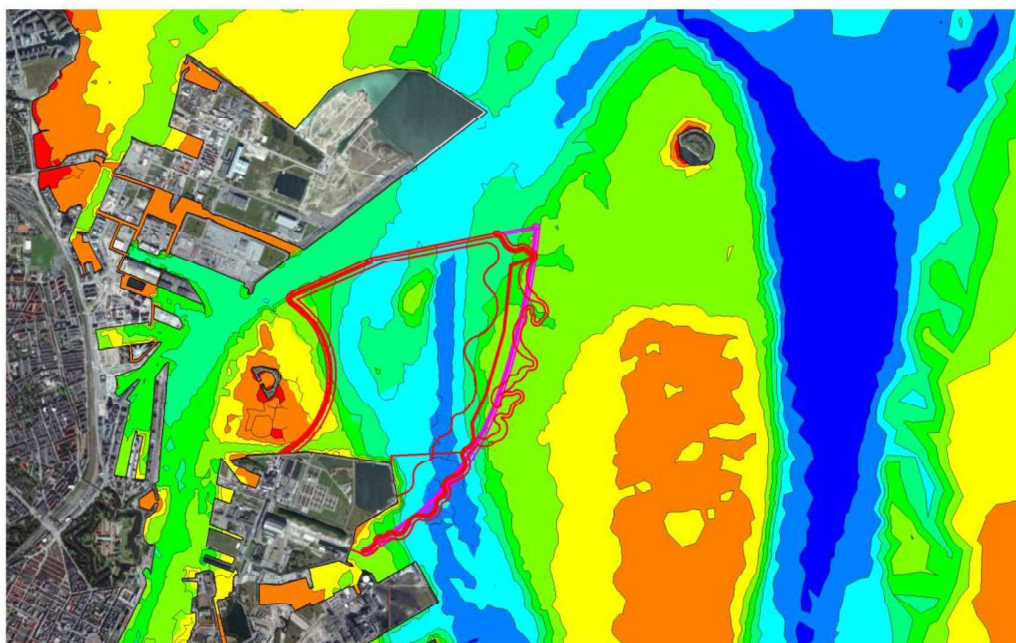




# Construction of Lynetteholm

EIA – Technical Background Report No 1

Hydraulic Surveys



Udviklingsselskabet By & Havn I/S

Report

October 2021

This report was prepared according to the DHI management system certified by Bureau Veritas for compliance with ISO 9001 for quality management



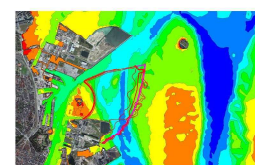
# Construction of Lynetteholm

EIA – Technical Background Report No 1

Hydraulic Surveys

Prepared for  
Represented by

Udviklingsselskabet By & Havn I/S  
Hans Vasehus, Harbour & Construction  
Manager



Main proposals 1 and 2

Project manager	Bo Brahtz Christensen
Quality manager	Jacob H Jensen
Project number	11823523-09
Approval date	6 October 2021 (English version) <i>(Translation of parts from report from 2 November 2020 (Danish version))</i>
Audit	Final: 1.0
Classification	<b>Limited:</b> This document is available to persons employed by the DHI Group but may not be shared with others outside the DHI Group without the customer's prior approval.

## TABLE OF CONTENTS

<b>1</b>	<b>Introduction .....</b>	<b>1</b>
<b>2</b>	<b>Summary.....</b>	<b>2</b>
<b>3</b>	<b>Background .....</b>	<b>3</b>
<b>4</b>	<b>Basic studies .....</b>	<b>7</b>
4.1	Hydraulic basic surveys .....	7
4.2	Basic description of the hydraulic conditions in the area .....	7
4.2.1	General description of the hydrographic conditions of Øresund.....	7
4.2.2	General description of current and water levels .....	9
4.2.3	Numeric model .....	11
4.2.4	Selected modelling period.....	12
<b>5</b>	<b>Assessment of the environmental impact during the construction phase .....</b>	<b>14</b>
<b>6</b>	<b>Assessment of impacts during the operational phase .....</b>	<b>15</b>
6.1	Hydraulic and coastal morphological conditions.....	15
6.1.1	Assessment of changing sea levels.....	15
6.1.2	Assessment of changing current conditions .....	22
6.1.3	Assessment of changes in water temperature.....	66
6.1.4	Assessment of changes in salinity .....	78
6.1.5	Assessment of changed wave conditions .....	90
6.1.6	The impact of the project on flow conditions in Øresund and havneløbet (the inner harbour).....	107

## LIST OF FIGURES

Figure 3-1	Blueprint of the examined Main Proposal 1. ....	4
Figure 3-2	Blueprint of the examined Main Proposal 2. ....	5
Figure 3-3	Top: Indication of studies for Main Proposal 1 (pink curve) and Main Proposal 2 (red curve). Bottom: Indication of final layouts for Main Proposal 1 (pink curve) and Main Proposal 2 (red curve). The red curve shows the crest elevation of the profile, the water level line, and the profile's foot, where it joins the natural seabed.....	6
Figure 4-1	Øresund's bathymetric conditions and the extent of the baseline model. ....	8
Figure 4-2	Depth and areas in the southern part of Øresund. Depths are indicated in relation to DVR90.....	9
Figure 4-3	Measured water level variations in Hornbæk and Copenhagen in the period 1999-2019. ....	10
Figure 4-4	Correlation between trend-free storm surge levels in Copenhagen and Hornbæk (1881-2019).....	10
Figure 4-5	Bathymetry and computational mesh of the baseline model. ....	12
Figure 6-1	Change in the mean water level in 2018 with a Lynetteholm reclamation without a coastal landscape. ....	15
Figure 6-2	Change in the mean water level in 2018 with a Lynetteholm reclamation with a coastal landscape. ....	16



Figure 6-3	Modelled maximum water level year 2018 for baseline conditions (top), with a Lynetteholm reclamation without a coastal landscape (centre) and a Lynetteholm reclamation with a coastal landscape (bottom).....	17
Figure 6-4	Change of the present maximum water level owing to a Lynetteholm expansion without a coastal landscape.....	18
Figure 6-5	Change of the present maximum water level as a result of Lynetteholm's reclamation with a coastal landscape. ....	18
Figure 6-6	Modelled minimum water level year 2018 for baseline conditions (top), with the Lynetteholm reclamation without a coastal landscape (centre) and the Lynetteholm reclamation with a coastal landscape (bottom).....	20
Figure 6-7	Change of the minimum water level with a Lynetteholm reclamation without a coastal landscape. ....	21
Figure 6-8	Change of the minimum water level with a Lynetteholm reclamation with a coastal landscape.....	21
Figure 6-9	Depth-average current speed and water depths for conditions with strong southbound currents on January 28, 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with current vectors. ....	23
Figure 6-10	Depth-averaged current speed and water depths for conditions with strong southbound currents on January 28, 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with current vectors. ....	24
Figure 6-11	Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions with strong southbound current and reclamation without coastal landscape.....	25
Figure 6-12	Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions of strong southbound flow and reclamation with coastal landscape. ....	26
Figure 6-13	Surface velocity under conditions with strong southbound current on 28 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.....	27
Figure 6-14	Surface velocity under conditions with strong southbound current on 28 January 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.....	28
Figure 6-15	Vectorial (top) and scalar (bottom) calculated change of surface current for conditions with strong southbound current and Lynetteholm expansion without coastal landscape. ....	29
Figure 6-16	Vectorial (top) and scalar (bottom) calculated change of surface current for conditions with strong southbound current and Lynetteholm expansion with coastal landscape.....	30
Figure 6-17	Scalar calculated current change in the area south of the reclamation. Top: Reclamation without coastal landscape, Bottom: reclamation with coastal landscape.....	31
Figure 6-18	Bottom velocity for conditions with strong southbound current. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with depth-averaged current vectors for conditions with strong southbound current and water depth. ....	32
Figure 6-19	Bottom velocity for conditions with strong southbound current. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with in-depth-averaged current vectors for conditions with strong southbound current and water depth. ....	33
Figure 6-20	Vectorial (top) and scalar (bottom) calculated change of bottom current for conditions with strong southbound current and Lynetteholm reclamation without coastal landscape. ....	34
Figure 6-21	Vectorial (top) and scalar (bottom) calculated change of bottom current for conditions with strong southbound current and Lynetteholm reclamation with coastal landscape. ....	35

Figure 6-22	Depth-averaged current speed and water depths for conditions with strong northbound currents on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with current vectors. ....	36
Figure 6-23	Depth-averaged current speed and water depths for conditions with strong northbound currents on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with current vectors. ....	37
Figure 6-24	Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions of strong northbound current and reclamation coastal landscape. ....	38
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 .	40
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. ....	41
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. ....	42
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. ....	44
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. ....	45
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. ....	46
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. ....	47
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. ....	48
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. ....	49
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. ....	50
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. ....	51
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. ....	52
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. ....	53
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. ....	54
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. ....	55
Figure 6-40	Current extraction points P1-P3. ....	56
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. ....	56

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. ....	57
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. ....	58
Figure 6-44	Annual average of the depth-averaged gross current with baseline conditions. ....	59
Figure 6-45	Annual average of the depth-averaged gross current with Main Proposal 1 reclamation. ....	59
Figure 6-46	Annual average of the depth-averaged gross current with Main Proposal 2 reclamation. ....	60
Figure 6-47	Main Proposal 1. Change of annual average of gross current (depth-average). ...	61
Figure 6-48	Main Proposal 2. Change of annual average of gross current (depth-average). ...	62
Figure 6-49	Maximum depth-averaged current year 2018 with baseline conditions. ....	63
Figure 6-50	Maximum depth-averaged current year 2018 with Main Proposal 1 reclamation. .	63
Figure 6-51	Maximum depth-averaged current year 2018 with Main Proposal 2 reclamation. .	64
Figure 6-52	Main Proposal 1. Change of maximum depth-averaged current. ....	65
Figure 6-53	Main Proposal 2. Change of maximum depth-averaged current. ....	65
Figure 6-54	Annual average of depth-averaged water temperature for baseline conditions. ....	66
Figure 6-55	Annual average of the depth-averaged water temperature. Main Proposal 1 - without coastal landscape. ....	67
Figure 6-56	Annual average of the depth-averaged water temperature. Main Proposal 2 - with coastal landscape. ....	67
Figure 6-57	Calculated change in the annual mean water temperature for Main Proposal 1. ....	68
Figure 6-58	Calculated change of the annual mean water temperature for Main Proposal 2. ..	69
Figure 6-59	Average temperature in Denmark summer 2018, ref. /2/. ....	70
Figure 6-60	Annual maximum of the depth-averaged water temperature for baseline conditions. ....	70
Figure 6-61	Annual maximum of the depth-averaged water temperature. Main Proposal 1 - without coastal landscape. ....	71
Figure 6-62	Annual maximum of the depth-averaged water temperature. Main Proposal 2 - with coastal landscape. ....	72
Figure 6-63	Calculated change of maximum water temperatures for Main Proposal 1. ....	73
Figure 6-64	Calculated change of maximum water temperatures for Main Proposal 2. ....	73
Figure 6-65	Consistency between freezing point, maximum density and salinity, ref. /5/. ....	74
Figure 6-66	Annual minimum of the depth-averaged water temperature for baseline conditions. ....	75
Figure 6-67	Annual minimum of the depth-averaged water temperature. Main proposal 1 - without coastal landscape. ....	75
Figure 6-68	Annual minimum of the depth-averaged water temperature. Main proposal 2 - with coastal landscape. ....	76
Figure 6-69	Calculated change of the lowest water temperature for Main Proposal 1. ....	77
Figure 6-70	Calculated change of lowest water temperature for Main Proposal 2. ....	78
Figure 6-71	Annual mean of the depth-averaged salinity for baseline conditions. ....	79
Figure 6-72	Annual mean of the depth-averaged salinity. Main Proposal 1 – without coastal landscape. ....	80
Figure 6-73	Annual mean of the depth-averaged salinity. Main Proposal 2 – with coastal landscape. ....	81
Figure 6-74	Calculated change of the depth-averaged salinity for Main Proposal 1. ....	82
Figure 6-75	Calculated change of the depth-averaged salinity for Main Proposal 2. ....	83
Figure 6-76	Annual maximum of the depth-averaged salinity for baseline conditions. ....	84
Figure 6-77	Annual maximum of the depth-averaged salinity for Main Proposal 1 – without coastal landscape. ....	84
Figure 6-78	Annual maximum of the depth-averaged salinity for Main Proposal 2 – with coastal landscape. ....	85
Figure 6-79	Calculated change of maximum salinity for Main Proposal 1. ....	86
Figure 6-80	Calculated change of maximum salinity for Main Proposal 2. ....	86
Figure 6-81	Annual minimum of depth-averaged salinity for baseline conditions. ....	87

Figure 6-82 Annual minimum of depth-averaged salinity for Main Proposal 1 – without coastal landscape.....	88
Figure 6-83 Annual minimum of depth-averaged salinity for Main Proposal 2 – with coastal landscape.....	88
Figure 6-84 Calculated change of minimum salinity for Main Proposal 1.....	89
Figure 6-85 Calculated change of minimum salinity for Main Proposal 2.....	90
Figure 6-86 Analysed points in the wave analysis of Main Proposal 1.....	91
Figure 6-87 Outer funnel, wave roses for the present conditions and Main Proposal 1.....	92
Figure 6-88 Inner funnel, wave roses for the present conditions and Main Proposal 1.....	92
Figure 6-89 Waves roses for the present conditions (left) and Main Proposal 1 (right) for point 1, Charlottenlund.....	92
Figure 6-90 Waves roses for the present conditions (left) and Main Proposal 1 (right) for point 2, Hellerup.....	93
Figure 6-91 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 3, Nordhavn.....	93
Figure 6-92 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 4, Lynetteholm North.....	93
Figure 6-93 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 5, Central Lynetteholm.....	94
Figure 6-94 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 6, Lynetteholm South.....	94
Figure 6-95 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 7, Prøvestenen North.....	94
Figure 6-96 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 8, Prøvestenen South.....	95
Figure 6-97 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 9, Amager Beach North.....	95
Figure 6-98 Wave roses for the present conditions (left) and Main Proposal 1 (right) for point 10, Amager Beach South.....	95
Figure 6-99 Changes in the average annual wave height caused by Main Proposal 1.....	96
Figure 6-100 Maximum reduction in significant wave height.....	96
Figure 6-101 Maximum increase in significant wave height.....	97
Figure 6-102 Main directions for incoming waves in analysis points with the present conditions and a Main Proposal 1 reclamation.....	97
Figure 6-103 Analysed points in the wave analysis carried out for Main Proposal 2.....	99
Figure 6-104 Outer funnel, wave roses for baseline and Main Proposal 2.....	100
Figure 6-105 Inner funnel, wave roses for baseline and Main Proposal 2.....	100
Figure 6-106 Wave roses for baseline (left) and Main Proposal 2 (right) for point 1, Charlottenlund.....	100
Figure 6-107 Wave roses for baseline (left) and Main Proposal 2 (right) for point 2, Hellerup.....	101
Figure 6-108 Wave roses for baseline (left) and Main Proposal 2 (right) for point 3, Nordhavn.....	101
Figure 6-109 Wave roses for baseline (left) and Main Proposal 2 (right) for point 4, Lynetteholm North.....	101
Figure 6-110 Wave roses for baseline (left) and Main Proposal 2 (right) for point 5, Central Lynetteholm.....	102
Figure 6-111 Wave roses for baseline (left) and Main Proposal 2 (right) for point 6, Lynetteholm South.....	102
Figure 6-112 Wave roses for baseline (left) and Main Proposal 2 (right) for point 7, Prøvestenen North.....	102
Figure 6-113 Wave roses for baseline (left) and Main Proposal 2 (right) for point 8, Prøvestenen South.....	103
Figure 6-114 Wave roses for baseline (left) and Main Proposal 2 (right) for point 9, Amager Beach North.....	103
Figure 6-115 Wave roses for baseline (left) and Main Proposal 2 (right) for point 10, Amager Beach North.....	103
Figure 6-116 Changes in the annual wave height by Main Proposal 2.....	104



Figure 6-117	Maximum reduction in significant wave height. ....	105
Figure 6-118	Maximum increase of significant wave height. ....	105
Figure 6-119	Main directions for incoming waves in analysis points with the present conditions and a Main Proposal 2 reclamation. ....	106
Figure 6-120	Cross-section through which the water flow and salt transport are calculated for present and future conditions. ....	108
Figure 6-121	Cross-sectional water flow east of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	109
Figure 6-122	Cross-sectional water flow west of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	109
Figure 6-123	Cross-sectional water flow through Øresund with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	109
Figure 6-124	Cross-sectional water flow through the havneløbet (the inner harbour) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	110
Figure 6-125	Water flow in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	110
Figure 6-126	Cross-sectional flow west of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	112
Figure 6-127	Cross-sectional flow east of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	112
Figure 6-128	Cross-sectional flow through Øresund with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	112
Figure 6-129	Cross-sectional flow through the havneløbet (the inner harbour) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	113
Figure 6-130	Flow in Kronløbet (cross-section between the tip of Nordhavn and Middelgrundsfortet) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	113
Figure 6-131	Blocking factors for water flow in the cross-section west of Peberholm. Black curve: Main proposal 1, green curve: Main proposal 2. ....	115
Figure 6-132	Blocking factors for water flow in the cross-section east of Peberholm. Black curve: Main proposal 1, green curve: Main proposal 2. ....	115
Figure 6-133	Blocking factors for water flow in the Øresund cross-section. Black curve: Main proposal 1, green curve: Main proposal 2. ....	115
Figure 6-134	Blocking factors for water flow in the havneløbet (the inner harbour). Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	116
Figure 6-135	Blocking factors for water flow in the cross-section in Kronløbet (the cross-section between the tip of Nordhavn and Middelgrundsfortet). Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	116
Figure 6-136	Effect of the project and a sea rise on the blocking in the cross-section west of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2. ....	118
Figure 6-137	Effect of the project and a sea rise on the blocking in the cross-section east of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2. ....	119
Figure 6-138	The effect of the project and the water level increase on the blocking in the Øresund cross-section. Top: Main Proposal 1, bottom: Main Proposal 2. ....	120
Figure 6-139	The effect of the project and the water level increase on the blocking in the havneløbet (the inner harbour). Top: Main Proposal 1, bottom: Main Proposal 2. ....	121

