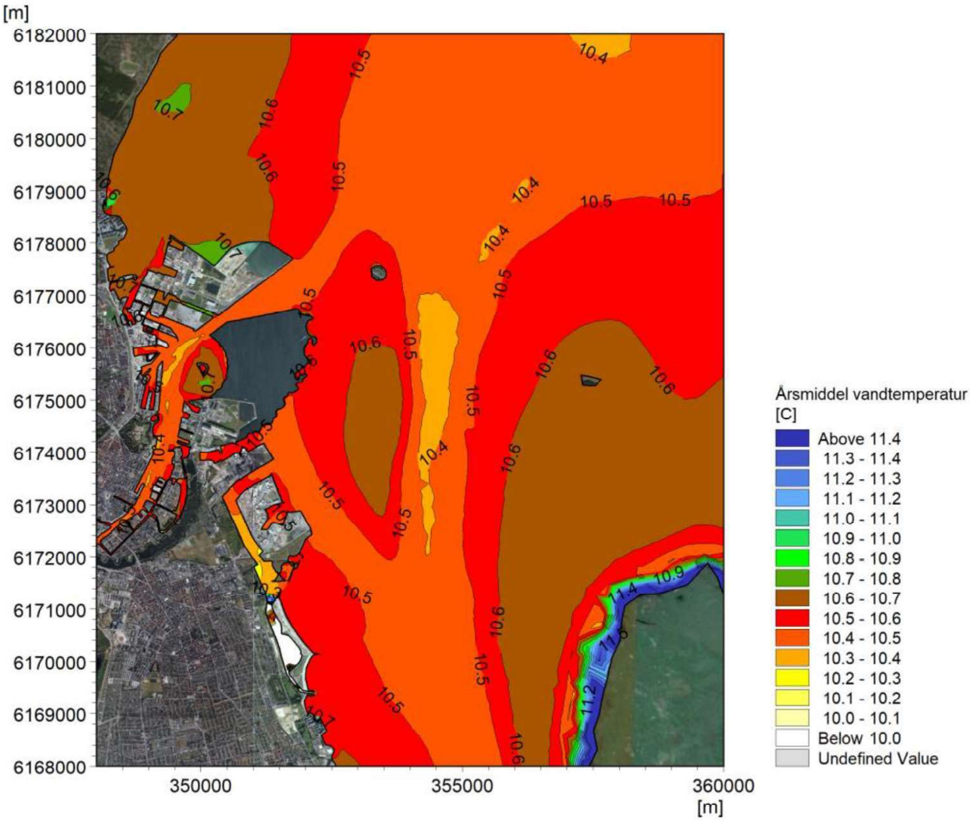

Figure 6-56 Annual average of the depth-averaged water temperature. Main Proposal 2 - with coastal landscape.

6.1.3.2 Assessment of changes in annual mean water temperature

Figure 6-57 shows the change in the annual mean water temperature calculated for Main Proposal 1 compared to the baseline, while Figure 6-58 shows the corresponding plot for Main Proposal 2. As expected, the changes are minimal and will not be detectable. Temperatures are dropping slightly east of Lynetteholm because heavier and cooler bottom water previously led through Kongedybet in the future will be led east of the reclamation. Similarly, the temperature increases slightly in the area north of Nordhavn, as this area is less affected by heavier and cooler bottom water. The overall pattern of temperature changes is identical for both main proposals. However, the trend towards increased warming is slightly more significant for Main Proposal 2, as this proposal reduces the flow across the Middelgrunden a little more than Main Proposal 1.

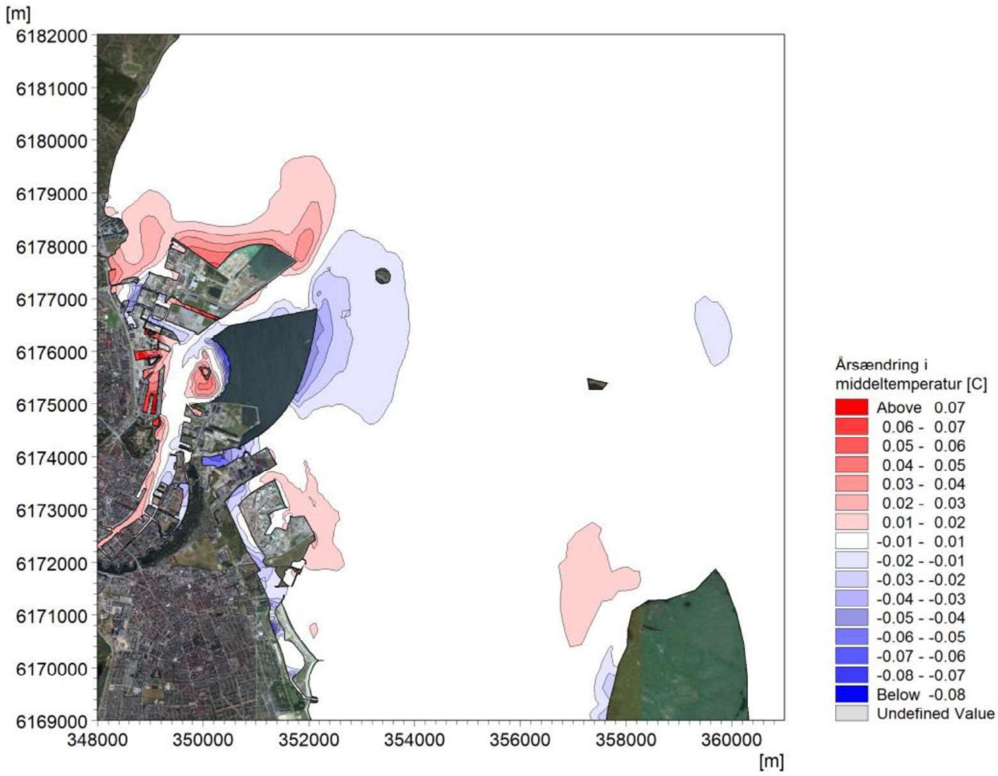

Figure 6-57 Calculated change in the annual mean water temperature for Main Proposal 1.

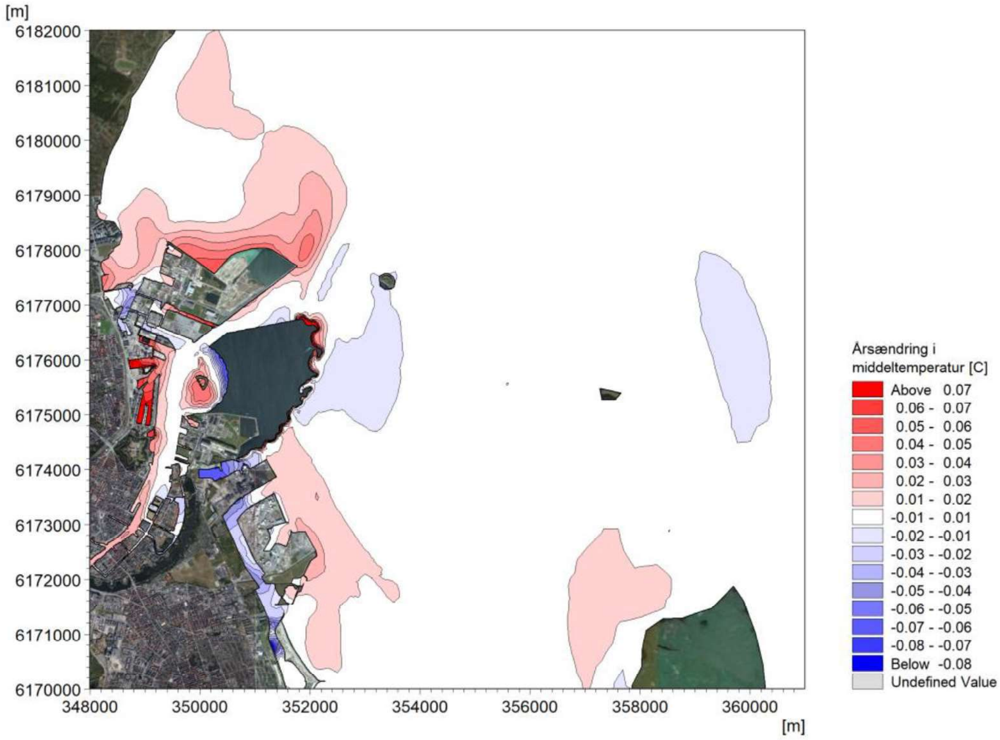

Figure 6-58 Calculated change of the annual mean water temperature for Main Proposal 2.

6.1.3.3 Maximum water temperatures

The annual maximum water temperature varies very much from year to year, as it is closely related to the length and warmth of a Danish summer of the given year. The results presented here only relate to the year 2018, which according to DMI, ref. /2/ is the warmest recorded summer since 1874. The calendar summer 2018 (June, July, and August) reached a mean temperature for the whole country of 17.7 °C, which is 2.5 °C above average for the period 1961-1990 and 1.6 °C above the 10-year average calculated for the period 2006-2015. The summer of 2018 had a total of 26.7 summer days nationwide, with the normal for 1961-1990 being 6.8 days. A summer day is defined by a temperature exceeding 25 °C during a calendar day. The temperature was not evenly distributed in Denmark. As Figure 6-59 shows, Copenhagen had the highest mean temperature (approximately 19.5 °C).

Figure 6-60 – Figure 6-62 show the calculated maximum water temperature (depth-average) in summer 2018 for baseline conditions and the two main proposals. The water temperature of +24 °C this year reached levels known from the Mediterranean. The highest water temperatures occur in the area with low water depth and limited water exchange. It should also be noted that the maximum temperatures have been found by statistical analysis and are therefore not necessarily a snapshot.

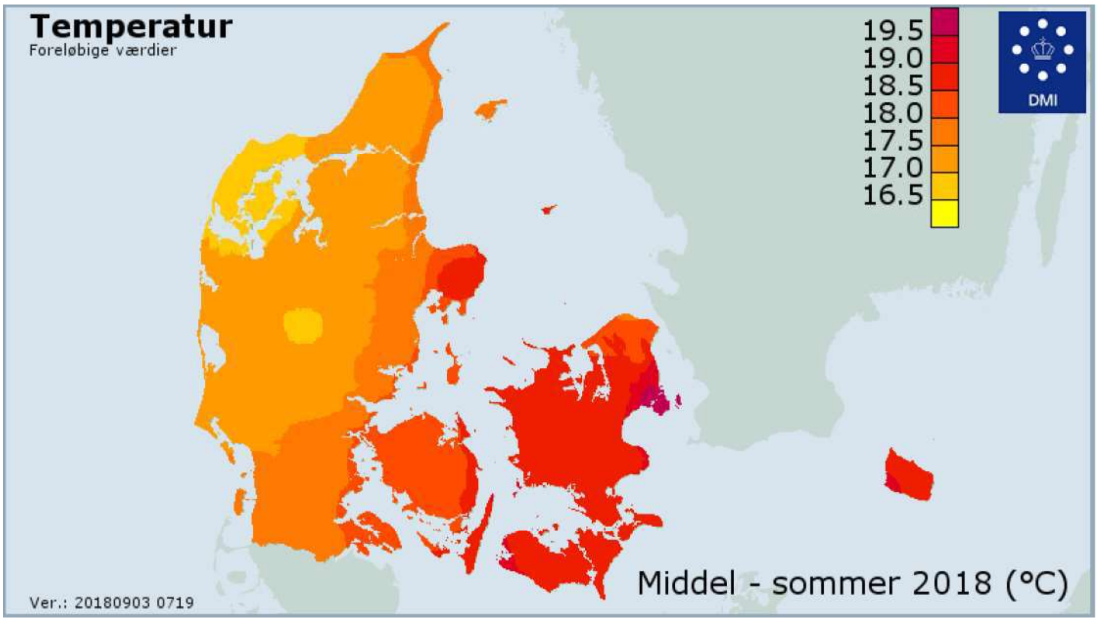

Figure 6-59 Average temperature in Denmark summer 2018, ref. /2/.

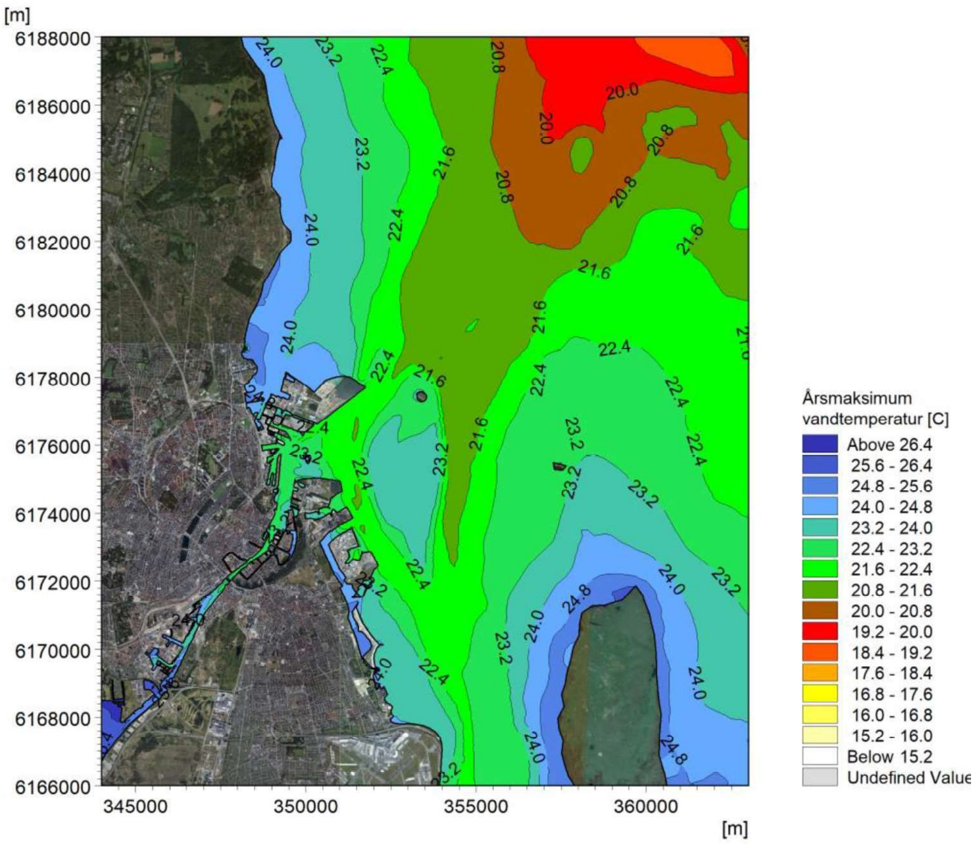

Figure 6-60 Annual maximum of the depth-averaged water temperature for baseline conditions.

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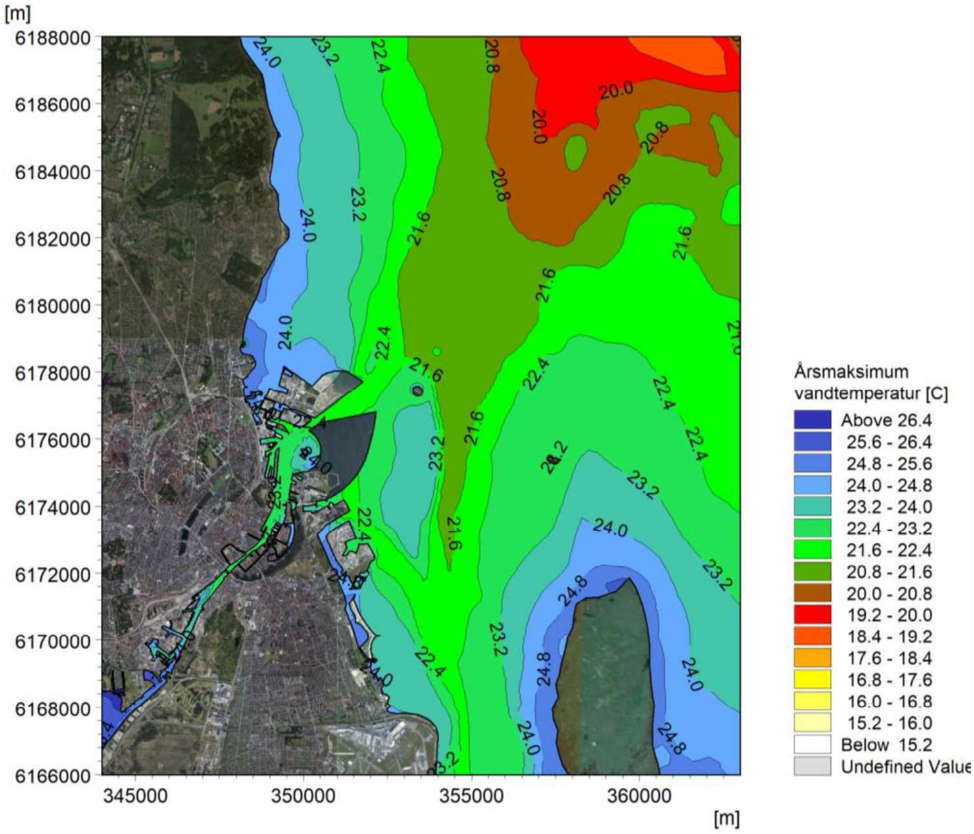

Figure 6-61 Annual maximum of the depth-averaged water temperature. Main Proposal 1 - without coastal landscape.

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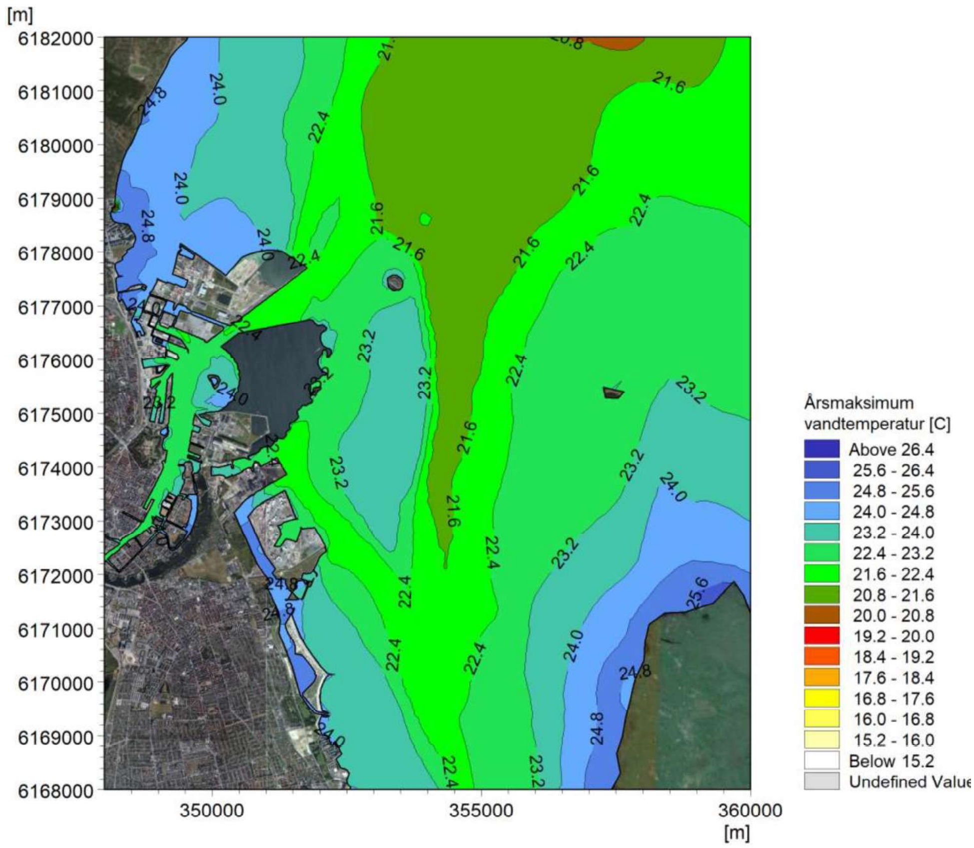

Figure 6-62 Annual maximum of the depth-averaged water temperature. Main Proposal 2 - with coastal landscape.

6.1.3.4 Assessment of changes of maximum water temperature

Figure 6-63 shows the changes in the highest water temperatures calculated for Main Proposal 1 compared to the baseline, while Figure 6-64 shows the corresponding plot for Main proposal 2. Water temperatures are rising in the area around Trekroner, in the funnel between Lynetteholm and Nordhavn, in Svanemøllebugten and Kongedybet, while it falls across Middelgrunden in the area east of the reclamation as well as in parts of the havneløbet (the inner harbour). The increases occur in areas with reduced water exchange; thereby, the sun gains more power resulting in a slightly increased water temperature. The temperature drops in havneløbet (the inner harbour) and on Middelgrunden because heavier and cooler bottom water is driven into the havneløbet and across Middelgrunden – both as a consequence of the blocking of Kongedybet.

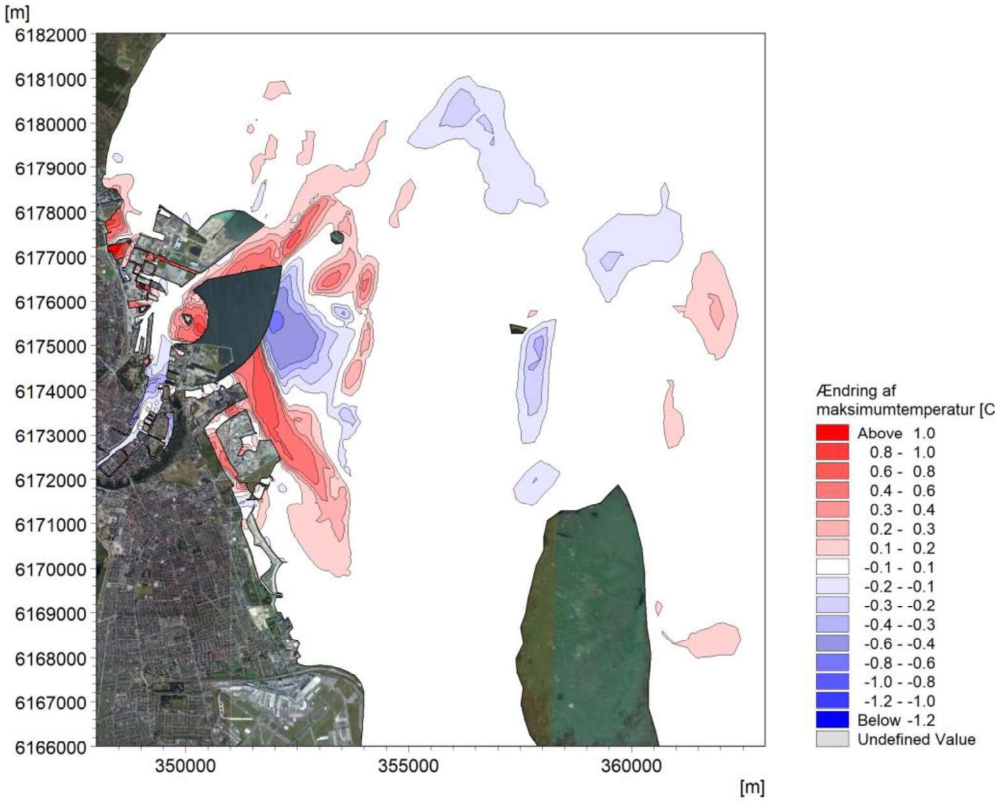

Figure 6-63 Calculated change of maximum water temperatures for Main Proposal 1.