Figure 6-140	The effect of the project and the water level increase on the blocking in the cross-section between the Nordhavn tip and Middelgrundsfortet. Top: Main Proposal 1, bottom: Main Proposal 2. ....	121
Figure 6-141	Transport of salt in the cross-section west of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	122
Figure 6-142	Transport of salt in the cross-section east of Peberholm with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	122
Figure 6-143	Transport of salt in the cross-section through Øresund with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	123
Figure 6-144	Transport of salt in the cross-section through the havneløbet (the inner harbour) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	123
Figure 6-145	Transport of salt in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet) with existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	123
Figure 6-146	Accumulated transport of salt in the cross-section west of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	124
Figure 6-147	Accumulated transport of salt in the cross-section east of Peberholm with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	124
Figure 6-148	Accumulated transport of salt in the cross-section through Øresund with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	124
Figure 6-149	Accumulated transport of salt in the cross-section through the havneløbet (the inner harbour) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	125
Figure 6-150	Accumulated transport of salt in Kronløbet (the cross-section between the tip of Nordhavn and Middelgrundsfortet) with the existing conditions (black curve), reclamation without landscape (green curve) and reclamation with landscape (blue curve). ....	125
Figure 6-151	The profile's course from the start of the Drogden shipping lane and further up north past the project area. ....	126
Figure 6-152	Vertical profile of salinity during a period of balance. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2. ....	126
Figure 6-153	Vertical profile of salinity during a period of saltwater intrusion. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2. ....	127
Figure 6-154	Vertical profile of salinity during a period of loss of salt. Top: baseline, middle: Main Proposal 1 and bottom: Main Proposal 2. ....	127
Figure 6-155	Blocking factors for salt transport in the cross-section west of Peberholm. Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	129
Figure 6-156	Blocking factors for salt transport in the cross-section east of Peberholm. Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	129
Figure 6-157	Blocking factors for salt transport in the Øresund cross-section. Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	129
Figure 6-158	Blocking factors for salt transport in the havneløbet (the inner harbour). Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	130
Figure 6-159	Blocking factors for salt transport in Kronløbet (the cross-section between the Nordhavn tip and Middelgrundsfortet). Black curve: Main Proposal 1, green curve: Main Proposal 2. ....	130
Figure 6-160	Effect of the project and a sea-level rise on the blocking in the cross-section west of Peberholm. Top: Main proposal 1, bottom: Main Proposal 2. ....	132
Figure 6-161	The effect of the project and of a sea-level rise on the blocking in the cross-section east of Peberholm. Top: Main Proposal 1, bottom: Main Proposal 2. ....	132

Figure 6-162	The effect of the project and of a sea-level rise on the blocking in the Øresund cross-section. Top: Main Proposal 1, bottom: Main Proposal 2. ....	133
Figure 6-163	Impact of the project and of a sea-level rise on the blocking of the havneløbet (the inner harbour). Top: Main Proposal 1, bottom: Main Proposal 2. ....	134
Figure 6-164	Effects of the project and of a sea-level rise on the blockage in the cross-section between the Nordhavn tip and Middelgrundsfortet. Top: Main Proposal 1, bottom: Main Proposal 2. ....	135

## LIST OF TABLES

Table 6-1	Average wave directions and 12 hours of significant wave heights at the selected points. ....	98
Table 6-2	Average wave directions and 12 hours of significant wave heights at the selected points. ....	107
Table 6-3	Annual mean gross water flow and its impact on existing conditions and after reclamation without coastal landscape (Main Proposal 1). ....	111
Table 6-4	Annual mean gross water flow and its impact on existing conditions and after reclamation with coastal landscape (Main Proposal 2). ....	111
Table 6-5	Net water flow and its impact on existing conditions and after reclamation without a coastal landscape (Main Proposal 1). ....	114
Table 6-6	Net water flow and its impact on existing conditions and after reclamation with a coastal landscape (Main Proposal 2). ....	114
Table 6-7	Main Proposal 1: Estimated blocking factors for water flow in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic. ....	117
Table 6-8	Main Proposal 2: Estimated blocking factors for water flow in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic. ....	117
Table 6-9	Net transport of salt and its impact on existing conditions and a Main Proposal 1 reclamation. ....	128
Table 6-10	Net transport of salt and its impact on existing conditions and a Main Proposal 2 reclamation. ....	128
Table 6-11	Main Proposal 1: Estimated blocking factors for salt transport in selected cross-sections. ....	130
Table 6-12	Main Proposal 2: Estimated blocking factors for salt transport in selected cross-sections. Positive values indicate an increased dynamic, while negative values reflect a weakened dynamic. ....	131

# 1 Introduction

As part of the EIA process for the establishment of Lynetteholmen, a reclamation planned between Nordhavn and Refshaleøen, 4 technical background reports have been prepared to document the studies and calculations which form the basis for the environmental impact assessments. This report constitutes background report number 1 and focuses on the hydraulic impacts of the project, as well as the conditions of discharge and mixing of surplus water from the borrow area and the environmental pollutants emitted during the construction and operational phases. In addition, the report describes the effects of waste during digging associated with the replacement of the gyttja-containing sediments found along the entire outer perimeter. This bottom replacement is necessary to ensure sufficient carrying capacity.

Background report 2 describes water quality topics, focusing on the occurrence of seaweed, bathing water quality, and overall water quality. The third background report focuses on design parameters for the construction of the outer perimeter, as well as effects generated by expected future sea level rises.

The first three reports are all based on a variant of the two final main proposals, but the deviation from the final designs is slight and only has a local impact on the hydraulic conditions. Background report number 4 compares the examined and final designs, to document that the minor modification of the dog-leg in the funnel between Nordhavn and Lynetteholm has only a local impact on the hydraulic conditions, and that the three technical background reports can therefore fully assess the impacts of the project and its final design as documented in the EIA.



## 2 Summary

*Not included*

### 3 Background

The storm Bodil - which caused extensive damage in areas such as Copenhagen and Roskilde in December 2013 - was a first warning of what may be in store, at more frequent intervals, as climate-created sea level rise accelerates and the risk of flooding increases. As parts of Copenhagen are low-lying, such as Sluseholmen, there is a need to do something long-term to future-proof Copenhagen from storm surge. In Copenhagen, there are large amounts of surplus land from infrastructure projects and intense construction activity. Furthermore, as a metropolis, Copenhagen attracts people, thus increasing the need for new residential development areas.

Lynetteholm is intended as a project that together can meet the above three challenges, namely: 1) As an essential element in the storm surge protection of Copenhagen with the preparation of storm surge ports/lock gates for securing and closing the harbour entrance. 2) Meeting the need to dispose of surplus soil, and 3) Be a part of a new central district connected to the Metro and Østre Ringvej, and access to nature and potentially also beaches.

Two similar project proposals have been prepared for Lynetteholm. Main proposal 1 is a reclamation without a coastal landscape, where the outer perimeter consists of sheet piling walls and rubble mound protections. Main proposal 2 is a reclamation where a varied semi-open coastal landscape is established along the eastern perimeter. The coastal landscape of the project proposal contains both beaches with pebbles and sandy beaches shielded from impact by strong currents.

Lynetteholm will be connected to Refshaleøen, which means that the Lynette entrance used today by yachtsmen will be closed and filled up. With the establishment of Lynetteholm, their access to Copenhagen harbour will only be via Kronløbet, which means that in future, this entrance will have to be shared between commercial traffic and yachters. Today, Kronløbet is reserved for commercial traffic.

A blueprint of the Main Proposal 1 reclamation (without a coastal landscape) is shown in Figure 3-1. The eastern perimeter of the reclamation is designed with a convex shape to reduce the flow resistance along the reclamation. The northeasternmost point is located so that there is a smooth transition to the northern tip of the Nordhavn reclamation. The design ensures that the reclamation does not shield the incoming waves along the beaches at Svanemøllen, Hellerup and Charlottenlund. Likewise, the design ensures that incoming waves at Amager beach park are also not affected.

Figure 3-2 shows a blueprint of the Main Proposal 2 reclamation. The proposal, which contains a coastal landscape. This proposal only differs from Main Proposal 1 along the eastern perimeter, where a sinuous course has been built instead of a convex circle layer. The beach line must have concave elements for the sandy beaches to keep their material. Therefore, it is necessary to break up the convex circle layer in a sinuous course so that a series of concavely designed bays can be established, where protruding hardpoints help maintain the beaches. The water depths in the area nearby are so large that sand eroded from the beaches cannot be transported back onto the beaches. Therefore, hardpoints and the orientation of the beaches must be designed to retain the sand that makes up the artificially landscaped beach areas.

In both layouts, space has been made for a future gate barrier. A gate barrier or lock becomes necessary when the effects of a sea-level rise are so well manifested that the risk of flooding in Copenhagen in the event of a storm surge becomes too high. Because of the expected development in the mean water level (sea level rise adjusted for land elevation), a gate barrier solution may become relevant around 2050. That is, at the same time as it is expected that the area will be reclaimed.

When Lynetteholm is built, Trekroner's "arms" will be removed, i.e. the two stone piers at each side of the Trekroner Island that shield the harbour from wave impacts today. Likewise, the approach to the narrow harbour entrance will be adjusted, which means that the projecting northern pier with the lighthouse at the opening to the Orient Basin is removed. These changes, together with the reclaimed areas, are included in the examined scenarios.

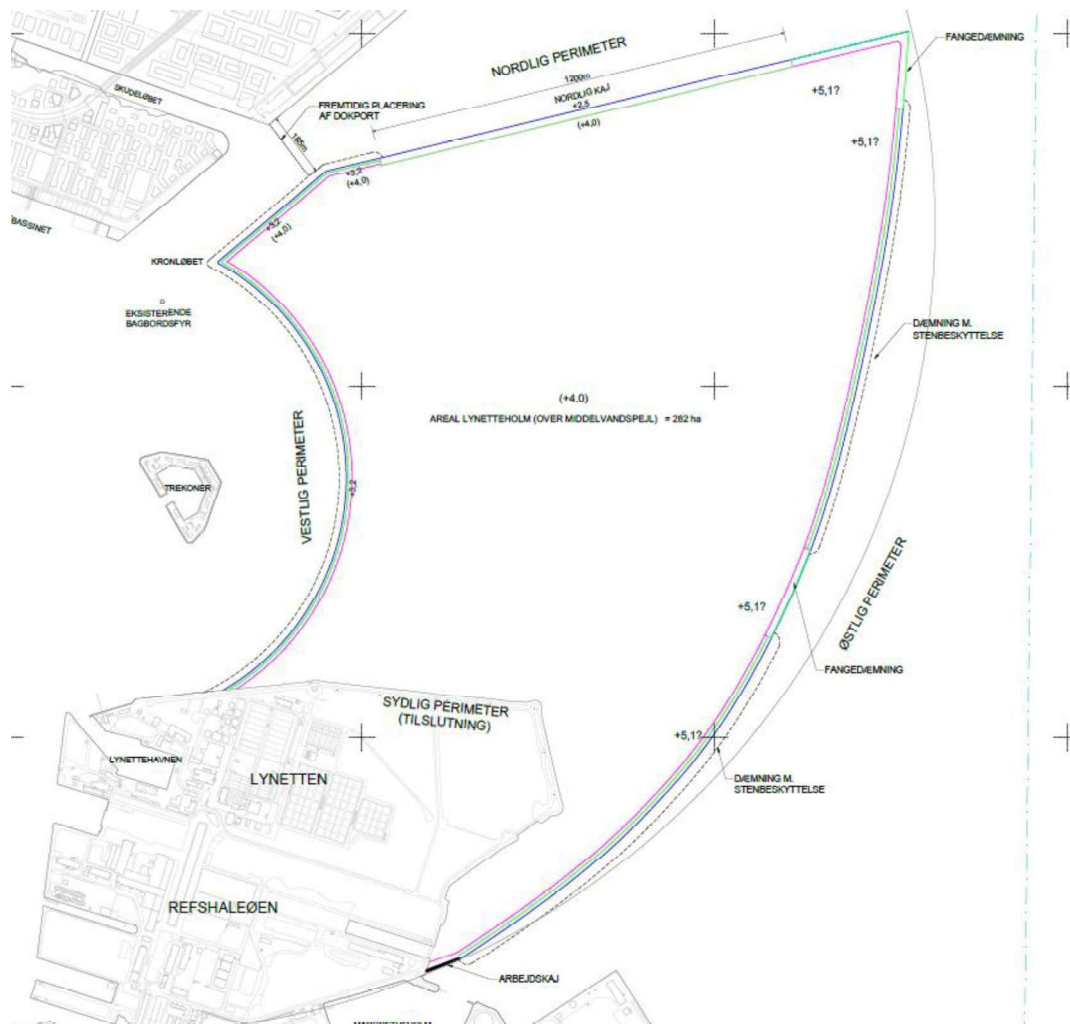


Figure 3-1 Blueprint of the examined Main Proposal 1.

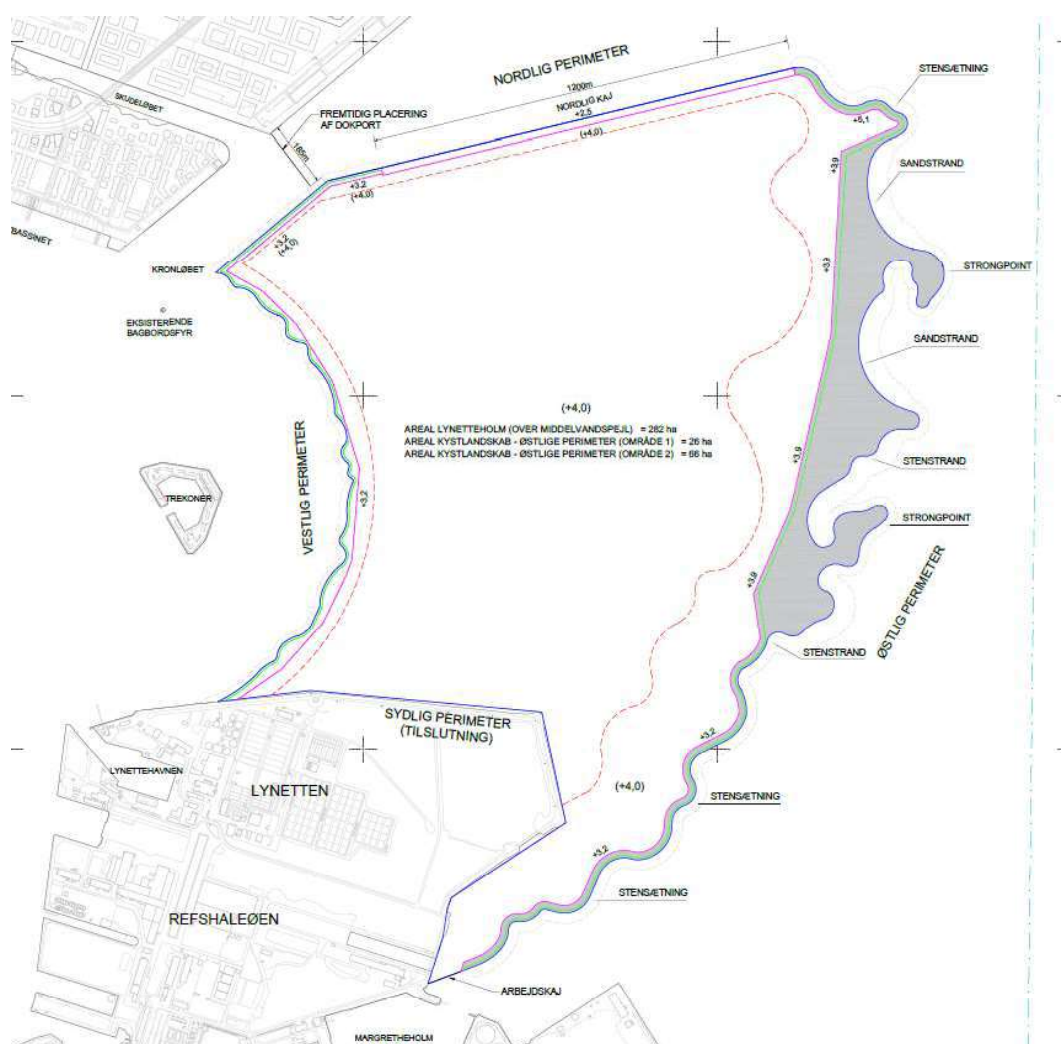


Figure 3-2 Blueprint of the examined Main Proposal 2.