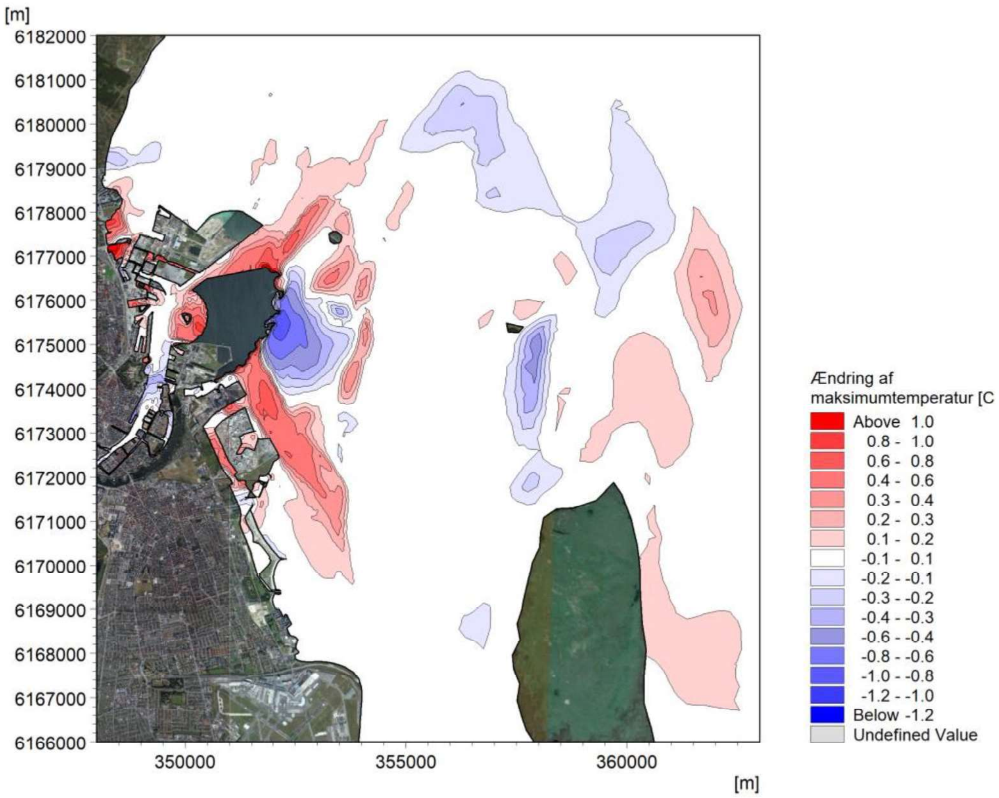

Figure 6-64 Calculated change of maximum water temperatures for Main Proposal 2.

6.1.3.5 Minimum water temperatures

The model year covers parts of two winter seasons, with January and February belonging to winter 2017-18 and December to winter 2018-19. According to DMI, ref /3/, the calendar winter 2017-18 (December, January and February) had a mean temperature of 1.9°C nationwide, which is 1.4 °C above the climate normal calculated for the period 1961-90 and 0.2 °C warmer than the average for the period 2006-15. In January, the mean temperature was 2.3 °C and thus 2.3 degrees warmer than the climate normal for the period 1961-90 and 0.9 °C warmer than the average for 2006-15. In February, the mean temperature was -0.7 °C and thus 0.7°C colder than usual for 1961-90 and 1.8 °C colder than in the period 2006-15. There were 13.0 frost days recorded in January and 23.3 frost days in February. The lowest temperature of the winter was registered on 28 February at Sjælsmark in North Zealand in connection with a cold ending of the winter season and a period of continuous ice days where the temperature is not above the freezing point. According to ref. /4/, December 2018, had a mean temperature of 4.3 °C and thus did not determine the minimum temperatures found.

The density and the freezing point of brackish water vary with the salinity, as shown in Figure 6-65. When brackish water cools at the surface, it becomes heavier and sinks through the water column (vertical mixing). This process continues until the surface water reaches the maximum density or freezing point when an ice cover is formed instead. The vertical mixing that the heavier surface water generates results in faster cooling of the entire water column. Unlike the process of solar heating, where the warmer and lighter water remains at the surface. The model does not calculate ice, i.e. in the area where the water is subcooled, (i.e. below the freezing point of seawater); it is in fact, an indication of ice formation in the area.

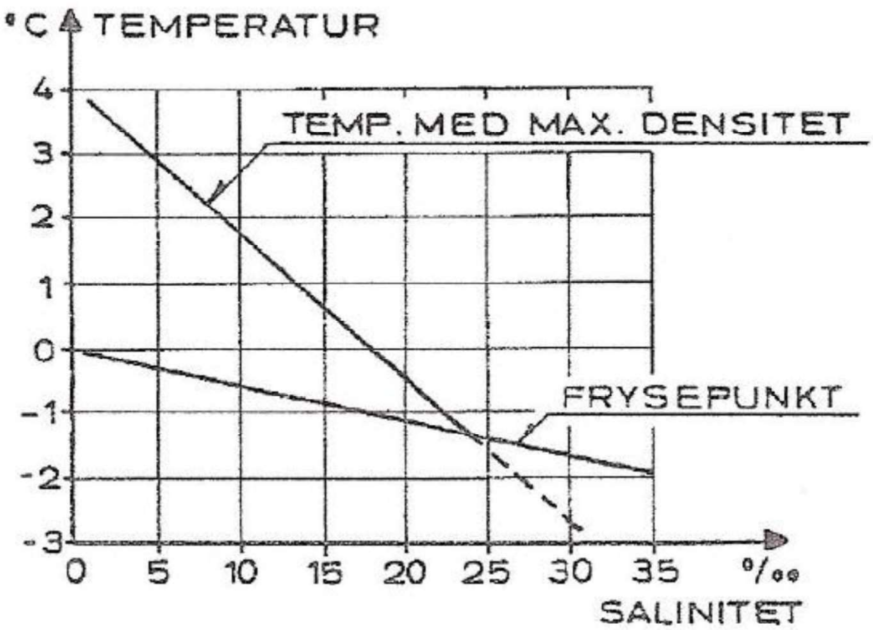

Figure 6-65 Consistency between freezing point, maximum density and salinity, ref. /5/.

Figure 6-66 to Figure 6-68 show the calculated minimum water temperature (the depth-average) in February-March 2018 for baseline conditions and the two main proposals. The water temperature in the nearshore areas is below the freezing points and thus ice formation. The highest water temperatures occur in areas with current and considerable water depth. The minimum temperatures are found by statistical analysis and, the conditions shown are therefore not necessarily a snapshot.

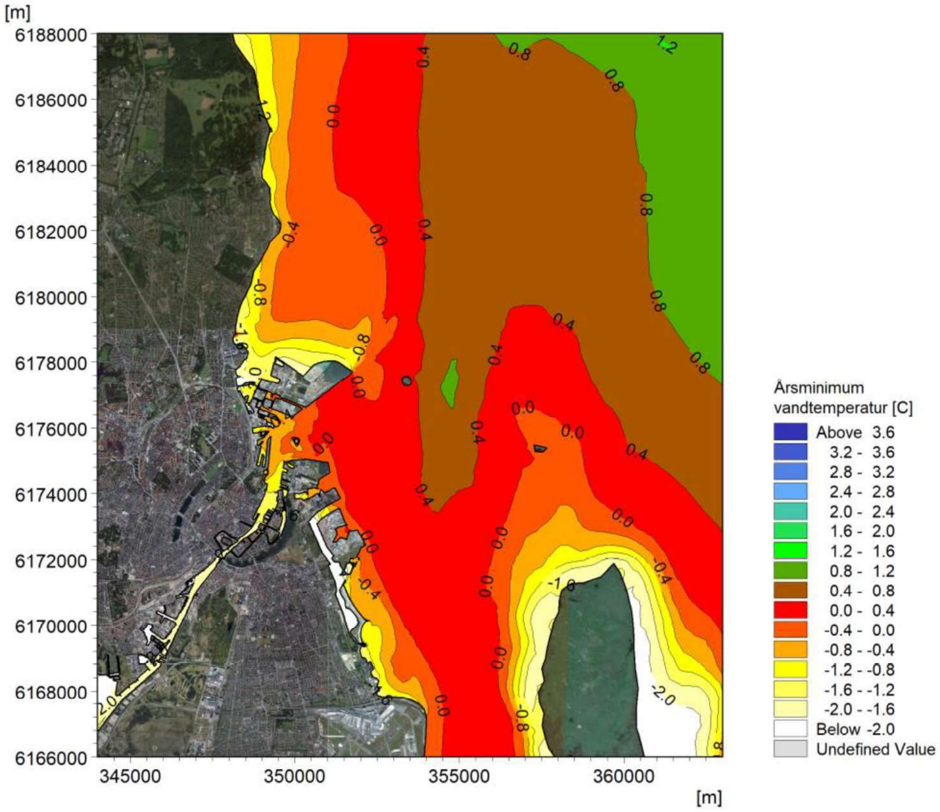

Figure 6-66 Annual minimum of the depth-averaged water temperature for baseline conditions.

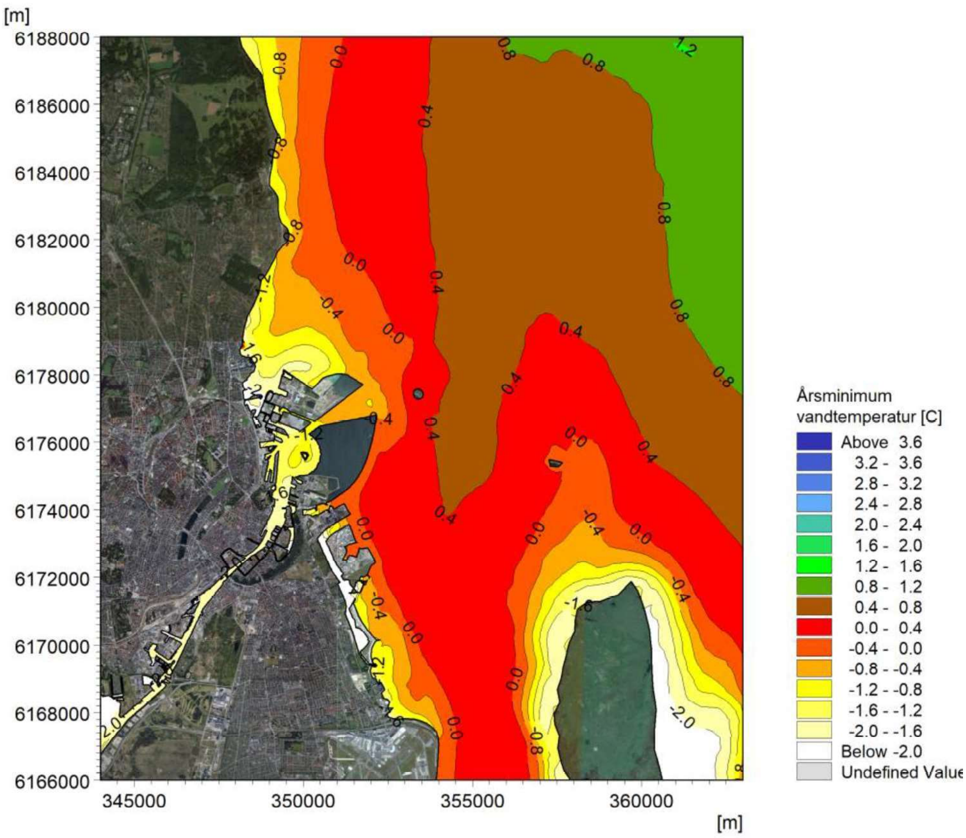

Figure 6-67 Annual minimum of the depth-averaged water temperature. Main proposal 1 - without coastal landscape.

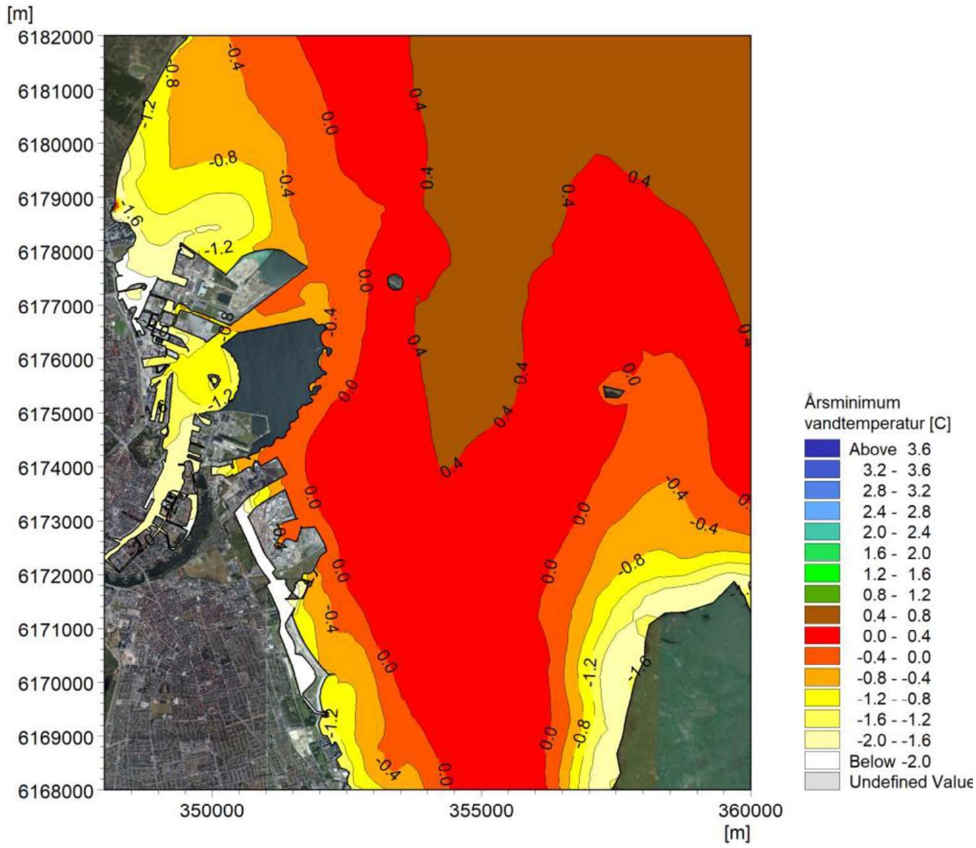

Figure 6-68 Annual minimum of the depth-averaged water temperature. Main proposal 2 - with coastal landscape.

6.1.3.6 Assessment of changes in minimum water temperature

Figure 6-69 shows the change in the lowest water temperatures calculated for Main Proposal 1 compared to the baseline, while Figure 6-70 shows the corresponding plot for Main Proposal 2. It can be seen that water temperatures are dropping in the area around Trekroner, in the funnel between Lynetteholm and Nordhavn, in Svanemøllebugten and areas east of the reclamation. On the other hand, the minimum temperature increases in a wedge north of the Nordhavn reclamation and parts of Hollænderdybet. The temperature drop takes place in areas with reduced water exchange and heavy cooling to space. The temperature increases are due to changing flow conditions.

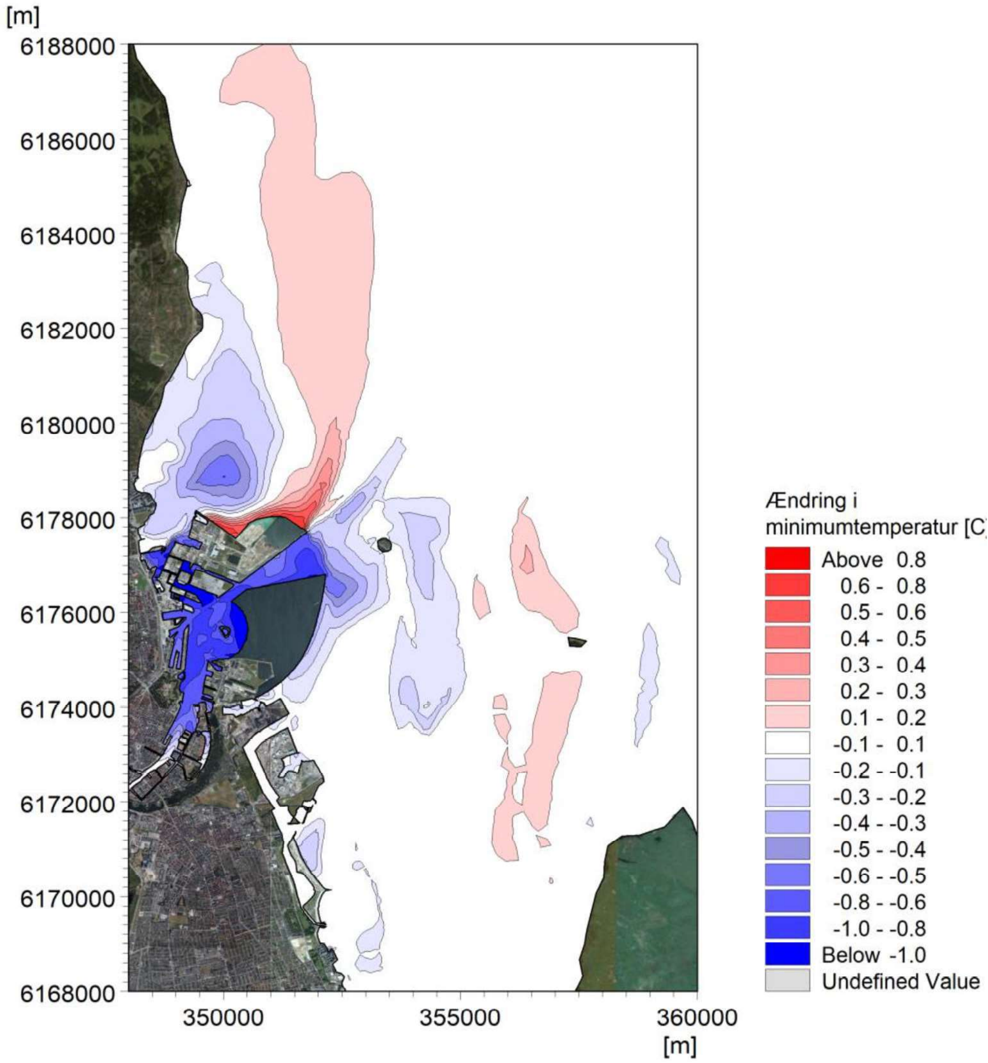

Figure 6-69 Calculated change of the lowest water temperature for Main Proposal 1.

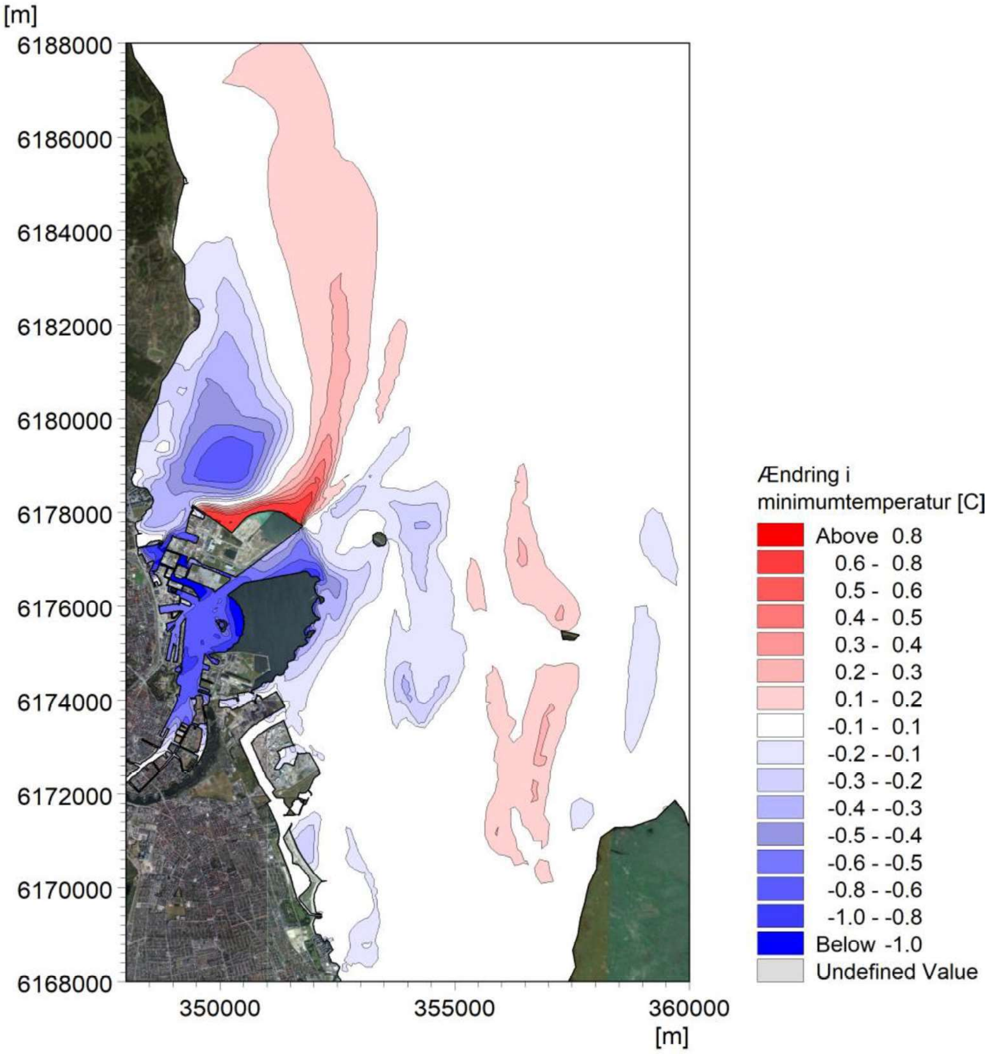

Figure 6-70 Calculated change of lowest water temperature for Main Proposal 2.