The blueprints shown above are variants of the final main proposals, as in June 2020, a minor modification of the dog-leg in the funnel between Nordhavn and Lynetteholm was made. The change in the layout has only a very local impact on the hydraulic conditions, as the flow cross-section increases slightly over a relatively short distance. The design change only has a local effect on the hydraulic conditions, and the conditions described herein are therefore comprehensive and sufficient to assess the influences of the project and its final design as documented EIA.

The two examined main proposals are superposed on the bathymetry (seabed level) in the area around Lynetteholm and shown at the top of Figure 3-3.

Similarly, a figure is shown at the bottom with the final outlines of the two main proposals. It can be seen that the difference is relatively small and does not change the blocking of Kongedybet and the perimeter's course towards Øresund. The current in Havnsløbet (the inner harbour) is regulated mainly by the sluice gates in Sydhavnen and will therefore not be influenced by the design changes.

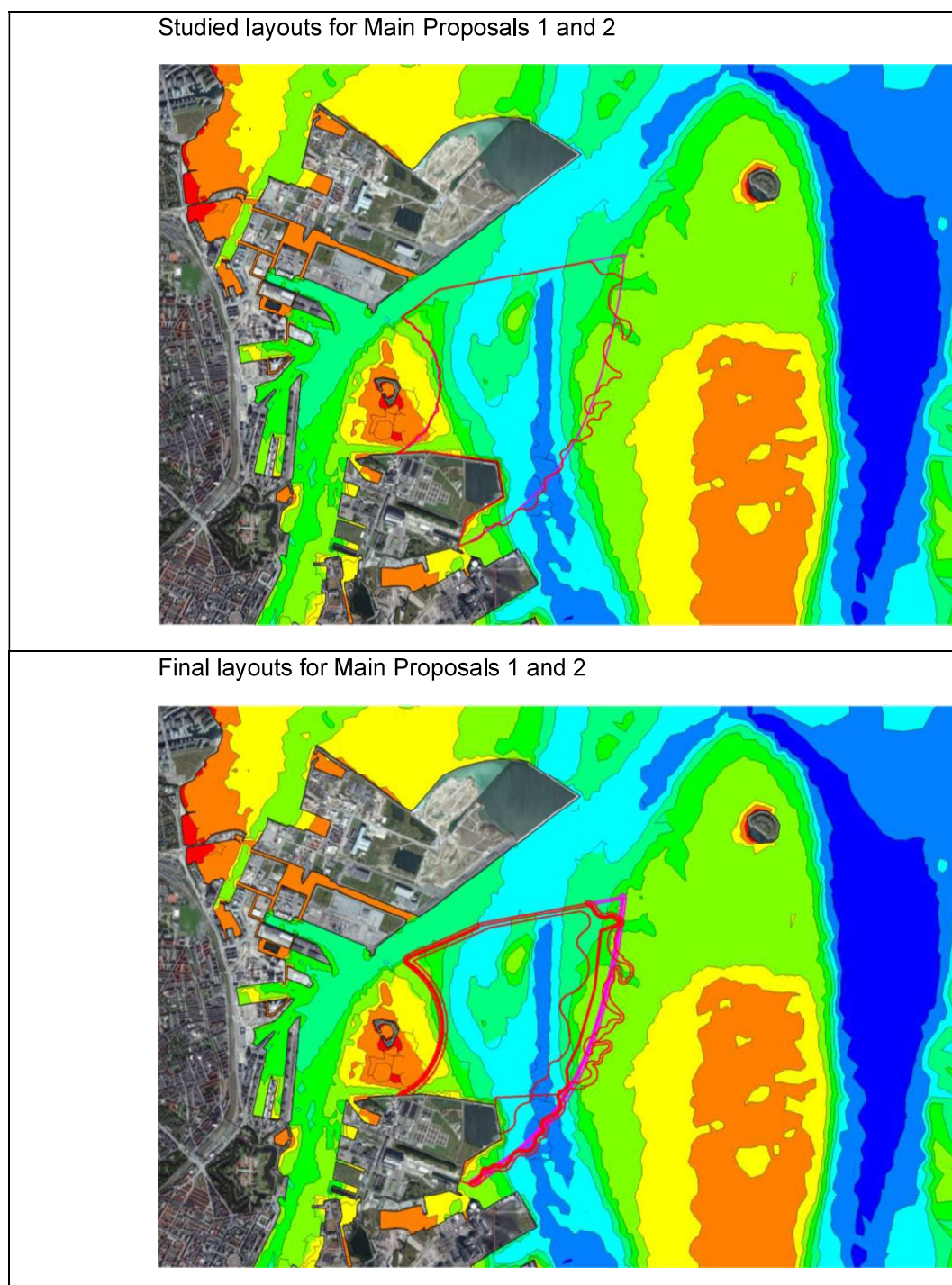


Figure 3-3 Top: Indication of studies for Main Proposal 1 (pink curve) and Main Proposal 2 (red curve). Bottom: Indication of final layouts for Main Proposal 1 (pink curve) and Main Proposal 2 (red curve). The red curve shows the crest elevation of the profile, the water level line, and the profile's foot, where it joins the natural seabed.



## 4 Basic studies

### 4.1 Hydraulic basic surveys

The following sections describe the existing current-, wave-, and water level conditions in Øresund and the area around the planned reclamation, also called Lynetteholmen. Furthermore, the section describes the hydrodynamic 3D model used, which represents water depths, wind and tidal-generated currents, salt and temperature in Øresund and Copenhagen Harbour. The model has been used to assess the following:

- Impact of reclamation on the water and salt balance through Øresund and the exchange of water between Kattegat and the Baltic Sea
- Impact of reclamation on local currents and water levels
- The local effect of reclamation on water temperature and salinity
- The impact of the reclamation on the cooling water of Amager Power Station
- The importance of the reclamation for the coastal morphology
- The general morphological influence of the reclamation

In addition, the model is used to calculate the spread of:

- Environmental pollutants emitted with surplus water from the borrow area
- Sediments associated with excavation work
- Contaminated substances tied to the sediment and released into the water phase

### 4.2 Basic description of the hydraulic conditions in the area

#### 4.2.1 General description of the hydrographic conditions of Øresund

Øresund is the second largest of the three belts Lillebælt, Storebælt and Øresund, which connect Kattegat and the Baltic Sea. The northernmost part of the Sound is shaped like a funnel, which from the section of Gilleleje-Kullen gradually narrows towards Helsingør-Helsingborg. The area contains a natural deep trench (>30 m) where stratification occurs due to the exchange between brackish water from the Baltic Sea and salty seawater from the North Sea/Kattegat. In the deepest parts of the water column, salinity is almost as in the North Sea. The deep trench runs east around Ven to just south of Landskrona. South of Landskrona Øresund gradually becomes wider, and the depths of the trenches are reduced accordingly, see Figure 4-1. In the south, the flow is divided into two by Saltholm.

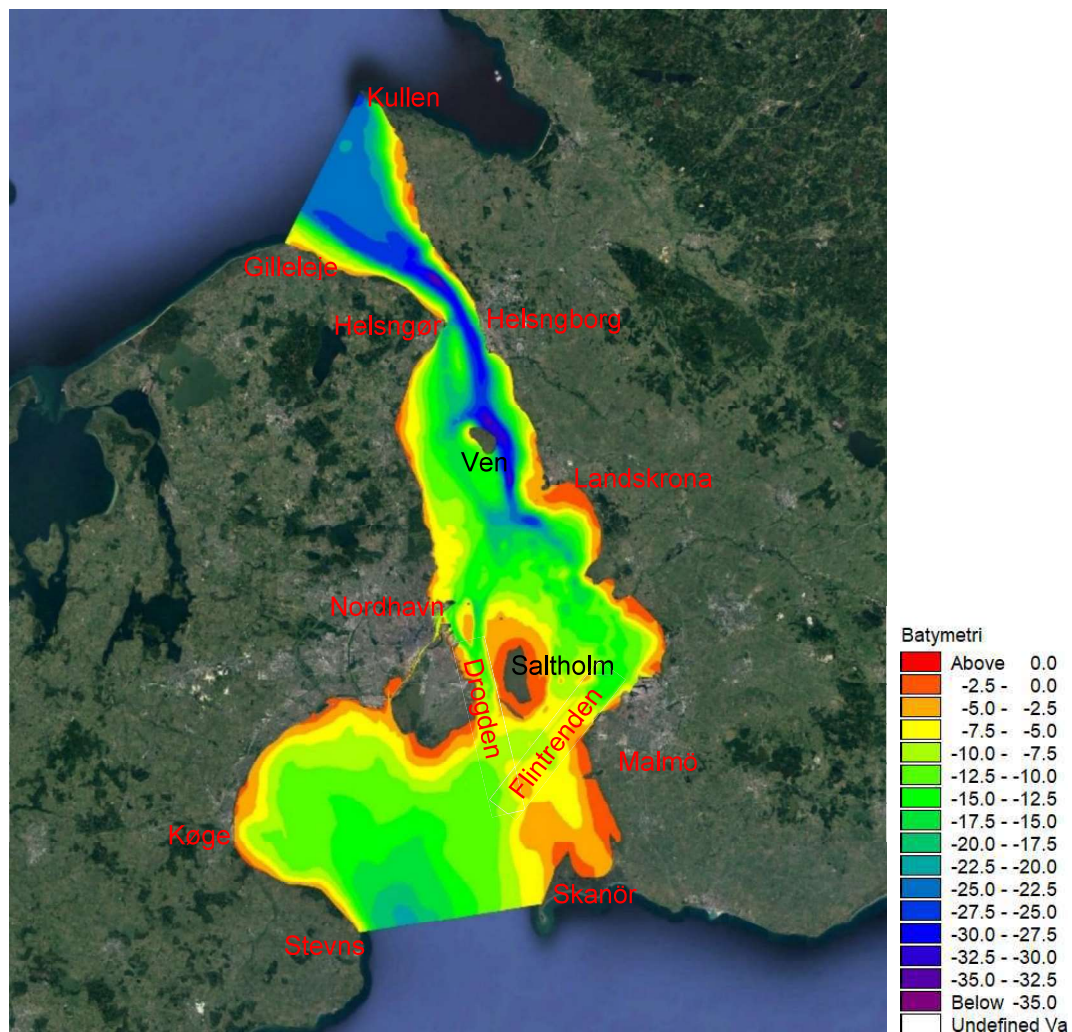


Figure 4-1 Øresund's bathymetric conditions and the extent of the baseline model.

On the Danish side of Øresund to the west, the current is focused on the deep trenches: Hollænderdybet east of Middelgrunden, Kongedybet west of Middelgrunden and Kronløbet northwest of Middelgrunden. Further south to Hollænderdybet and Kongedybet lies the Drogden shipping lane, which is deepened to guarantee a depth of at least 8 meters at mean water level, see Figure 4-2. On the Swedish side of Øresund, Lommabugten to the west and north of Malmö is a broader area with water depths between 10-15 metres. To the south is the Drogden threshold, where the water depth is between 5-8 meters. In the Swedish part, the Drogden threshold is bisected by Flinterenden, which has been further excavated to somewhere between 8 and 10 meters. Due to the relatively narrow flow width and the low water depths, the Drogden threshold is the part of Øresund where the cross-sectional area of the flow is the smallest. Therefore, the Drogden threshold is the area that provides the most significant blockage and thus determines the exchange of water and salt with the Baltic Sea. South of Drogden, the cross-section expands and moves on to Køge Bay to finally become part of the Baltic Sea.

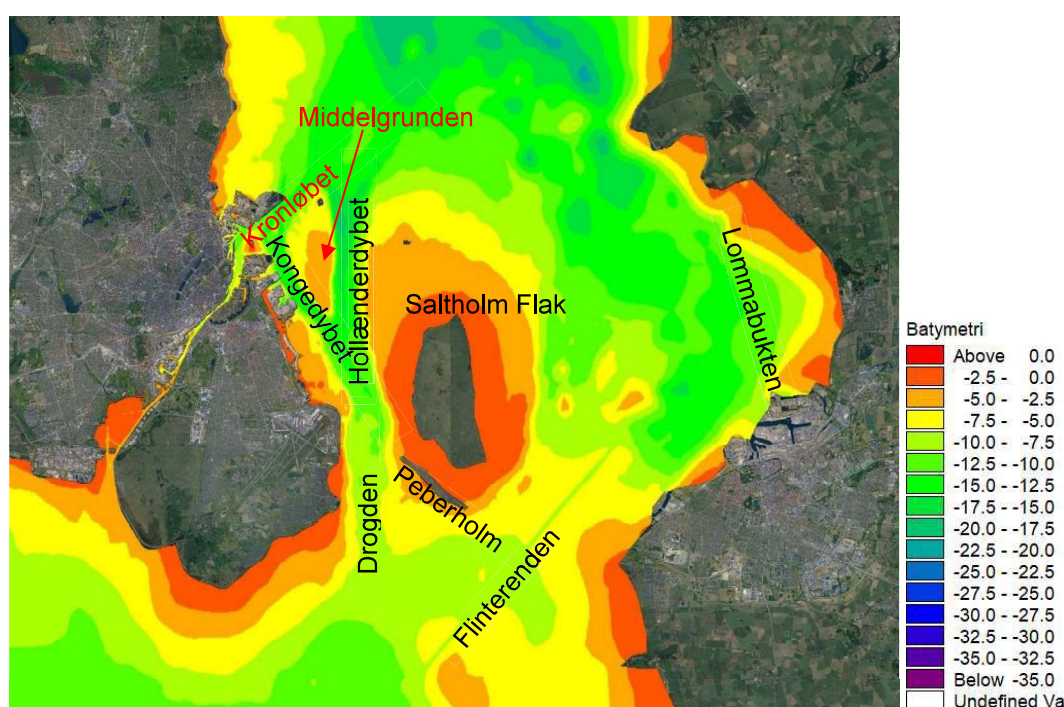


Figure 4-2 Depth and areas in the southern part of Øresund. Depths are indicated in relation to DVR90.

#### 4.2.2 General description of current and water levels

In quiet weather conditions, the current conditions in Øresund are determined by the tides and the surplus supply of fresh water supplied from rivers and streams with estuaries in the Baltic Sea. During quiet periods there are therefore changing calm currents, but with predominantly northbound currents. During periods of more severe weather conditions, the regional wind and air pressure conditions around the Baltic Sea and Kattegat have a major impact on the water exchange through Øresund. The effect of the wind causes water to be stowed up in either the Western Baltic Sea or the Kattegat depending on the wind direction. Measured water level time series for Hornbæk and Copenhagen are shown in Figure 4-3 for the period 1999-2019. It can be seen that the water level variations in Copenhagen are generally smaller than in Hornbæk, partly due to a slightly weaker tide but also due to a less pronounced stowing effect of the wind. Figure 4-4 shows a comparison of the trend-free water levels in<sup>1</sup> Hornbæk and Copenhagen in connection with the 15 worst storm surge events recorded in Copenhagen in the period 1889-2019. It can be seen that the level of a storm surge event will typically be 30 cm higher at Hornbæk than in Copenhagen.

Strong winds from directions between the west and northeast thus give rise to high water levels in the southern part of the Kattegat and in Øresund north of the Drogden threshold, while strong winds from the southeast give rise to low water levels in Øresund. The difference in water levels north and south of the Drogden threshold determines the dominant current direction in the Sound. Regional strong winds with directions between the southwest and north-west cause water from the North Sea to be squeezed into the Kattegat, thus creating the basis for southbound currents in Øresund. Strong winds with directions between northeast and south causes water to be pile up in the western part of the Baltic Sea or to be squeezed out of the Kattegat with a northbound current as a result.

<sup>1</sup> A trend-free water level is cleaned of effects of changing sea level and land elevation.



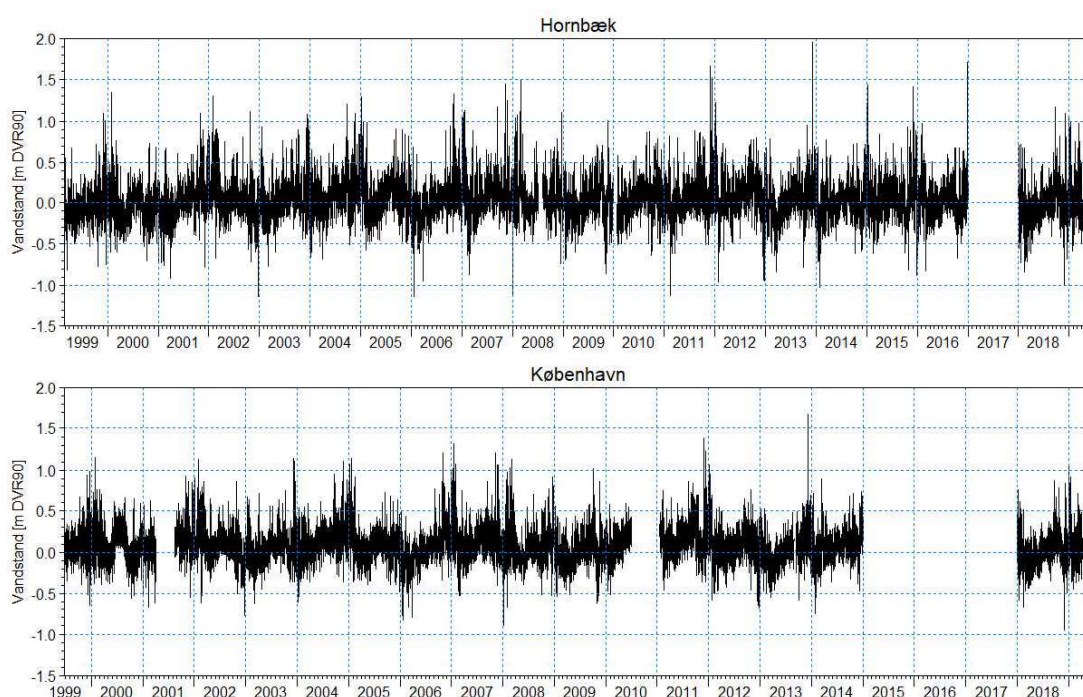


Figure 4-3 Measured water level variations in Hornbæk and Copenhagen in the period 1999-2019.