6.1.4 Assessment of changes in salinity

Differences in salinity affect water density more than differences in water temperature. Furthermore, the solar heating of the water surface is more evenly distributed, whereas differences in salinity are controlled by the exchange between Baltic brackish water and the North Sea/Kattegat seawater. The variation of salinity in a place and above the depth therefore creates three-dimensional flow phenomena such as heavy bottom currents and light surface current, which in situations with a strong stratification may be opposite. Changes in salinity will unavoidably have a minor effect on mixing conditions and the local flow circulation.

6.1.4.1 Annual average salinity

Salinity is much less seasonal than temperature and follows the dynamics of water levels and the water exchange between the Baltic Sea and the Kattegat to a much greater extent. In situations of significant runoff from the Baltic Sea, salinity will generally be lower, while in cases of substantial inflow into the Baltic Sea, it will be higher. In transition situations, there can be much variation over the depth and opposing flow at the surface and seabed (spring layers). Due to density-driven currents, the saltiest water is found near the bottom in the deeper channels where the water depths are most significant, and the heavier water naturally collects. Therefore, the calculated depth-averaged value for salinity will partly reflect the depth conditions (higher values in deep water, lower values in shallow water). Another controlling factor for the level and the vertical distribution is the Drogden threshold south of Saltholm, which due to the low water depth prevents/dampens the inflow of the heavy salty bottom water. Figure 6-71 to Figure 6-73 show the calculated annual mean of salinity (the depth-averaged) for the whole of 2018 for baseline conditions and the two main proposals. It can be seen that the local variations of salinity in the area shown vary between 11-19,5 ‰. In addition to this variation, the variation is over the depth. A variation that in the deeper channels will often exceed 20 ‰ in the difference between the bottom and surface. The level generally decreases in the direction from north to south. The salt transport to the Baltic Sea takes place primarily via the deeper channels. It can be seen that the salinity at baseline conditions is increased in both Kongedybet and Hollænderdybet. In both main proposals, Kongedybet is blocked. Therefore, the salinity has increased in the area around the funnel between Lynetteholm and Nordhavn, while it has been reduced in the remaining part of Kongedybet south of the reclamation. Parts of the area around Saltholm are not always covered with water. Therefore, the slightly higher levels are because no mean is calculated for the same duration as in the areas with constant water cover. The depth-average of salinity is the product of statistical analysis and therefore does not represent the conditions at a specific time.

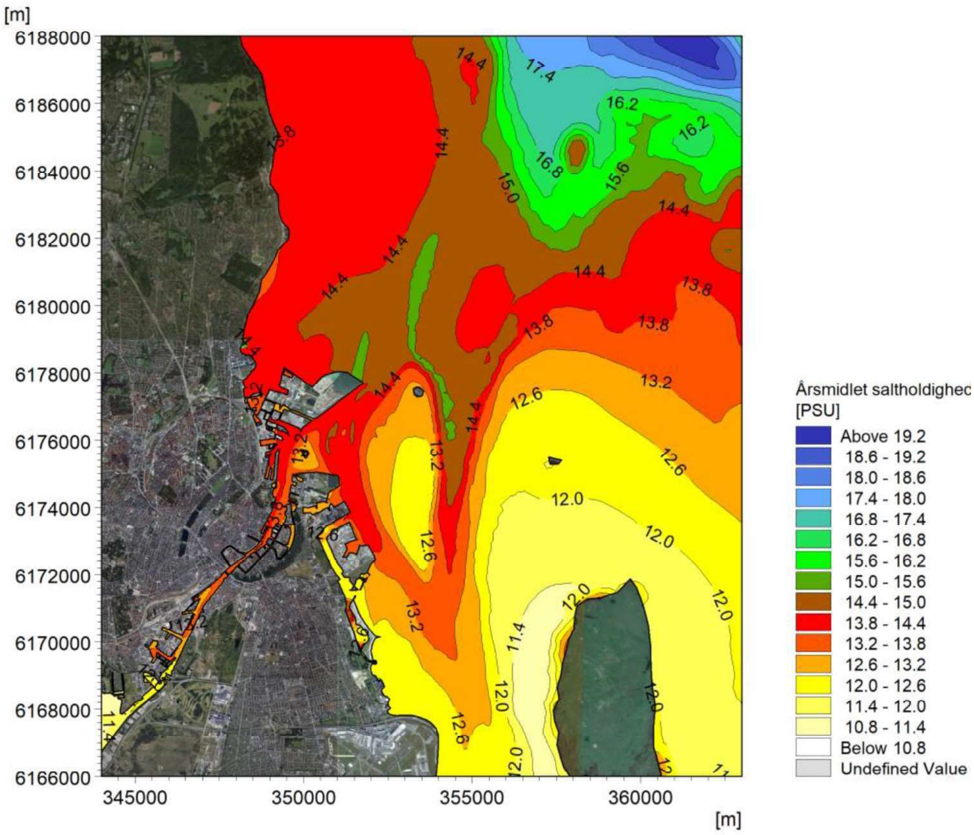

Figure 6-71 Annual mean of the depth-averaged salinity for baseline conditions.

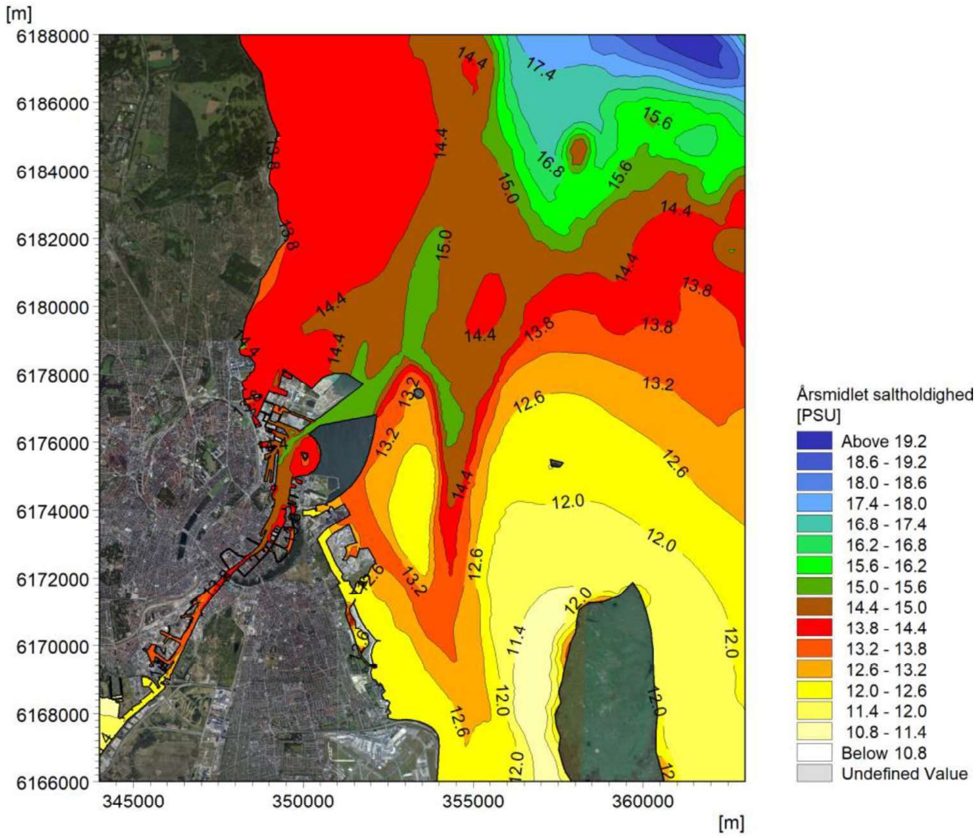

Figure 6-72 Annual mean of the depth-averaged salinity. Main Proposal 1 – without coastal landscape.

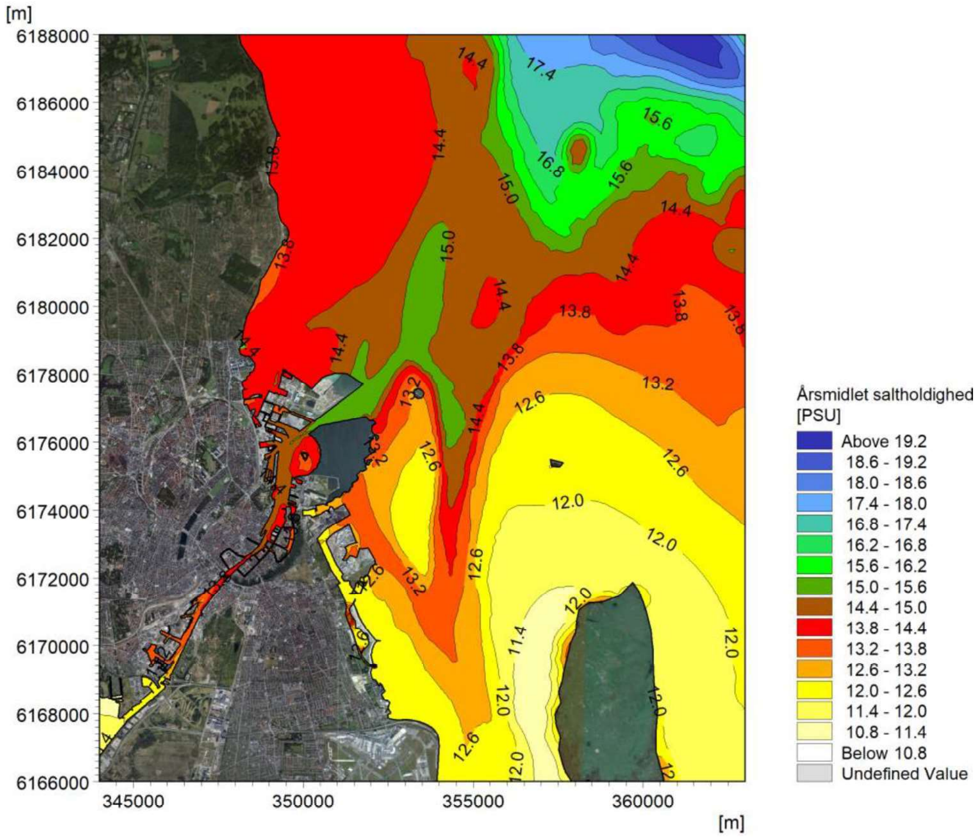

Figure 6-73 Annual mean of the depth-averaged salinity. Main Proposal 2 – with coastal landscape.