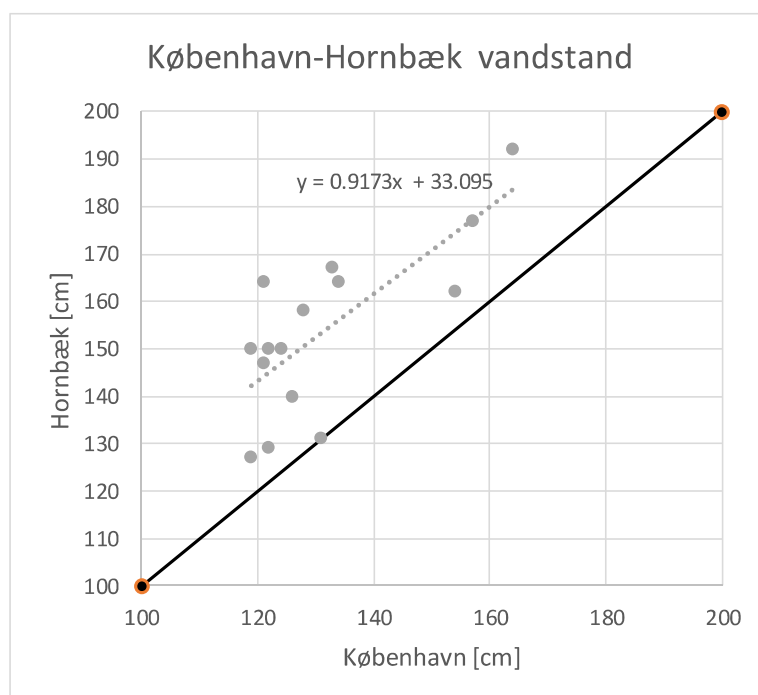


Figure 4-4 Correlation between trend-free storm surge levels in Copenhagen and Hornbæk (1881-2019).

In addition, the local wind also has an impact on the local surface current in parts of Øresund.

There is a frequent stratification in the deeper trenches of Øresund (and in the Kattegat) because the water in Kattegat's deeper layers has a salinity - and thus a density - almost as in the large oceans (30-35 ‰), while the water in the Baltic Sea is lighter brackish water due to the ample supply of freshwater from rivers with outlet in the Baltic Sea. The

stratification means that there is often a relatively fresh northbound surface current and a salty southbound bottom current. The stratification in Øresund is further maintained by the Drogden threshold, which inhibits the heavy bottom current and salt transport to the Baltic Sea. The net flow in Øresund is northbound due to the flow of water from the estuary rivers into the Baltic Sea, as Øresund, the Great Belt, and the Little Belt are the only outlets from the Baltic Sea. The transport of salt to the Baltic Sea occurs primarily by saltwater intrusions, i.e. incidents where water from the Kattegat is pushed through Øresund over the Drogden threshold and through the belts for an extended period.

#### 4.2.3 Numeric model

In order to estimate the blocking effect of Lynetteholmen on the transport of water and salt through Øresund and Copenhagen harbour and on the regional dynamics described above, it has been chosen to set up the three-dimensional (3D) hydrodynamic model so that it covers the entire Øresund from the Gilleleje-Kullen cross-section in the north to the cross-section Stevns-Falsterbonæsset in the south.

A 3D model divides the water depth into a series of layers vertically, so that the currents of the water can be calculated in all three directions. The model is formulated with a sigma-z solution, which means that all areas with a water depth less than 15 meters are resolved in 10 layers above the vertical, each with a height equal to 1/10 of the water depth. A fixed vertical mesh width is used on water depths greater than 15 meters, which in the part of the water column below 15 m is gradually stretched from 1.5 meters to 3 meters. The calculation network is designed to gradually be refined towards the Lynetteholm area, see Figure 4-5. The bathymetry is interpolated on the basis of survey data received from By & Havn, covering Copenhagen's water bodies, as well as the confluence south of Middelgrunden. In the other areas, navigation chart data from other sources have been used.

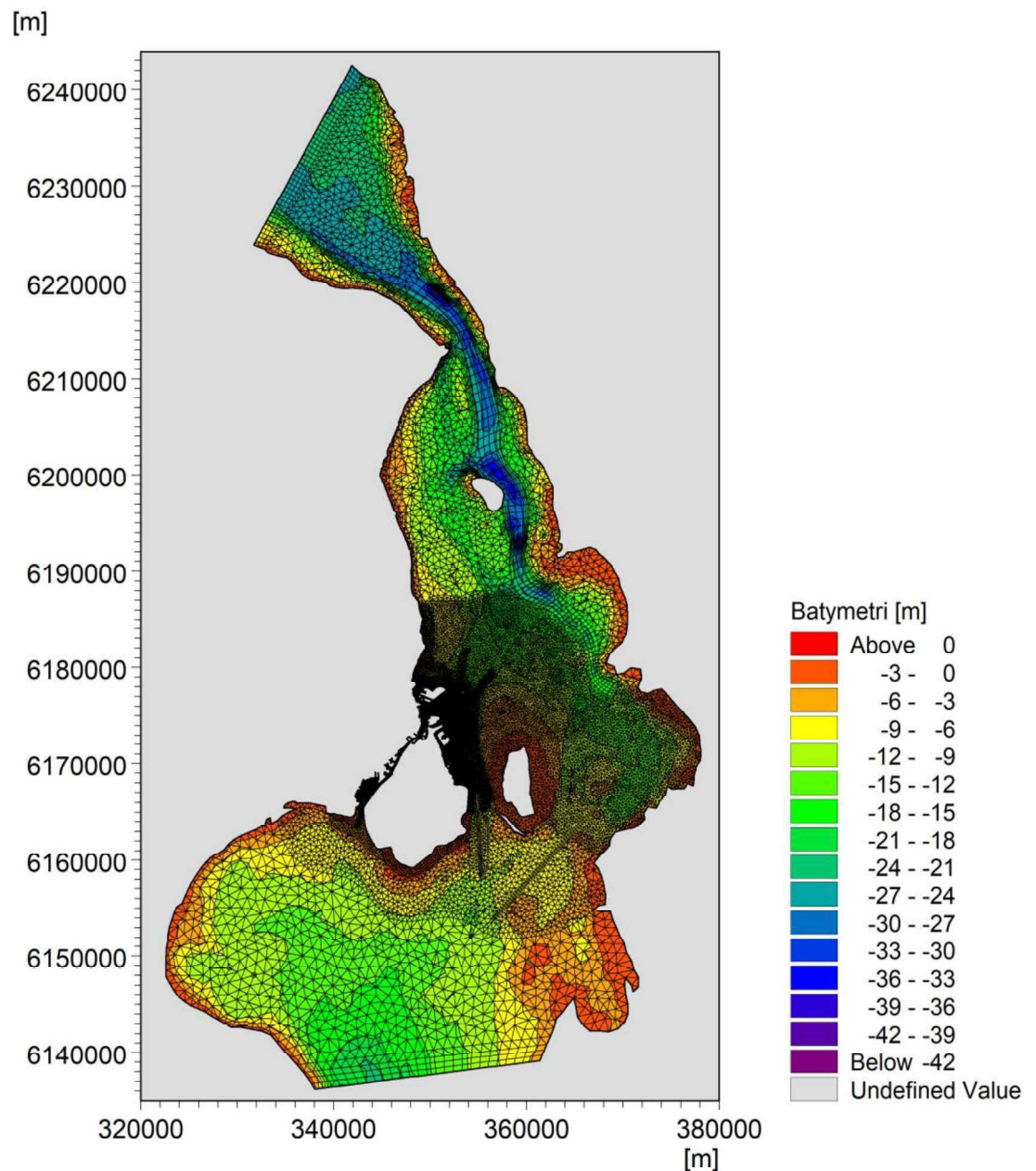


Figure 4-5 Bathymetry and computational mesh of the baseline model.

#### 4.2.4 Selected modelling period

Minor tidal oscillations control the water exchange through the Sound with a period of 12.5 hours. Tidal oscillations are typically superposed by more long-term oscillations lasting several days. The long-term period oscillations are mainly related to the passage of weather systems (storm low pressure systems), which guide the dynamic water exchange between the Baltic Sea and the North Sea. Saltwater intrusions occur during the more extreme events of this type, i.e. incidents where high salinity water (20-22 ‰) passes across the Drogden threshold. Large saltwater intrusions occur irregularly in time and often with intervals of every several years. On top of this dynamic, there is a contribution from the general run-off of the surplus supply of freshwater stemming from rivers and streams with their estuary in the Baltic Sea. The water flow contribution from the rivers varies throughout the year, as do the water temperatures, so it is chosen to model an entire year

to cover all seasonal variations. As a model year, it has been selected to use the most recent full calendar year of the surveys (2018). Results for model calibration against measured water levels and salinity profiles are shown in Annex A.

## 5      Assessment of the environmental impact during the construction phase

*Not included*

## 6 Assessment of impacts during the operational phase

### 6.1 Hydraulic and coastal morphological conditions

#### 6.1.1 Assessment of changing sea levels

Both main proposals for the Lynetteholm reclamation will close Kongedybet completely and will therefore significantly change the local flow conditions and thus also to some extent the water level conditions. Lynetteholm's impact on local water levels is illustrated below.

##### 6.1.1.1 Mean water level

As expected, both main proposal for Lynetteholm have virtually no impact on the mean water level. Based on the water level variation throughout the year 2018, Figure 6-1 and Figure 6-2 show the expected change in mean water levels that Lynetteholm will cause without and with a coastal landscape along the eastern perimeter, respectively. The figures show that the mean level will decrease by between 5-10 mm in the funnel between Nordhavnen and Lynetteholmen and along the northeastern part of the perimeter. In the proposal without a coastal landscape, the reduction can be felt all the way to Kvæsthusbroen. In the other areas, the change is less than 5 mm and thus no areas can be identified where the expansion will lead to an increase in the mean water level.

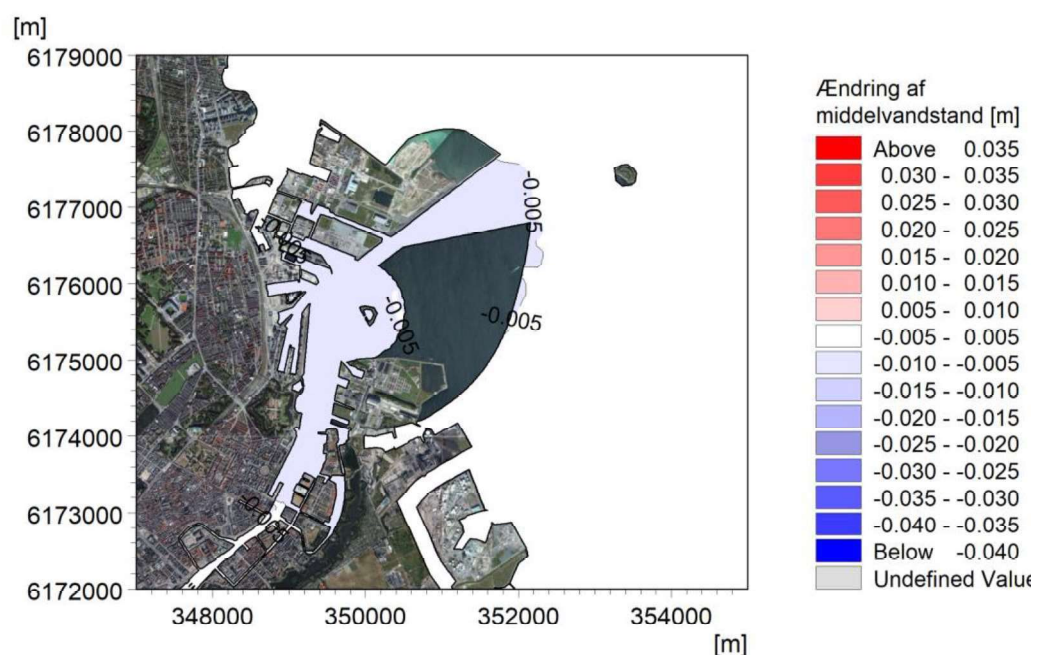


Figure 6-1 Change in the mean water level in 2018 with a Lynetteholm reclamation without a coastal landscape.



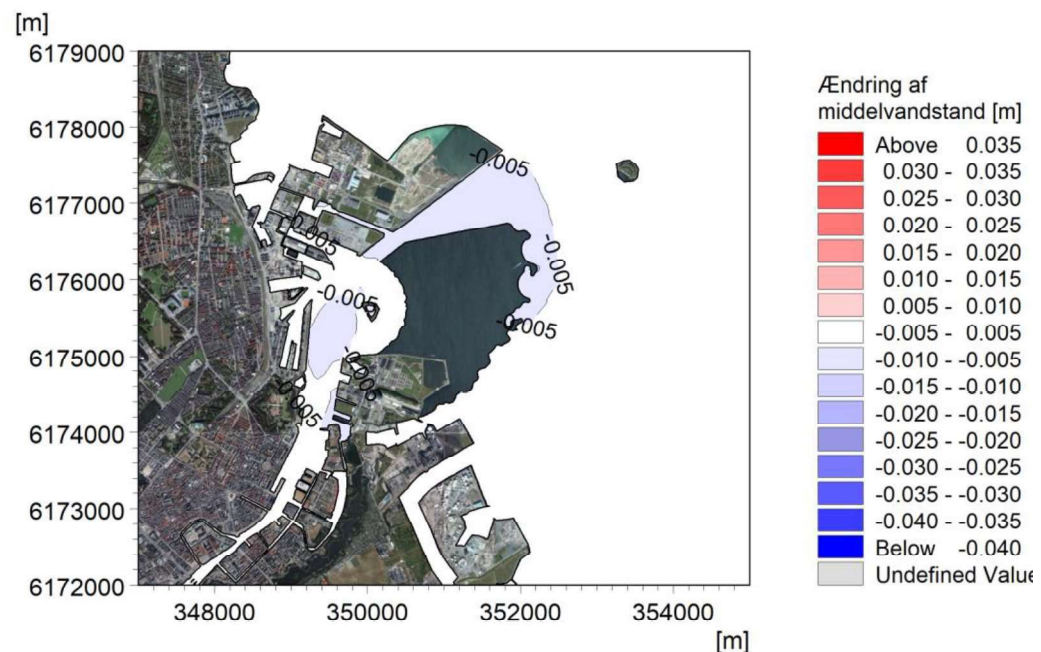


Figure 6-2 Change in the mean water level in 2018 with a Lynetteholm reclamation with a coastal landscape.

#### 6.1.1.2 Maximum water level

The year 2018 does not contain any actual storm surge events. The maximum water level is therefore associated with a moderate high-water event. Figure 6-3 shows the highest modelled water levels in 2018 for baseline and the two main proposals for a Lynetteholm reclamation. The plots are based on a statistical analysis and therefore do not represent the conditions at one specific moment. In general, the high-water levels north and south of the Drogden threshold will be associated with two different events. The Drogden threshold can be identified by the yellow and orange bands, where the water level is lowest.

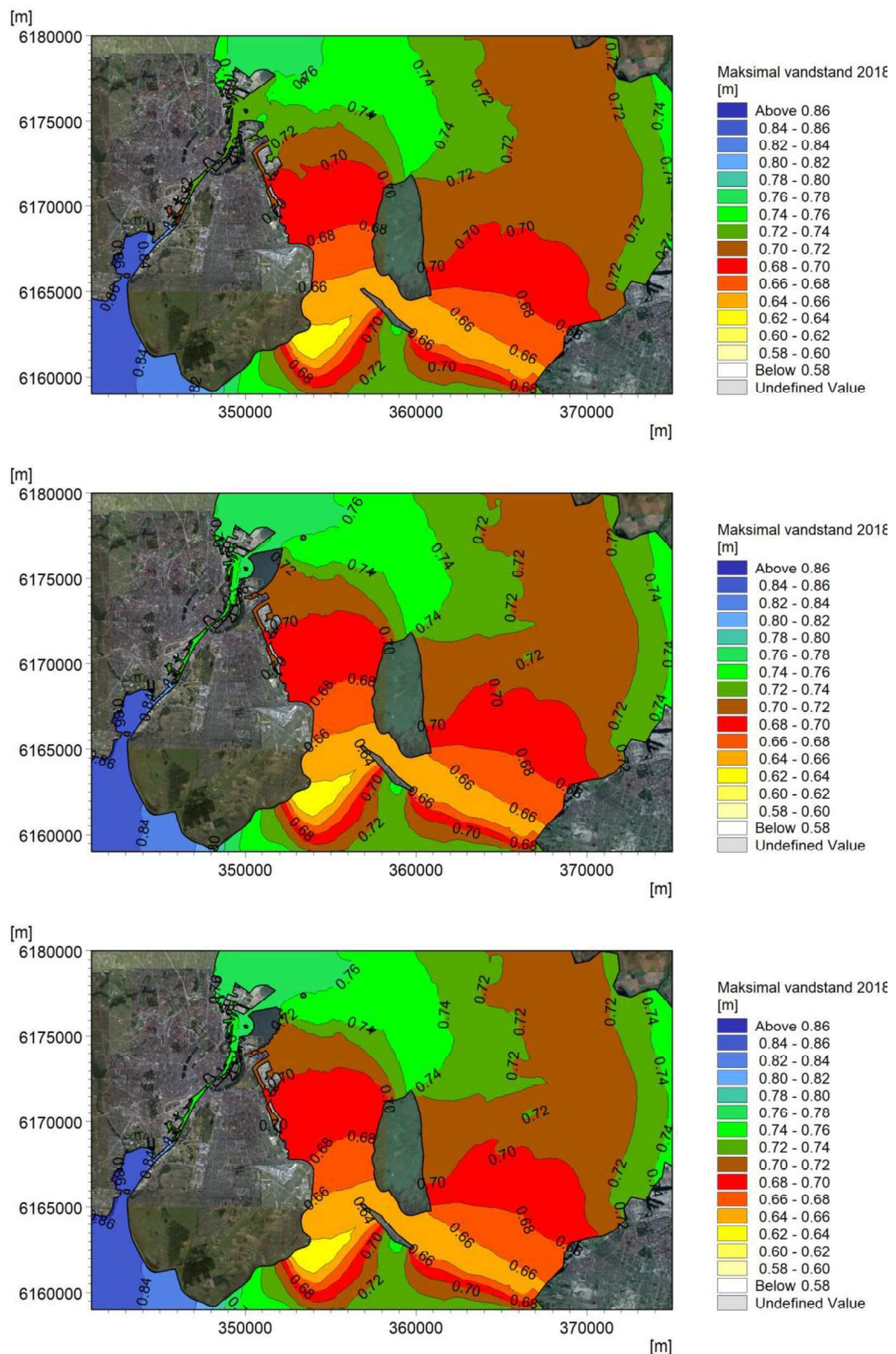


Figure 6-3 Modelled maximum water level year 2018 for baseline conditions (top), with a Lynetteholm reclamation without a coastal landscape (centre) and a Lynetteholm reclamation with a coastal landscape (bottom).

The change in maximum water levels is calculated and shown in Figure 6-4 for Main Proposal 1, which does not contain a coastal landscape. It can be seen that there is a tendency towards slightly increased water levels throughout the harbour towards the sluice



gates in Sydhavnen. The increase is between 20-25 mm in the area east of Trekroner and in the inner part of the Kronløbet. In the area southeast of Lynetteholm there is a reduction in the maximum water level of up to 30 mm. In general, it varies between 15-30 mm along the eastern perimeter.

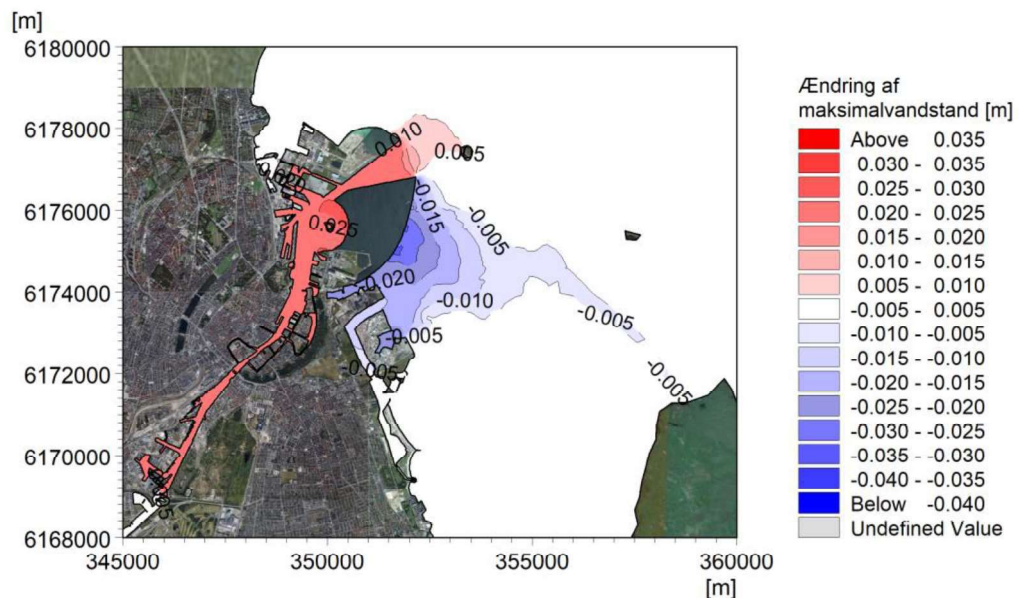


Figure 6-4 Change of the present maximum water level owing to a Lynetteholm expansion without a coastal landscape.

The increase in the high-water level inside the harbour, as shown in Figure 6-5, is much the same for Main Proposal 2 (25-30 mm) but a reduction the maximum water level along the eastern perimeter is slightly bigger. During most of the stretch along the eastern perimeter, the reduction is between 30-35 mm.

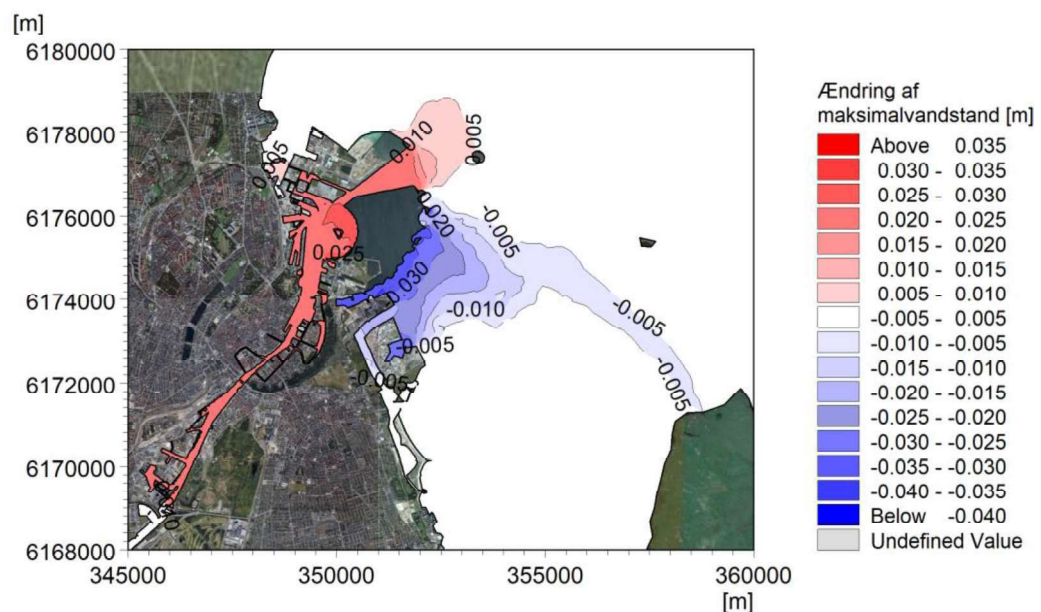


Figure 6-5 Change of the present maximum water level as a result of Lynetteholm's reclamation with a coastal landscape.

The effects on maximum water levels are local but imply that there will be a slightly increased water level in the harbour right up to the sluice gates in connection with a storm surge.

The Lynetteholm reclamation is intended as an essential element in the future storm surge protection of Copenhagen but has as an additional effect that it will slightly increase storm surge levels in the harbour until the establishment of a storm surge gate, which can be closed in connection with an increase of the water level. It can therefore be inferred that the Lynetteholm reclamation will accelerate the need for a storm surge gate as sea level rises of the mean water level prevail.

#### 6.1.1.3 Minimum water level

In 2018 an incident occurred with very low water levels which has not been surpassed in the past 20 years. Figure 6-6 shows the lowest modelled water levels in 2018 for baseline conditions and the two main proposals for a Lynetteholm reclamation. The plots are based on a statistical analysis and therefore do not represent the conditions at one specific moment.

The change of minimum water levels is calculated and shown in Figure 6-7 for Main Proposal 1, which does not contain a coastal landscape. It can be seen that there is a tendency towards slightly reduced water levels throughout the harbour towards the sluice gates in Sydhavnen. The reduction is between 25-62 mm and decreasing towards the sluice gates. The largest reduction of 50-62 mm occurs in the funnel between Nordhavnen and Lynetteholm and the effect with reduced water levels extends into Øresund in the form of a northeast oriented cone, which extends past the Middelgrund fort. In the area north of the Nordhavn reclamation there is a water level increase of up to 13 mm. In the area southeast of Lynetteholmen and all the way down to Peberholm there is an increase in the minimum water level of between 5-35 mm.

As Figure 6-8 shows, the changes to the minimum water level for Main Proposal 2 are virtually identical to Main Proposal 1.

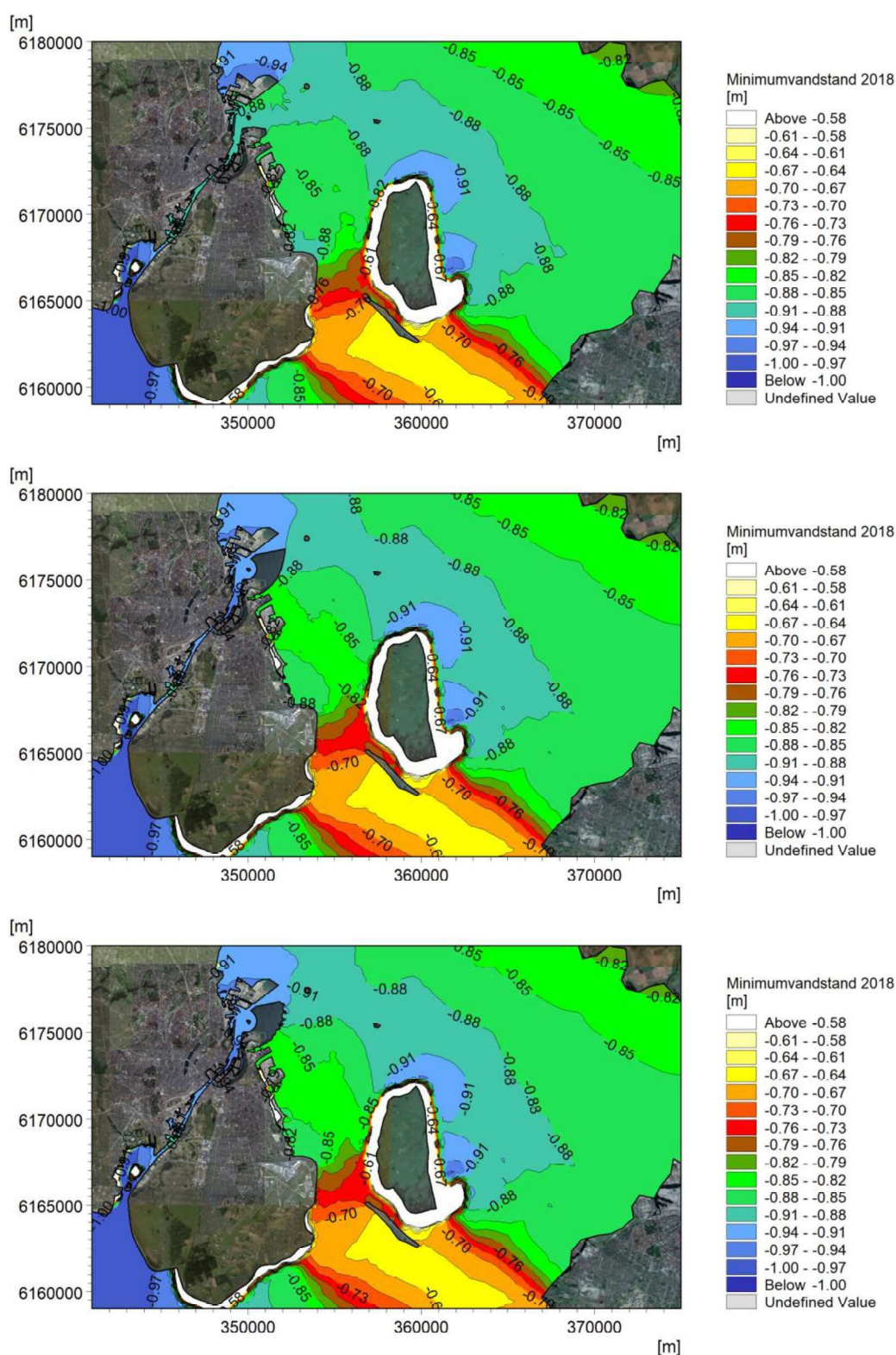


Figure 6-6 Modelled minimum water level year 2018 for baseline conditions (top), with the Lynetteholm reclamation without a coastal landscape (centre) and the Lynetteholm reclamation with a coastal landscape (bottom).



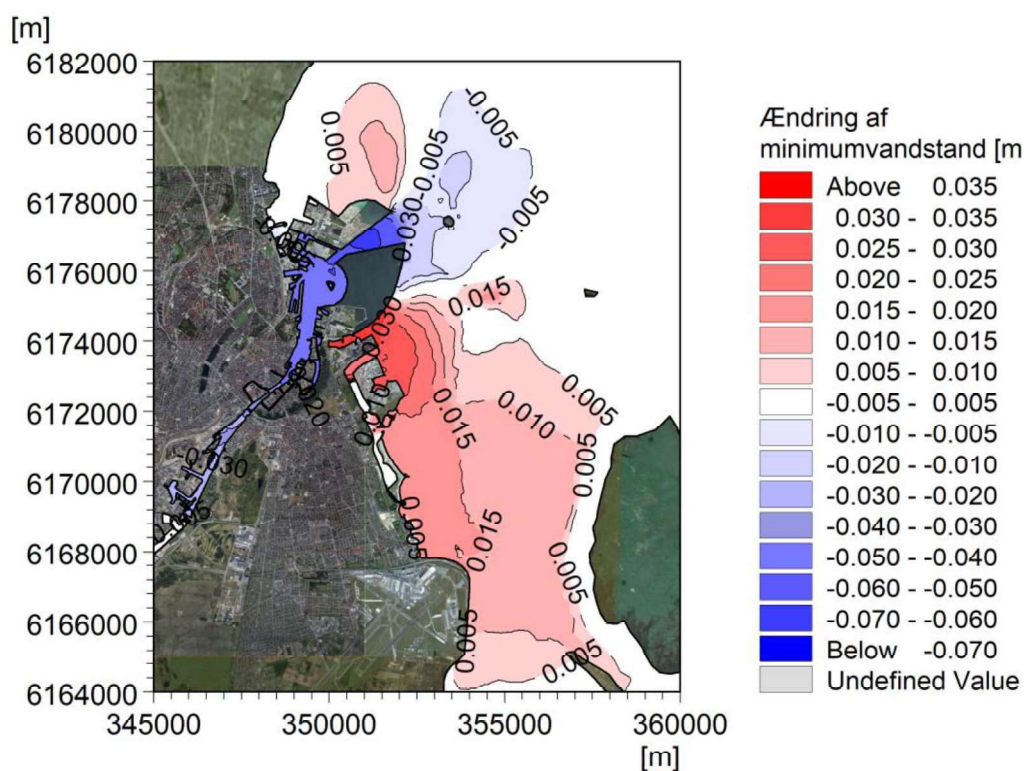


Figure 6-7 Change of the minimum water level with a Lynetteholm reclamation without a coastal landscape.