6.1.4.2 Assessment of changes in average annual salinity

The blocking of Kongedybet by Lynetteholm means that the southbound transport of salt will be reduced locally. This causes a generally increased salinity level (accumulation effect) in the funnel between Lynetteholm and Nordhavn, in the area northeast of this area and the havneløbet (the inner harbour), cf. Figure 6-74 and Figure 6-75. On the other hand, in Kongedybet south of the reclamation, the salinity level decreases due to the reduced supply from the north.

The changes found are small compared to the naturally occurring variations and are therefore not in themselves critical.

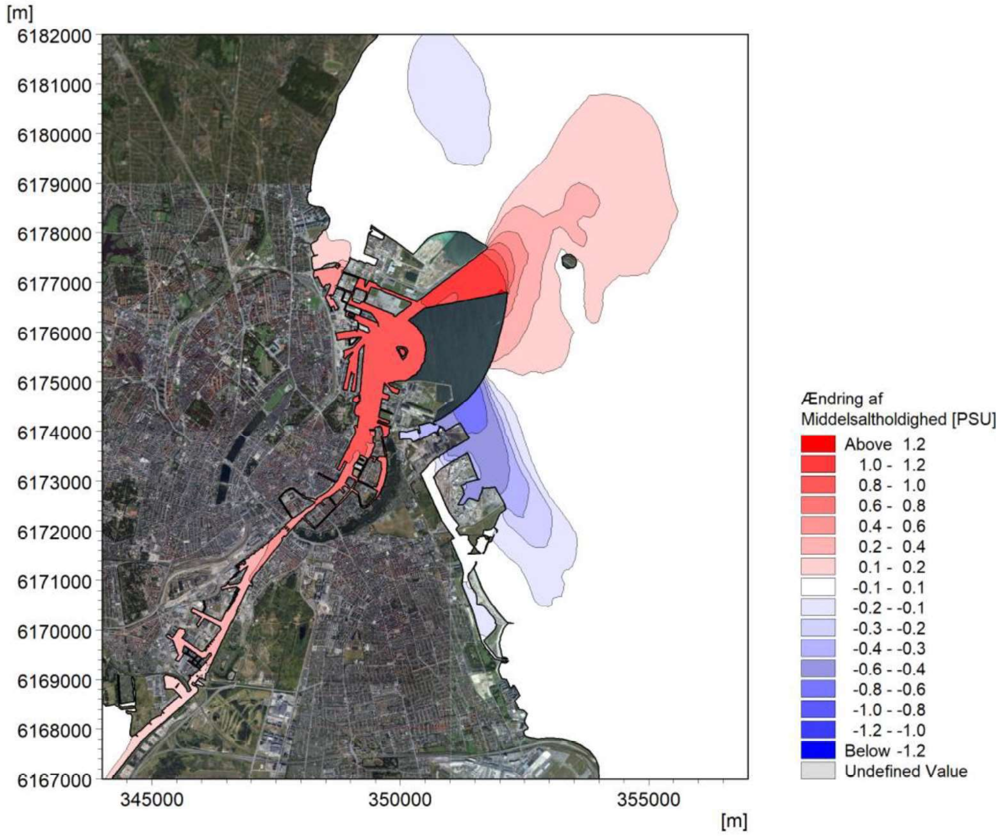

Figure 6-74 Calculated change of the depth-averaged salinity for Main Proposal 1.

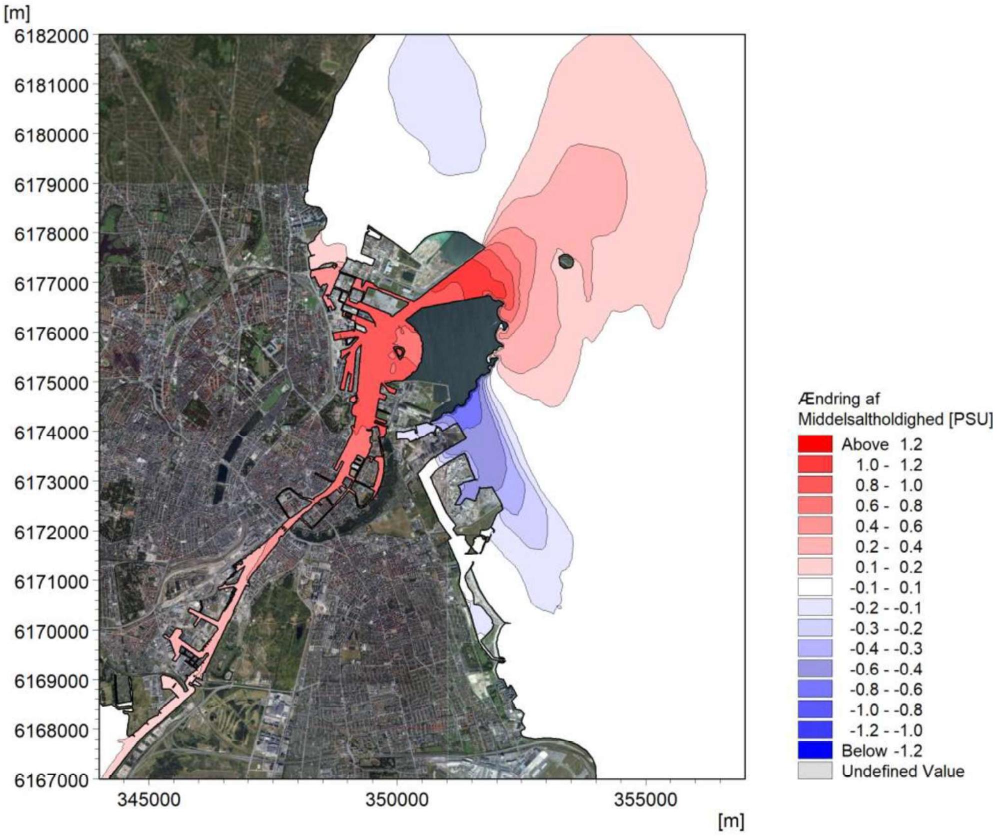

Figure 6-75 Calculated change of the depth-averaged salinity for Main Proposal 2.

6.1.4.3 Maximum salinity

Very high levels of salinity and salt inflows into the Baltic Sea typically occur in connection with northern storm surge events, when large amounts of saltwater are driven from the North Sea and via the Kattegat into the Baltic Sea. There are no extreme storm surge events in the chosen model year, but prolonged periods of dominant southbound current, where saltwater from the Kattegat is also driven into the Baltic Sea. Figure 6-76 to Figure 6-78 show the calculated maximum of the depth-averaged salinity in 2018 for baseline conditions and the two main proposals. It can be seen that the local variations in salinity in the sample shown vary from 21,5 to 28 ‰. In addition to this variation there is a variation over the depth, which is limited to a few per thousand in the difference between bottom and surface levels in these situations. The salinity generally decreases in the direction from north to south. The plots are the product of statistical analysis and therefore do not reflect the conditions at any given moment but represent conditions of prolonged southbound flow.

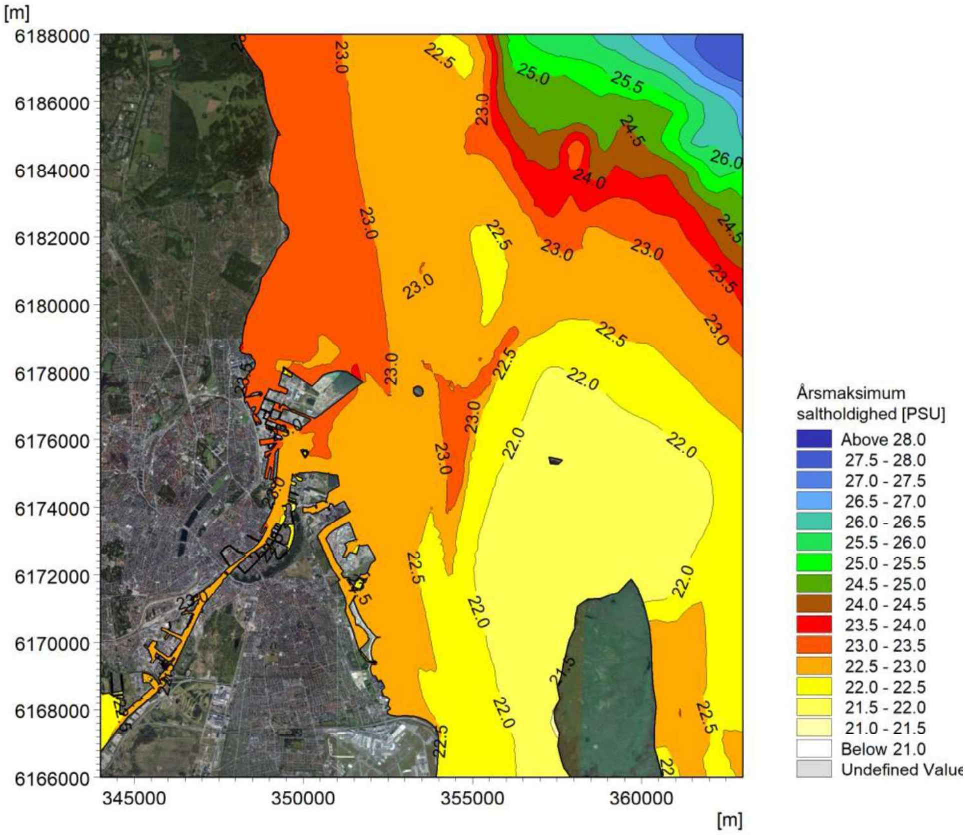

Figure 6-76 Annual maximum of the depth-averaged salinity for baseline conditions.

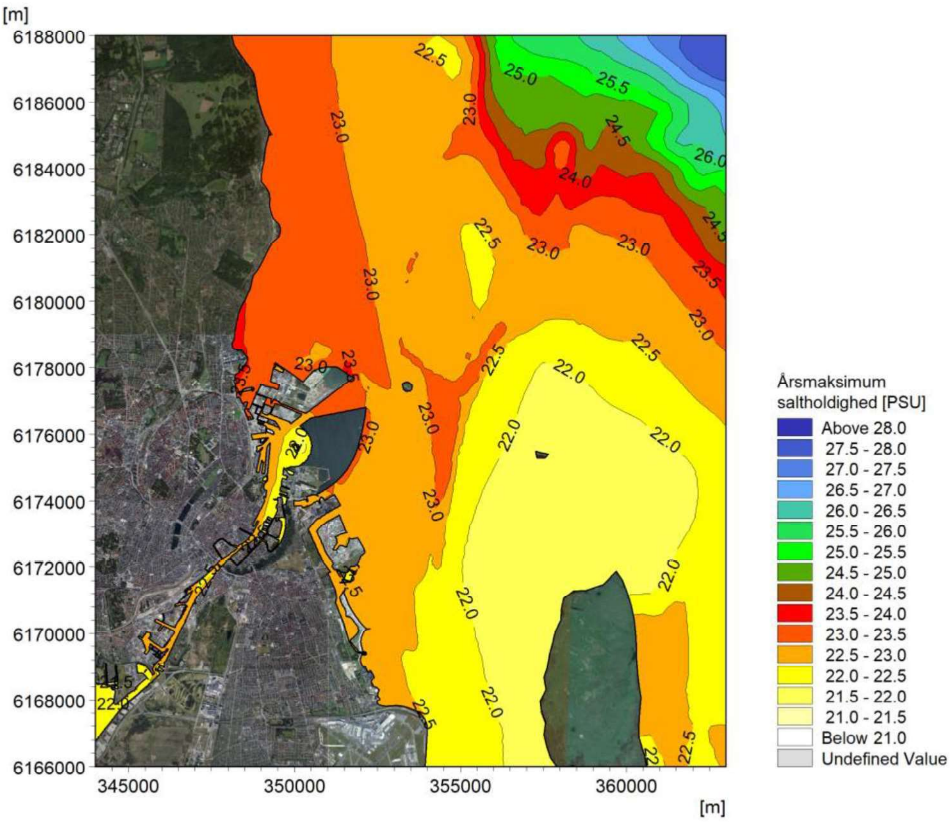

Figure 6-77 Annual maximum of the depth-averaged salinity for Main Proposal 1 – without coastal landscape.