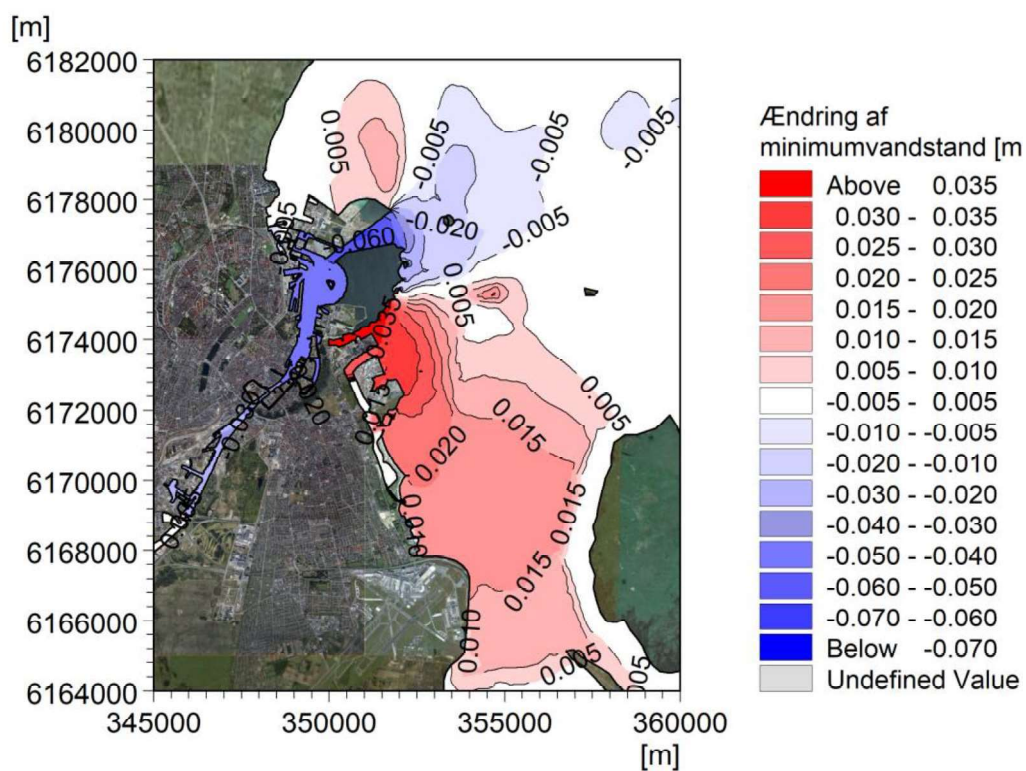


Figure 6-8 Change of the minimum water level with a Lynetteholm reclamation with a coastal landscape.

## 6.1.2 Assessment of changing current conditions

This section describes the local current conditions and the current changes that the Lynetteholm reclamation will cause. The current conditions and their impact are described for the two similar designs (i.e. with and without a coastal landscape). In the calculations carried out, it is assumed that the wings of the Trekronerfort (the two breakwaters at each side of the Trekroner Island) will be removed since, with the establishment of Lynetteholm, they have no purpose any longer. In addition, the protruding pier at the Orient Basin has been removed to improve the entry conditions through Kronløbet to the harbour.

### 6.1.2.1 Conditions with strong southbound current

The reclamation of Lynetteholm will close Kongedybet in both its designs and, therefore, significantly affect the local flow conditions. The impact will be most prominent in situations with strong northbound or southbound currents, as the current from Kongedybet is forced east around Lynetteholm. The current from Kongedybet will be distributed so that a current amplification is created over parts of Middelgrunden and more water passes through Hollænderdybet.

In Figure 6-9, the depth averaged current fields are shown for a situation with a strong southbound current (28 January 2018) for the existing conditions (top) and for a Lynetteholm reclamation without a landscape (centre). To help understand the current patterns, a plot of water depths (bottom) has also been inserted. The corresponding figure for a Lynetteholm reclamation with a coastal landscape along the eastern perimeter is inserted in Figure 6-10.

The current images show that for both designs a current increase occurs in the area east of the reclamation, but that the current weakens east of the Nordhavn tip and in Kongedybet off Amager power station as well as the Prøvestenen south of Lynetteholm. As the current is southbound, it is primarily the conditions off and downstream Lynetteholmen that are affected. It can be seen that the current attenuation in the area off the Amager power station is most substantial in the design with a coastal landscape.

Current conditions are described by a speed and a direction. Current changes can therefore be calculated and illustrated in two ways; as a vector change, considering the effects of changes in the speed and direction of the current and as a scalar change, considering only the speed of the current. Both calculation methods are used in the plots shown in Figure 6-11 and Figure 6-12. These plots are zoomed out to cover the entire impact area. The figures show noticeable current reduction in Kongedybet and Kronløbet at the mouth of the harbour. The current reduction in Kongedybet off Amager power station may impact the power station's use of cooling water. There is a natural current shelter in the beach pockets and therefore also strong current reduction in these areas.



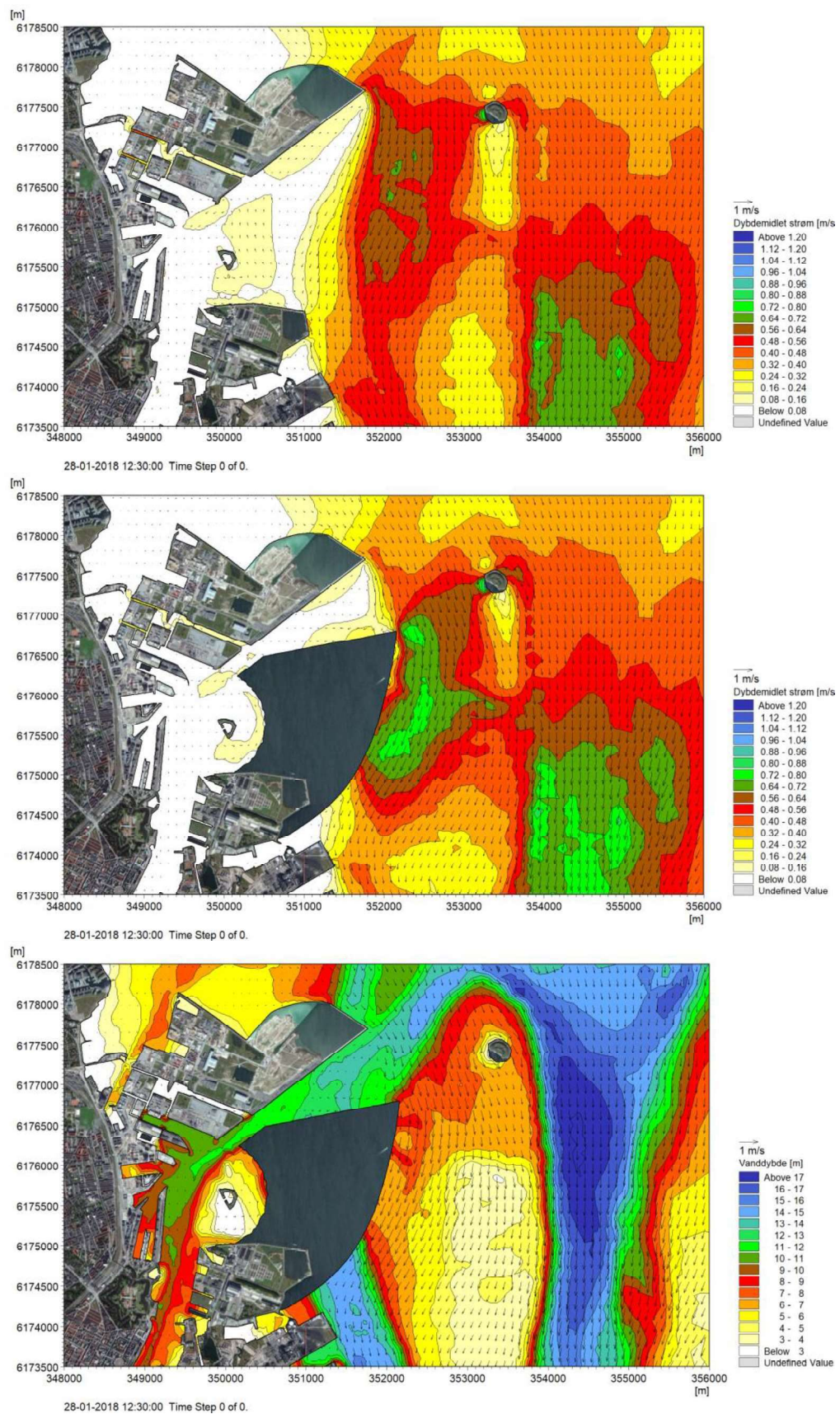


Figure 6-9 Depth-average current speed and water depths for conditions with strong southbound currents on January 28, 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with current vectors.



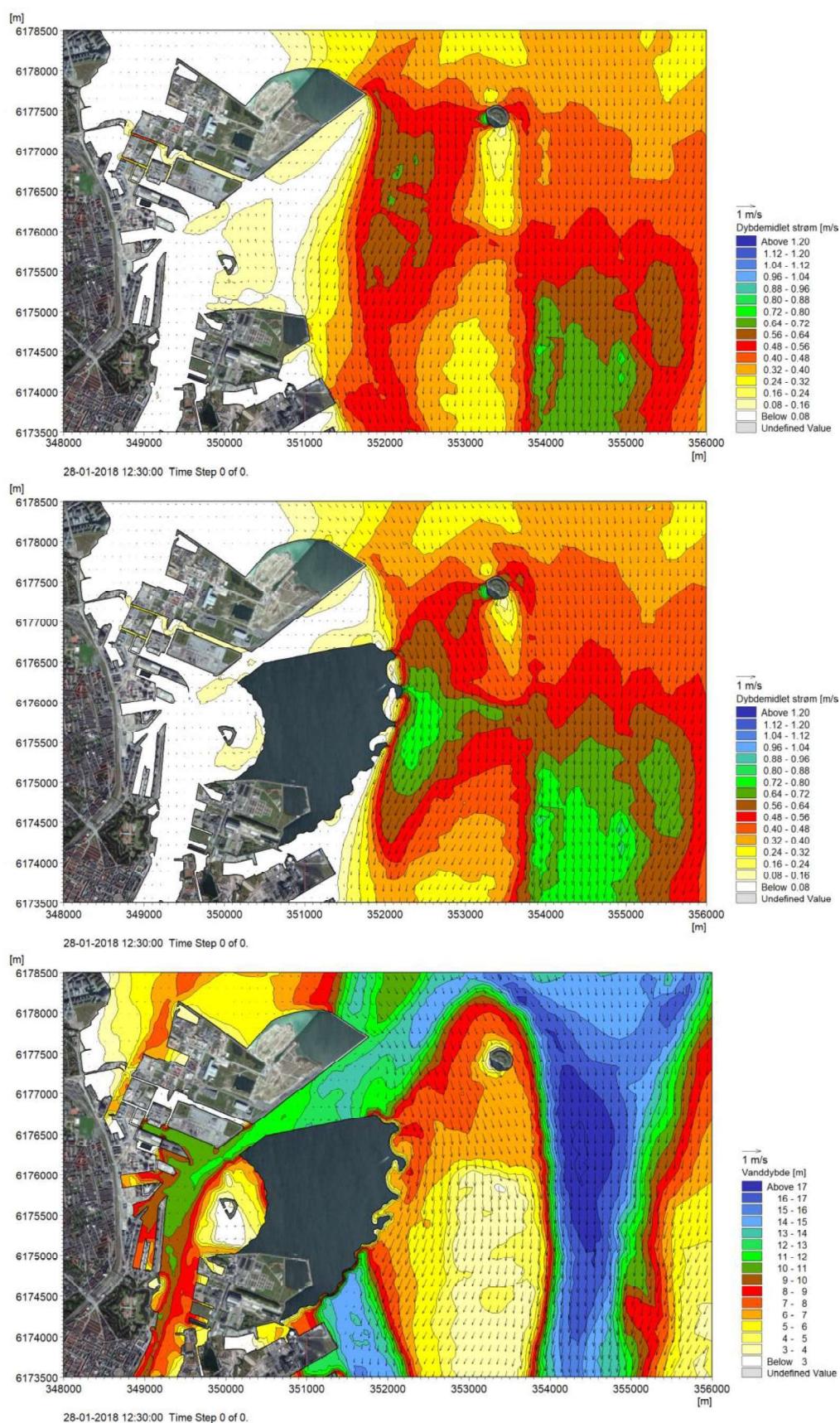


Figure 6-10 Depth-averaged current speed and water depths for conditions with strong southbound currents on January 28, 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with current vectors.

East of Lynetteholm is a larger area that will experience a current amplification. The current amplification decreases in the direction away from Lynetteholmen but can be identified as a current increase of more than 5 cm/s at a distance of up to 5 km. Likewise, there is a current amplification in Hollænderdybet, especially along the southernmost part of the Middelgrunden. East of Trekroner, there is also current reduction, as, after the reclamation, the area will be a foreclosed part of the harbour; today, it is part of Øresund.

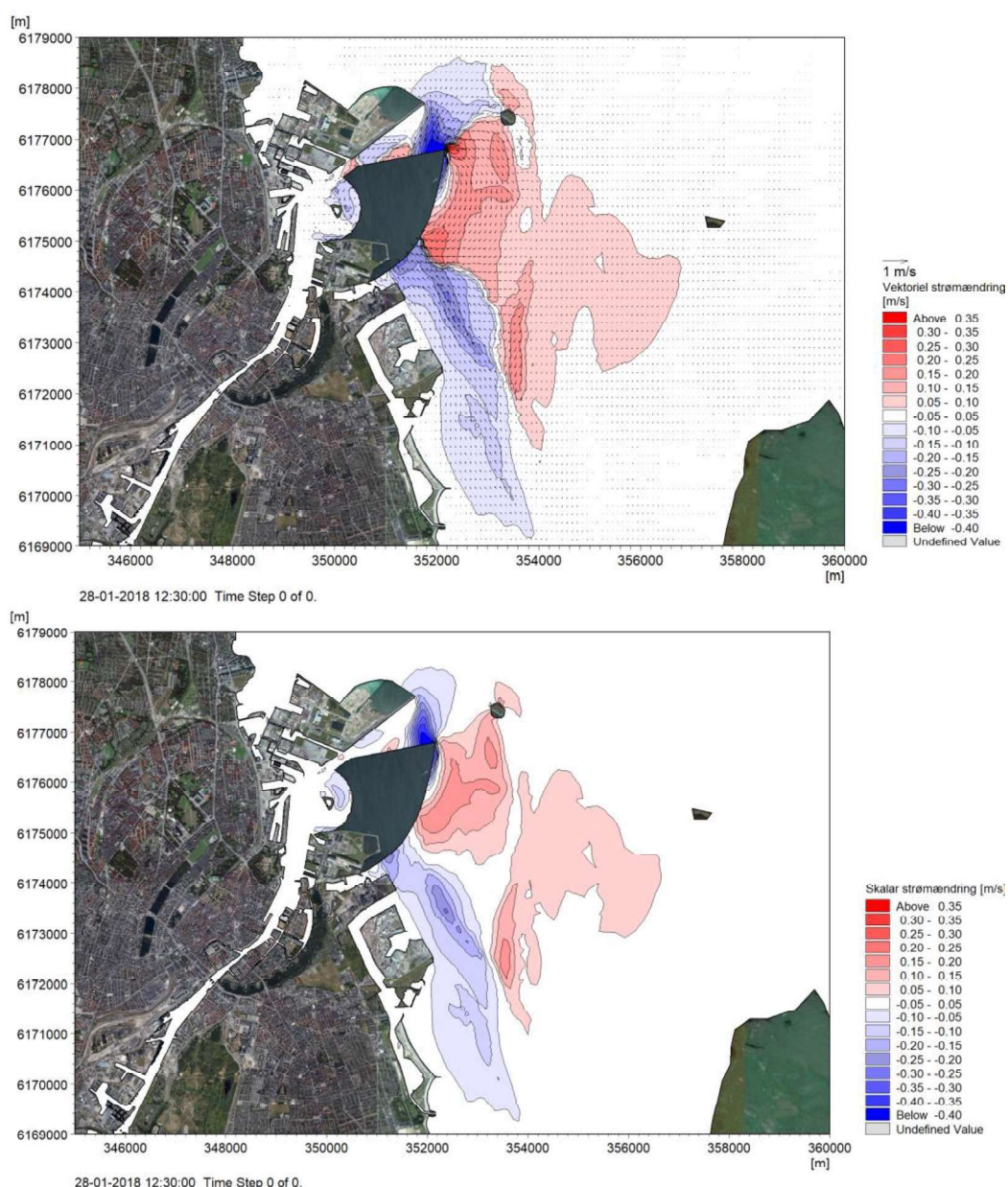


Figure 6-11 Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions with strong southbound current and reclamation without coastal landscape.



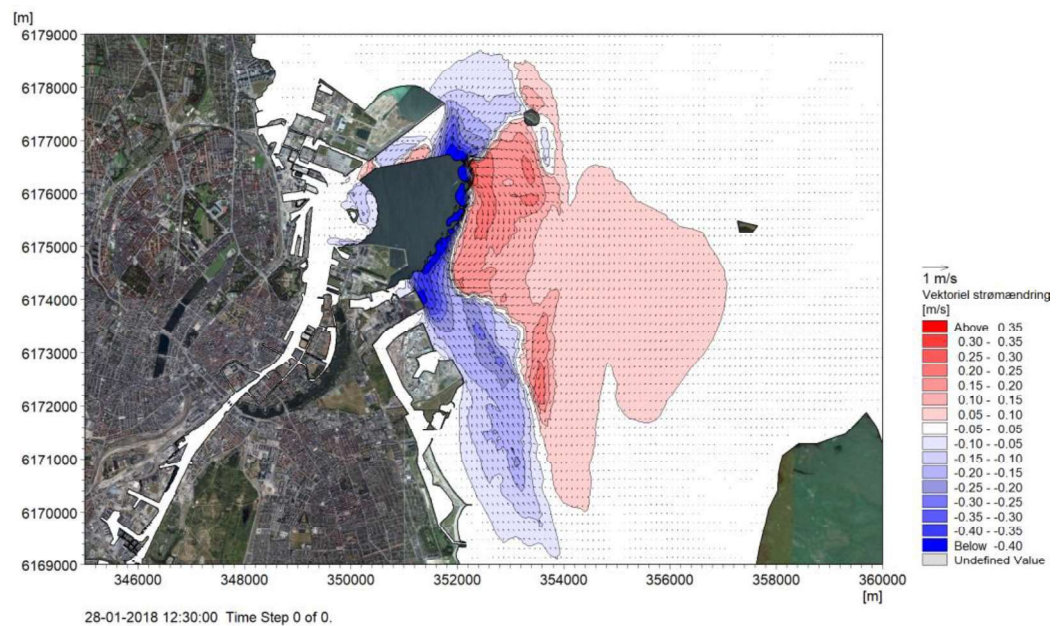


Figure 6-12 Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions of strong southbound flow and reclamation with coastal landscape.

For the same current situation with a solid southbound current, the surface velocities are shown in Figure 6-13 for the existing conditions and Lynetteholm expansion without coastal landscape and in Figure 6-14 for Lynetteholm with a coastal landscape. The surface velocities are higher than the depth-averaged velocities, so the impact appears relatively larger in these plots. A plot of water depths has been inserted again at the bottom of the shape to better understand the current image. The flow is reduced in the area at the north-eastern tip of the Nordhavn reclamation, where surplus water is currently discharged from the ongoing reclamation works. The reduced current conditions will make it easier to dock at the planned container terminal along the north-eastern quay of the Nordhavn reclamation due to the reduced cross-current effects.

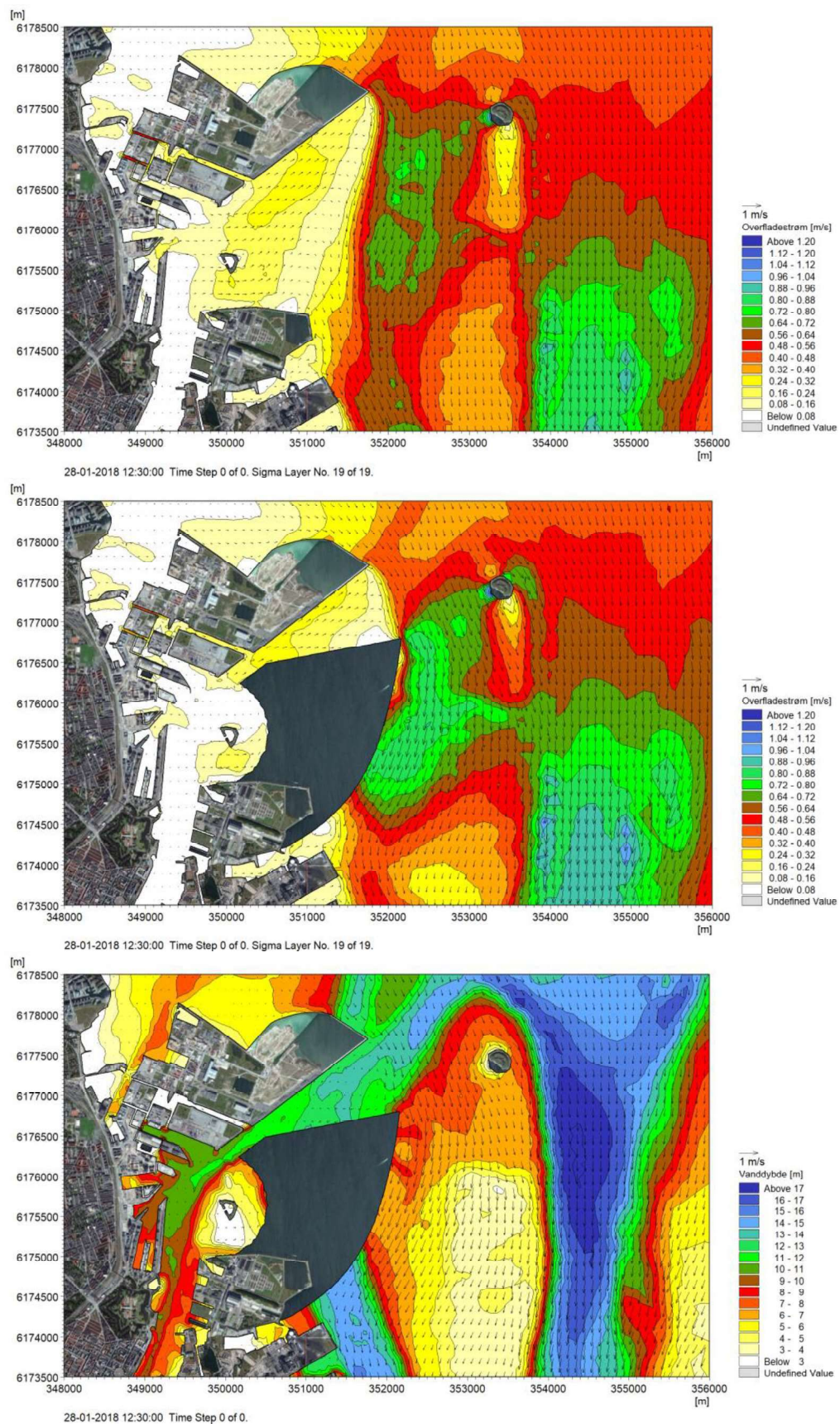


Figure 6-13 Surface velocity under conditions with strong southbound current on 28 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.



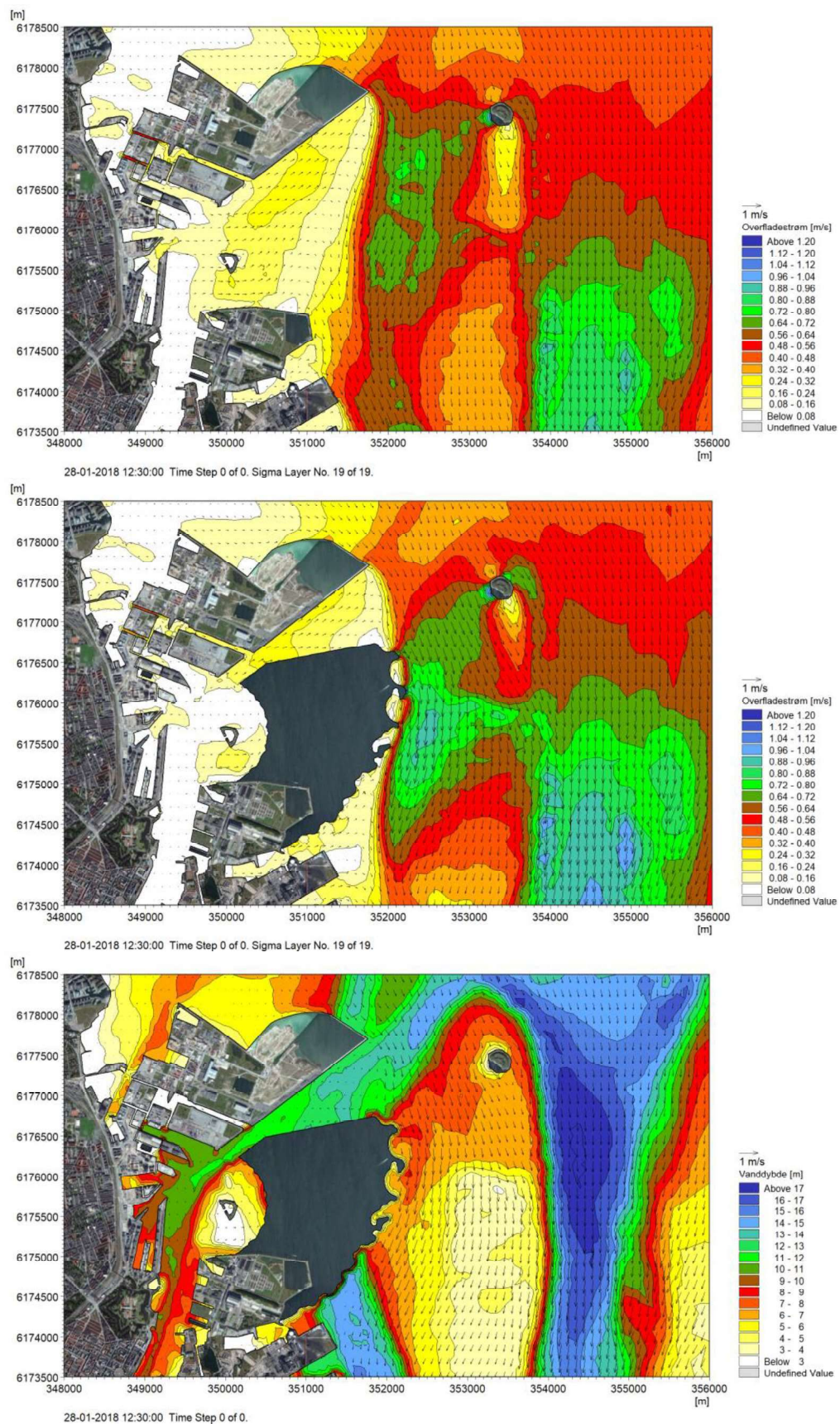


Figure 6-14 Surface velocity under conditions with strong southbound current on 28 January 2018. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with the depth-averaged current vectors.



The changes in the surface current of a reclamation without coastal landscape are shown at the top of Figure 6-15, calculated as the vector difference, considering changes in the direction of the current and at the bottom of a scalar calculation, considering only the change in the magnitude of the current. The impact on the surface current is analogous to the depth-averaged change, but the changes are more significant.

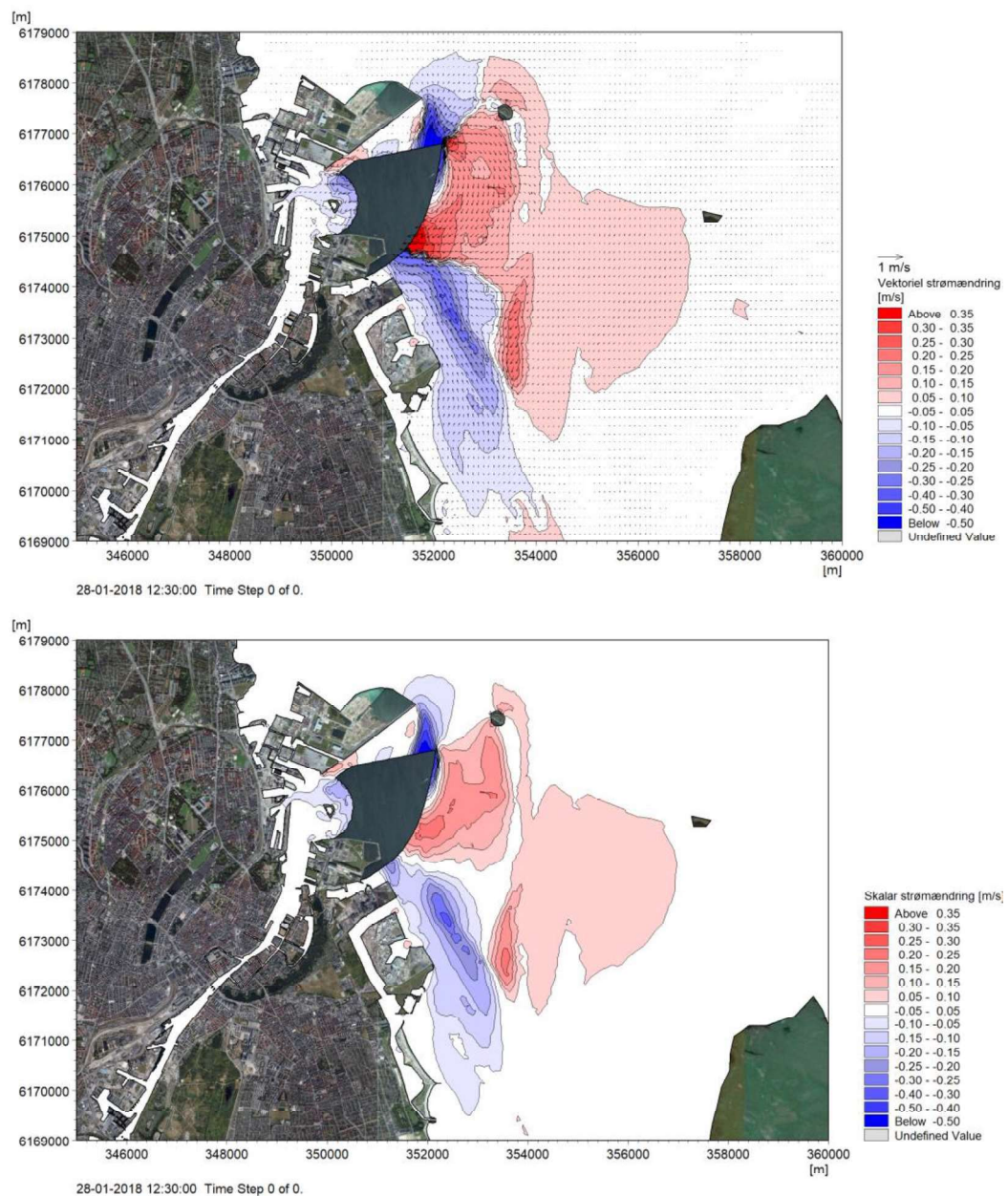


Figure 6-15 Vectorial (top) and scalar (bottom) calculated change of surface current for conditions with strong southbound current and Lynetteholm expansion without coastal landscape.

The corresponding current changes for a reclamation with a coastal landscape are shown in Figure 6-16. In the reclamation with a coastal landscape, the current reduction off the Amager power station is somewhat more considerable than by a reclamation without a coastal landscape. It can also be seen that the current increase in the area east of Lynetteholm is slightly more significant than for a reclamation without a coastal landscape.

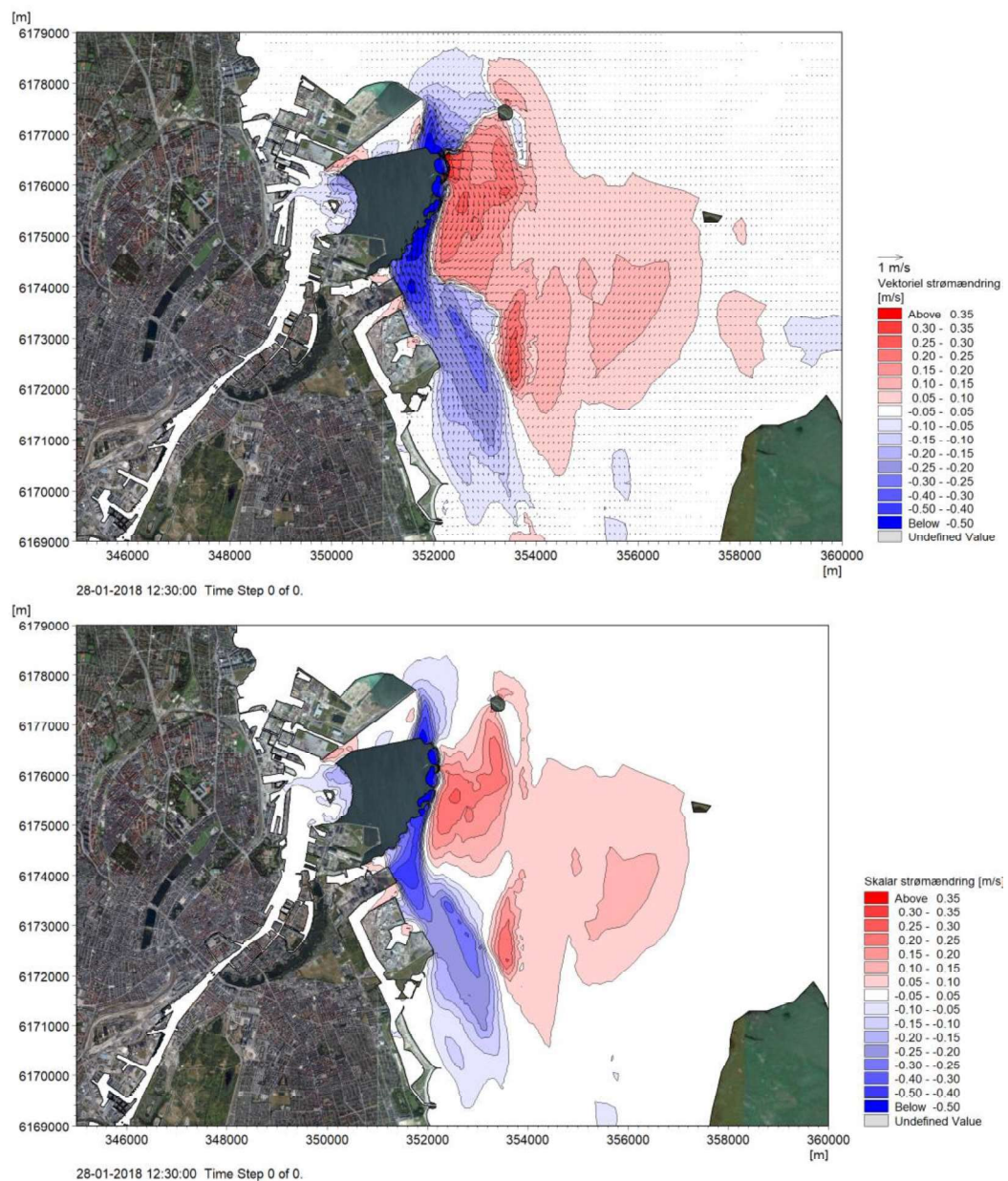


Figure 6-16 Vectorial (top) and scalar (bottom) calculated change of surface current for conditions with strong southbound current and Lynetteholm expansion with coastal landscape.