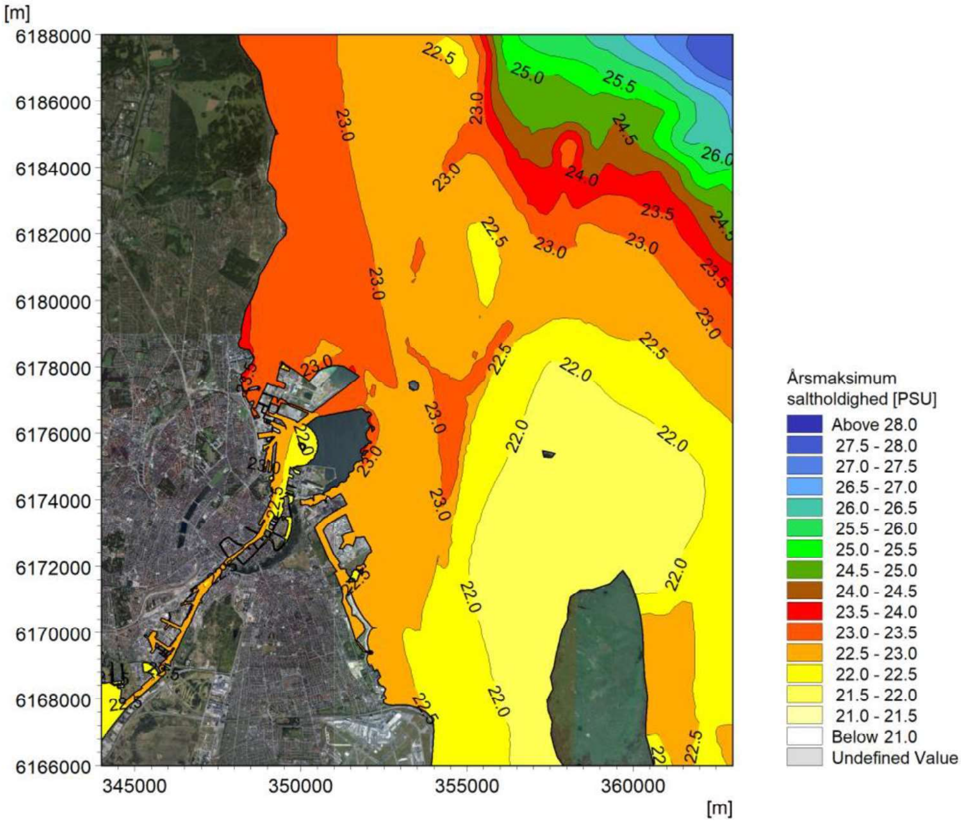

Figure 6-78 Annual maximum of the depth-averaged salinity for Main Proposal 2 – with coastal landscape.

6.1.4.4 Assessment of changes in maximum salinity

In situations of high salinity, there is a more effective mixing over the water column. Therefore, the local gradients in salinity, i.e. differences over a distance, are smaller than in situations with more normal current conditions. In high salinity situations, the three-dimensional flow effects are more subdued, which is why changes in the salt exchange between the Sound and the havneløbet (the inner harbour) brought about by the Lynetteholm reclamation become less marked Figure 6-79 and Figure 6-80 show the calculated change in maximum salinity (depth-average) for each of the two main proposals. There is a local increase in the outer part of the funnel and along the eastern perimeter of the reclamation, while there is a decrease in the entire length of havneløbet (the inner harbour). There is also a local increase along the eastern part of Middelgrunden. The most significant reduction is seen in the area just east of Trekroner, where there is no longer direct exchange with Øresund as a result of the reclamation.

The changes found are small compared to the naturally occurring variations and are therefore not in themselves critical.

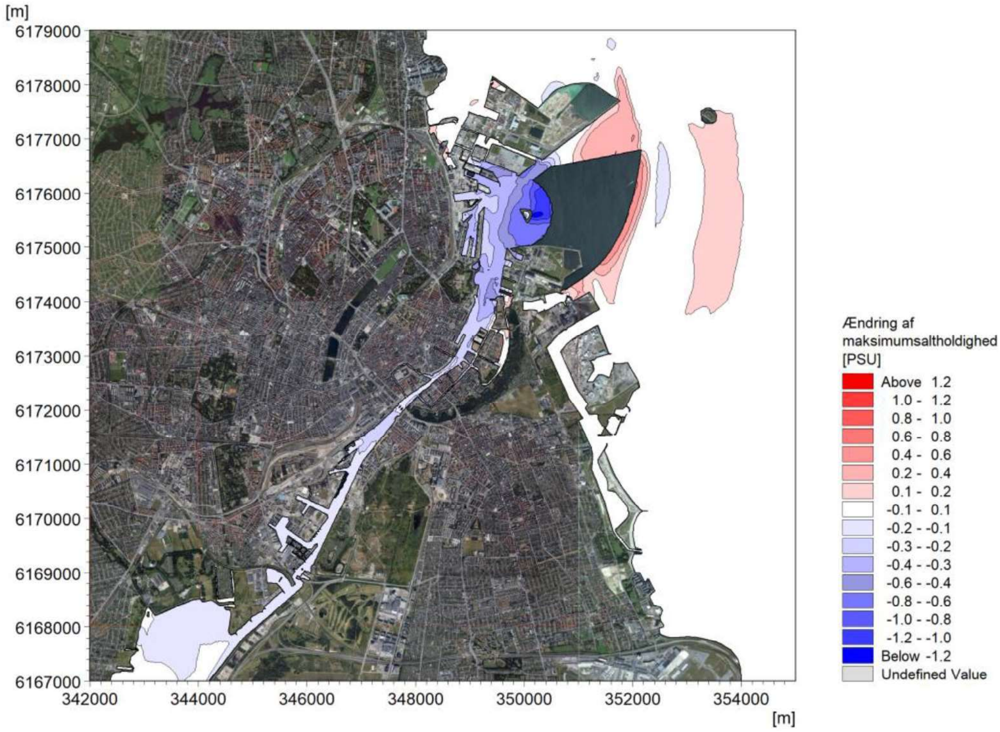

Figure 6-79 Calculated change of maximum salinity for Main Proposal 1.

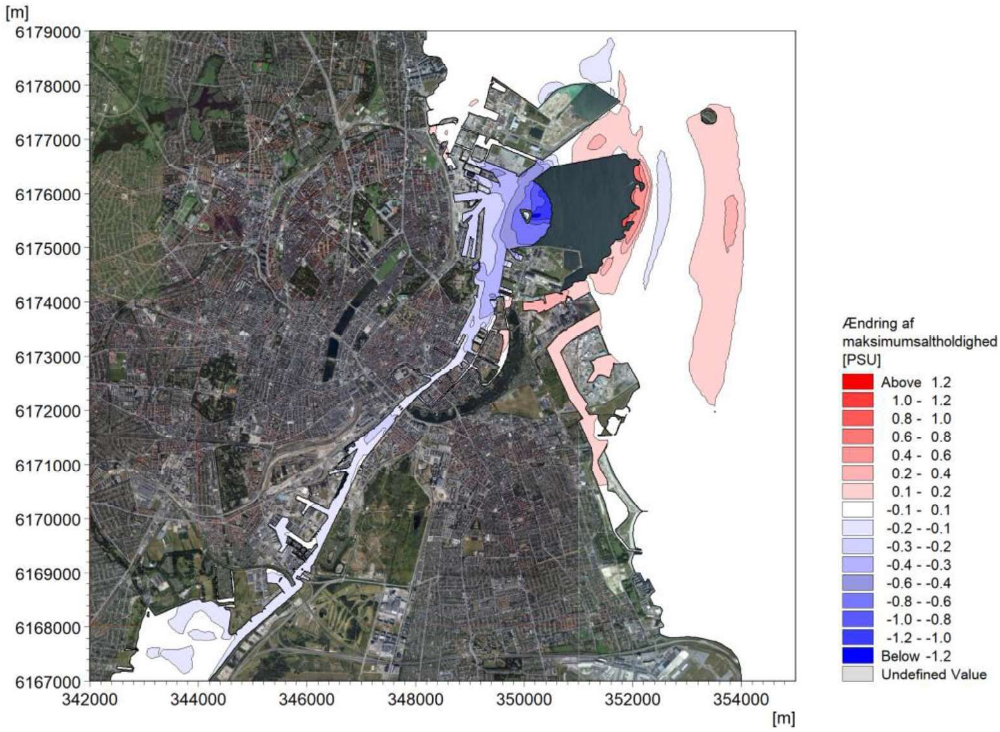

Figure 6-80 Calculated change of maximum salinity for Main Proposal 2.

6.1.4.5 Minimum salinity

Very low salinity levels typically occur when large amounts of brackish water from the Baltic Sea are driven into the Kattegat for a long time. Figure 6-81 to Figure 6-83 show the calculated minimum of the depth-averaged salinity in 2018 for baseline conditions, and the two examined main proposals. It can be seen that the local variations in salinity in the sample shown vary from 7-8.5 ‰. In addition to this variation, the variation over the depth is added, which in these situations is limited to a few per thousand in the difference between the bottom and surface levels. The level of salinity generally increases in the direction from south to north. The plots are the product of statistical analysis and therefore do not represent the conditions at any given moment but represent conditions of prolonged northbound current.

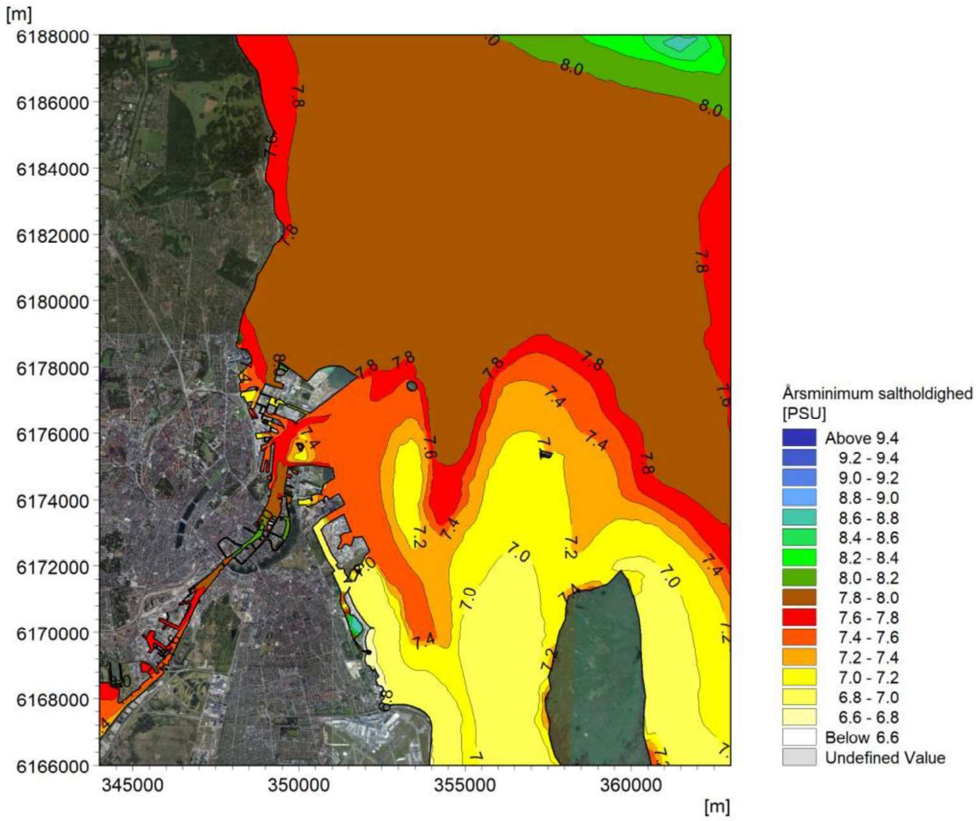

Figure 6-81 Annual minimum of depth-averaged salinity for baseline conditions.

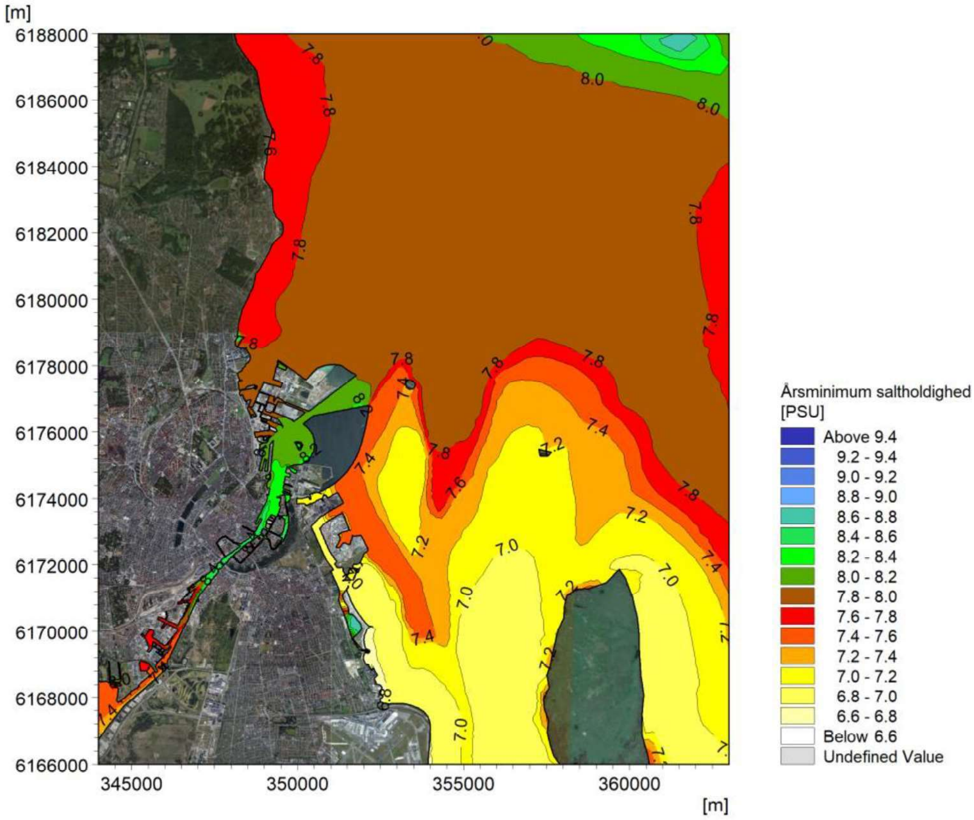

Figure 6-82 Annual minimum of depth-averaged salinity for Main Proposal 1 – without coastal landscape.

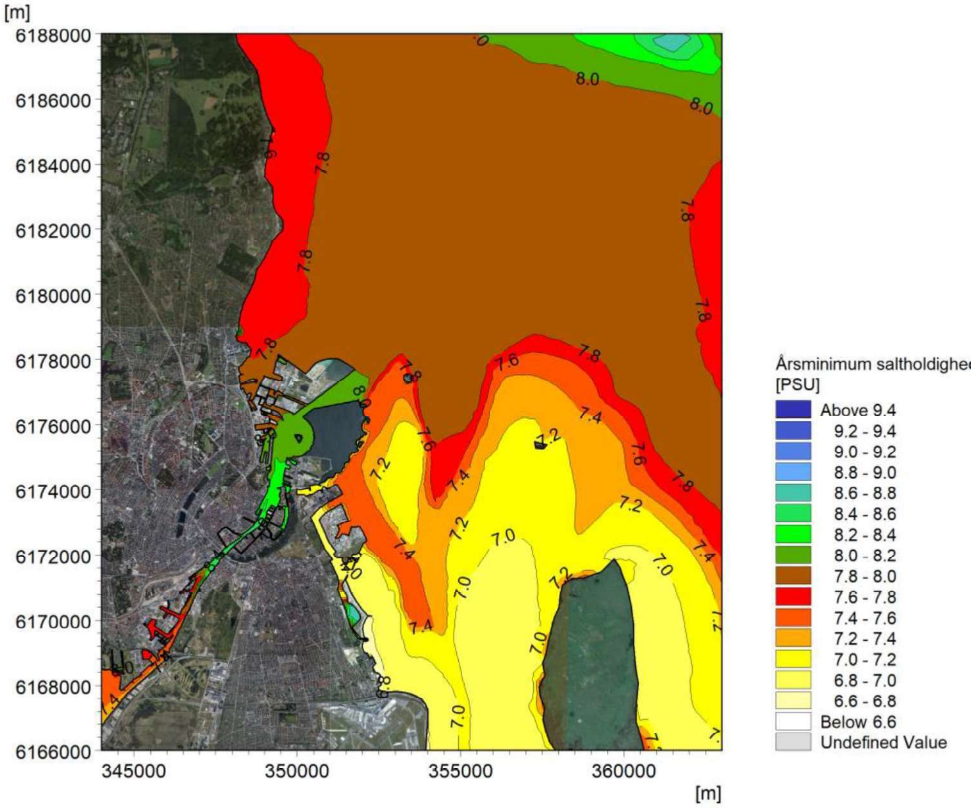

Figure 6-83 Annual minimum of depth-averaged salinity for Main Proposal 2 – with coastal landscape.

6.1.4.6 Assessment of changes of minimum salinity

Figure 6-84 and Figure 6-85 show the calculated changes in minimum salinity (depth-average) in 2018 for the two examined main proposals. It can be seen that there is an increase in salinity in the havneløbet (the inner harbour), in the funnel between Lynetteholm and Nordhavn and the inner part of Svanemøllebugten. There is a slight decrease in salinity to the east of the reclamation and the coastal area north of Nordhavn.

The maximum and minimum model calculations indicate that the salinity variations in the havneløbet (the inner harbour) will generally decrease after a Lynetteholm reclamation. However, the changes found are small compared to the naturally occurring variations and are therefore not critical.

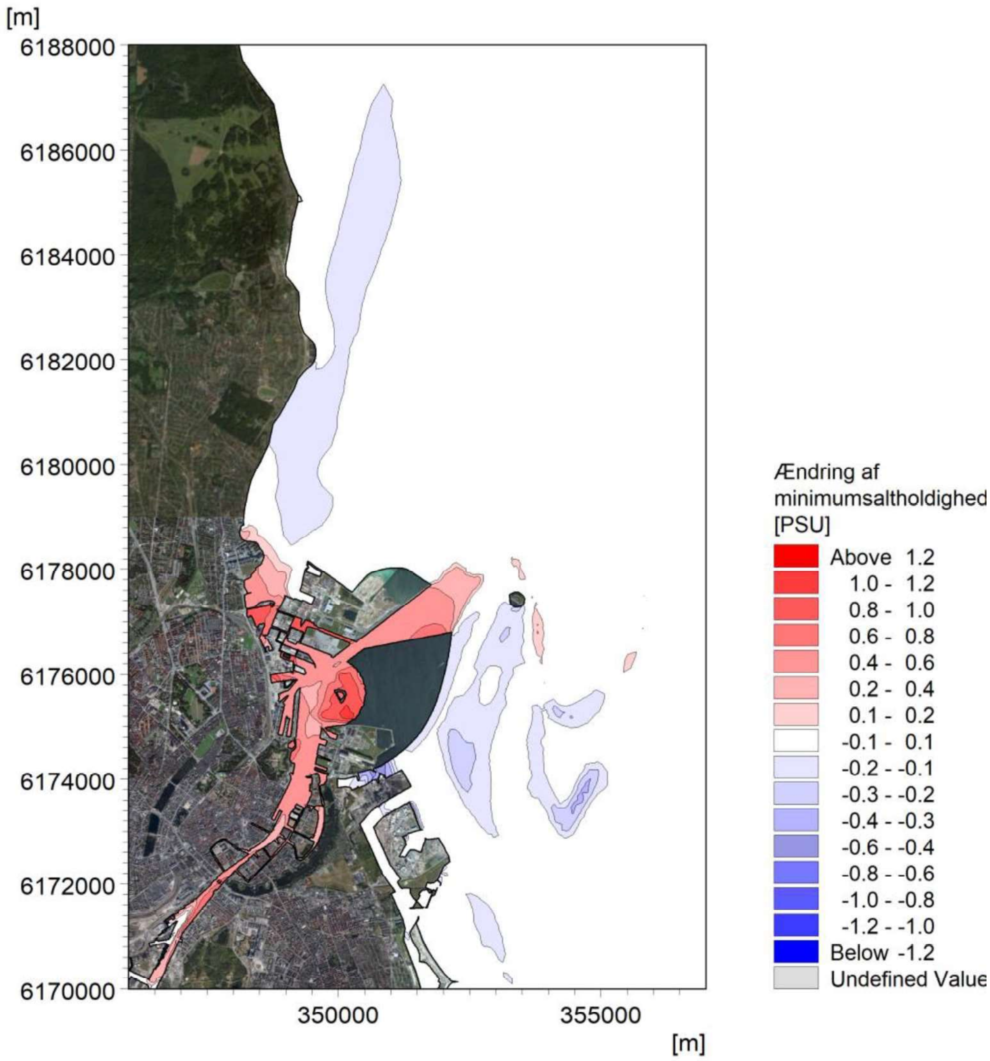

Figure 6-84 Calculated change of minimum salinity for Main Proposal 1.