South of the area shown in the figures above, there is a slight impact on the surface current in the central part of the Drogden trench, which can be seen up to about 4 km south of the Øresund Connection. The impact is typically between 5-7 cm/s. The impact areas for the two reclamations are shown in Figure 6-17. The expansion without a coastal landscape mainly creates a current increase in the area, while the reclamation with a coastal landscape shows an increased current in the western part and damping of the current in the eastern part of the Drogden trench.



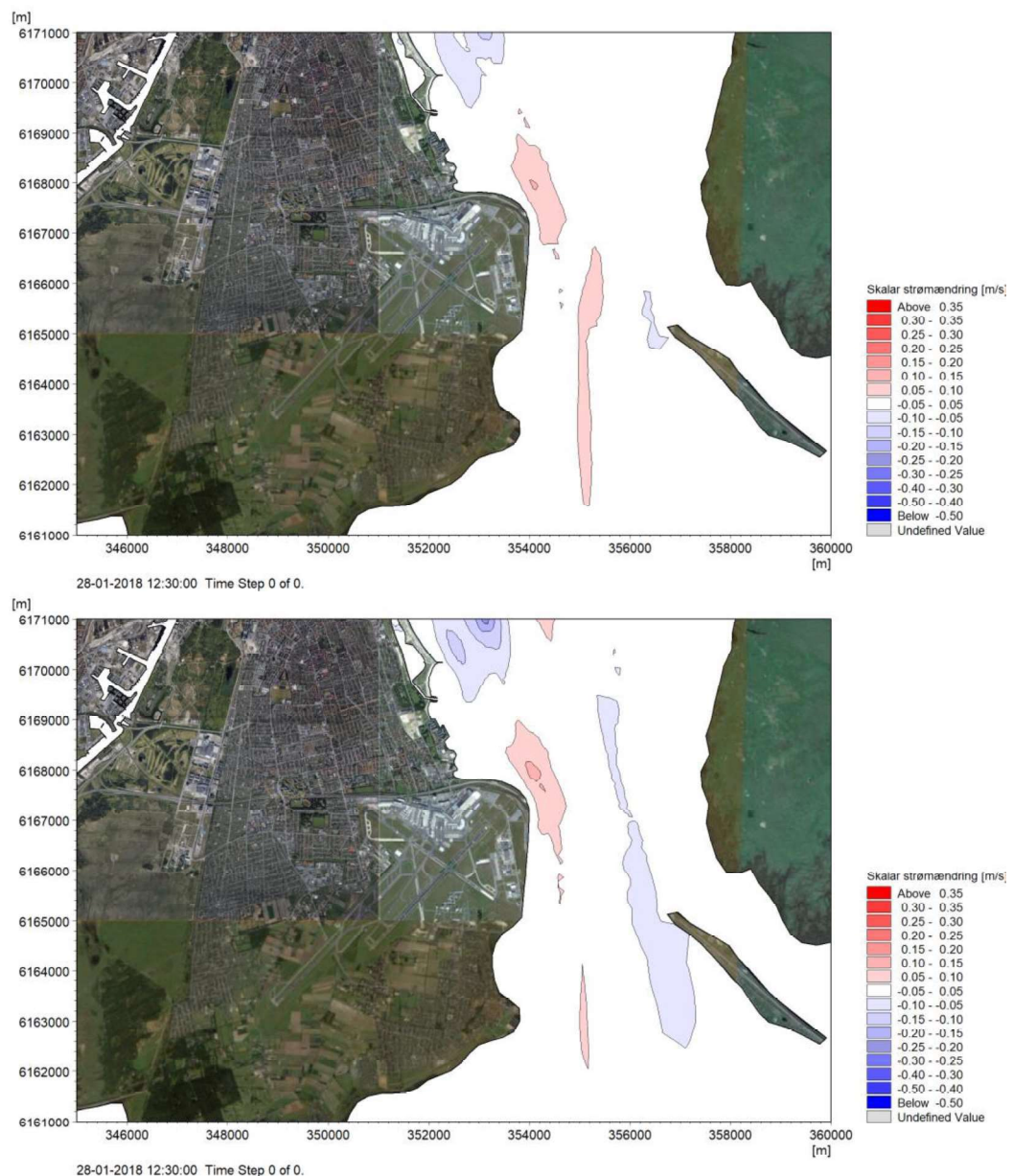
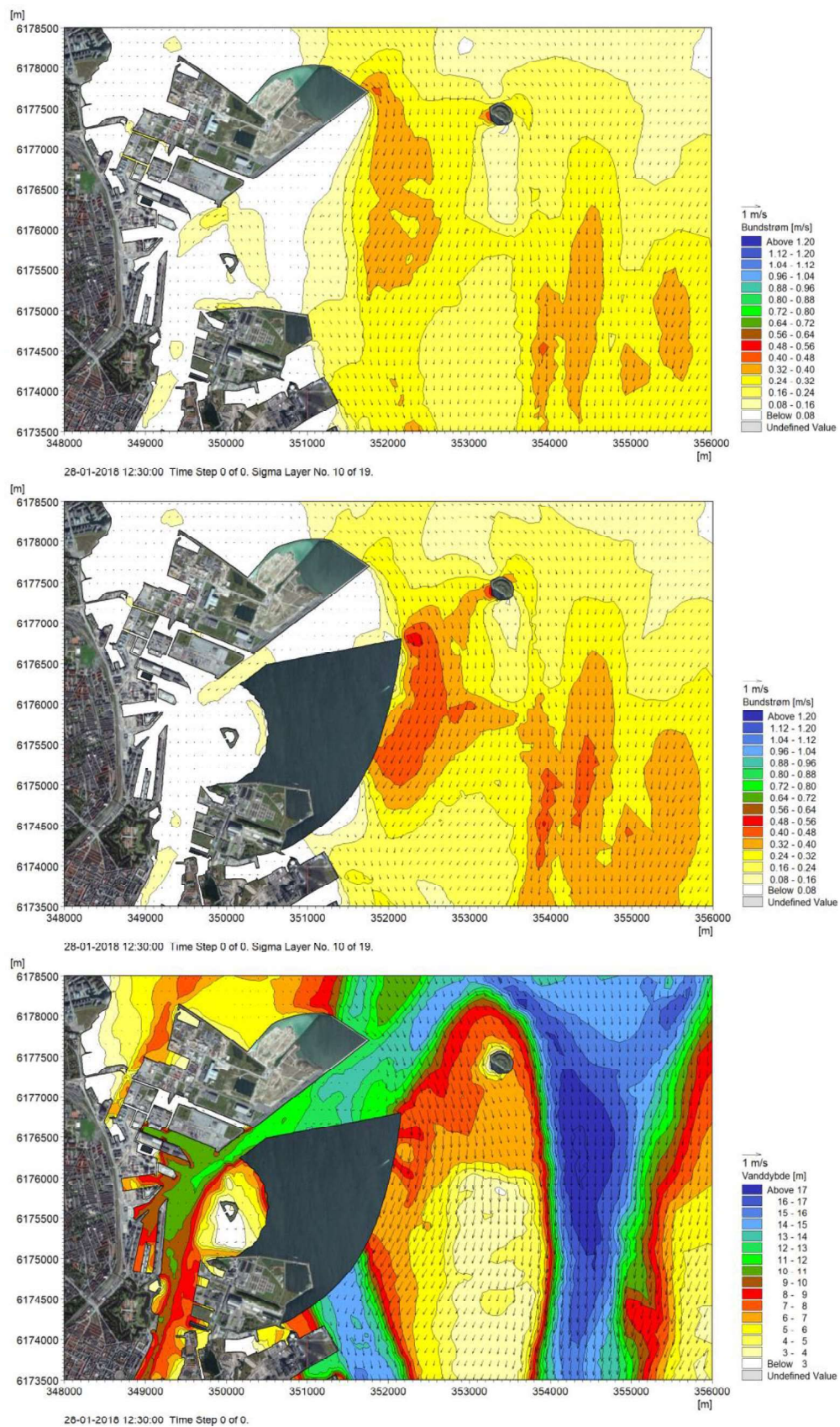


Figure 6-17 Scalar calculated current change in the area south of the reclamation. Top: Reclamation without coastal landscape, Bottom: reclamation with coastal landscape.

Figure 6-18 shows bottom velocities for the same event with a southbound current for existing conditions and a Lynetteholm reclamation without a coastal landscape, and in Figure 6-19 with a coastal landscape. Due to bottom friction, the bottom velocities are lower than the depth-averaged velocities, so the impact appears to be relatively smaller. To better understand the current pattern, a plot of the water depths has been inserted again.

Future changes in current conditions are shown in Figure 6-20 and Figure 6-21 for a Lynetteholm reclamation, without and with a coastal landscape along the eastern perimeter, respectively. These plots also show that the current through Kongedybet is cut and instead is led east of the reclamation across Middelgrundten and via Hollænderdybet.



**Figure 6-18** Bottom velocity for conditions with strong southbound current. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with depth-averaged current vectors for conditions with strong southbound current and water depth.



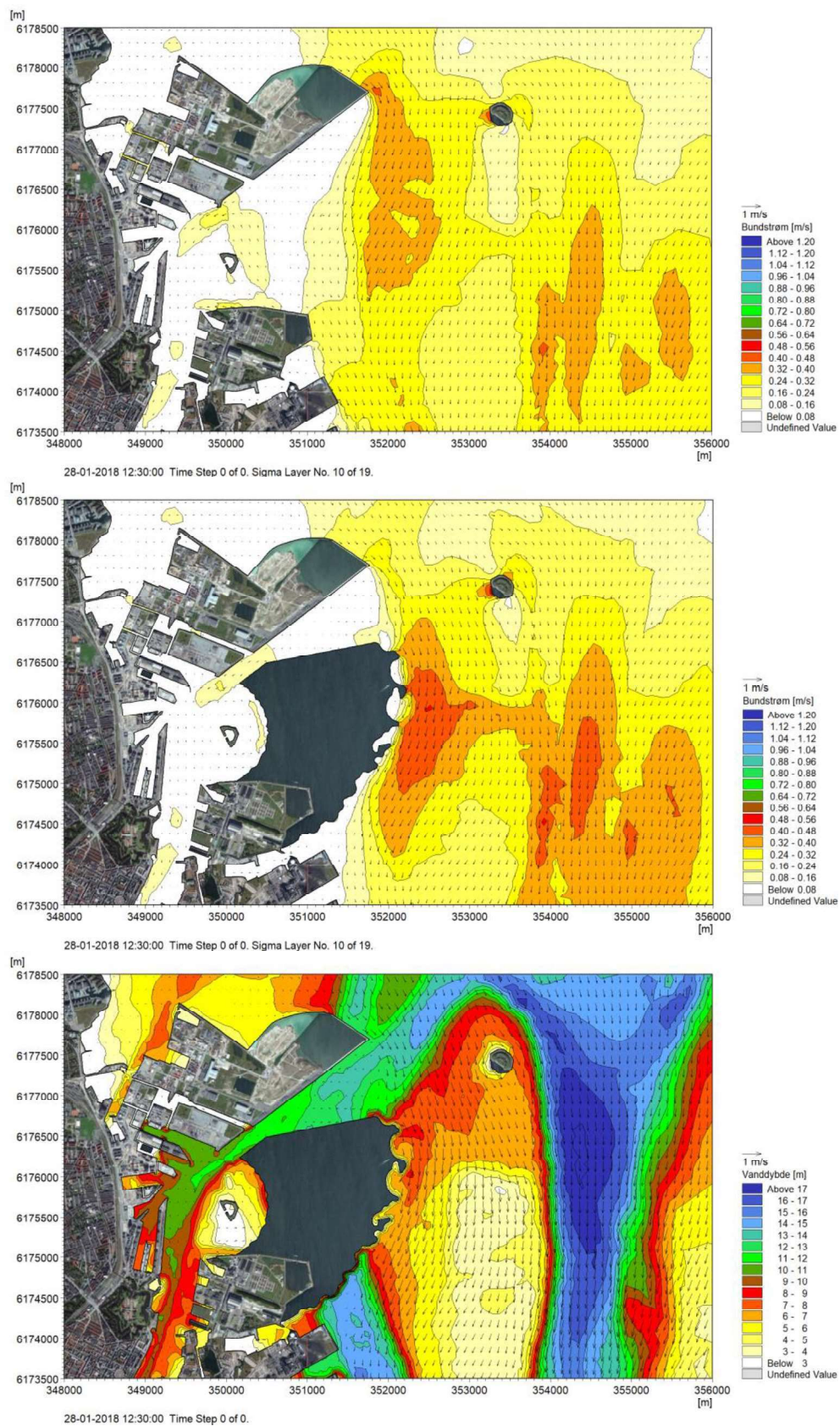


Figure 6-19 Bottom velocity for conditions with strong southbound current. Top: Existing conditions, Middle: Lynetteholm with coastal landscape, Bottom: Water depths superimposed with in-depth-averaged current vectors for conditions with strong southbound current and water depth.

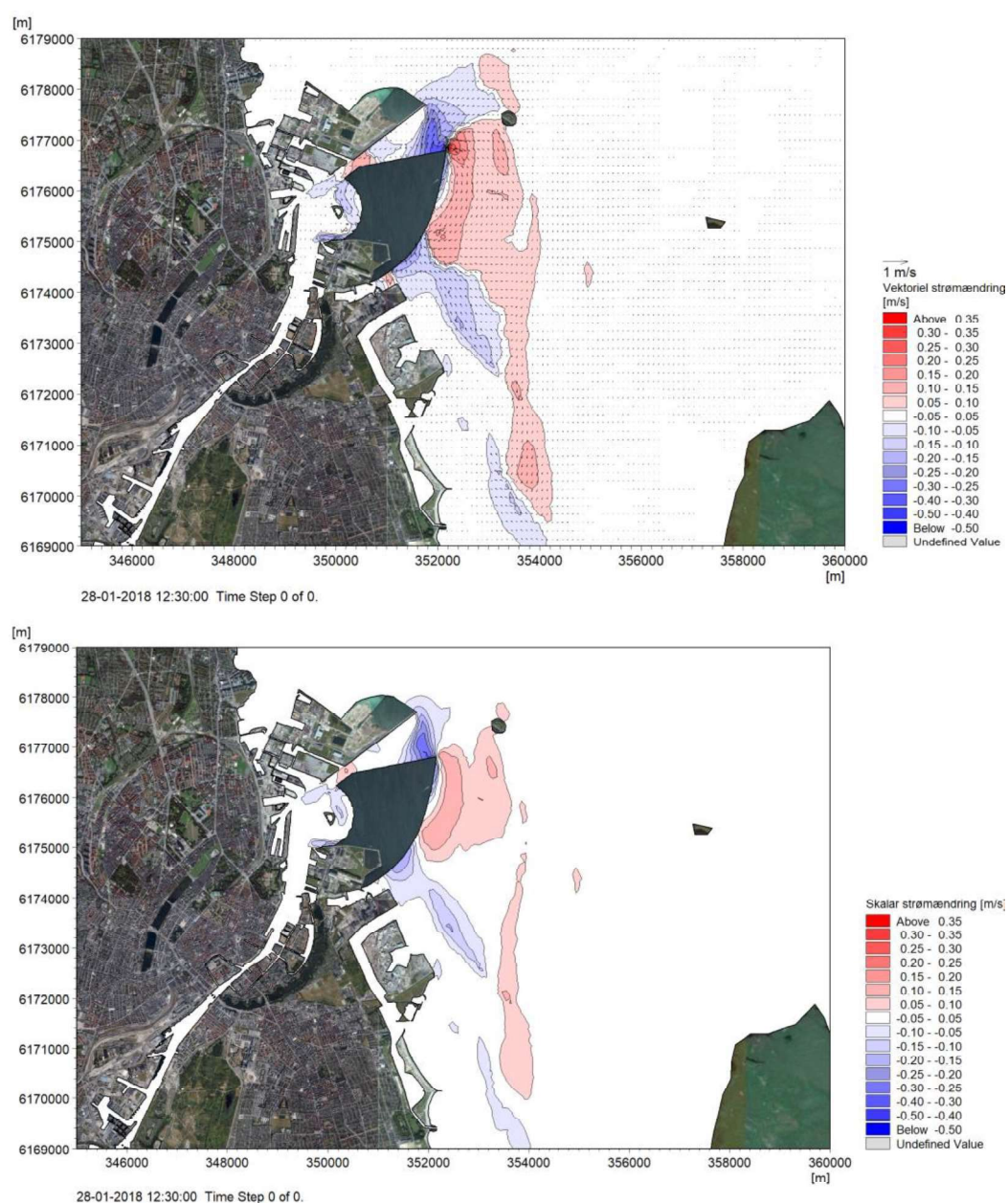


Figure 6-20 Vectorial (top) and scalar (bottom) calculated change of bottom current for conditions with strong southbound current and Lynetteholm reclamation without coastal landscape.



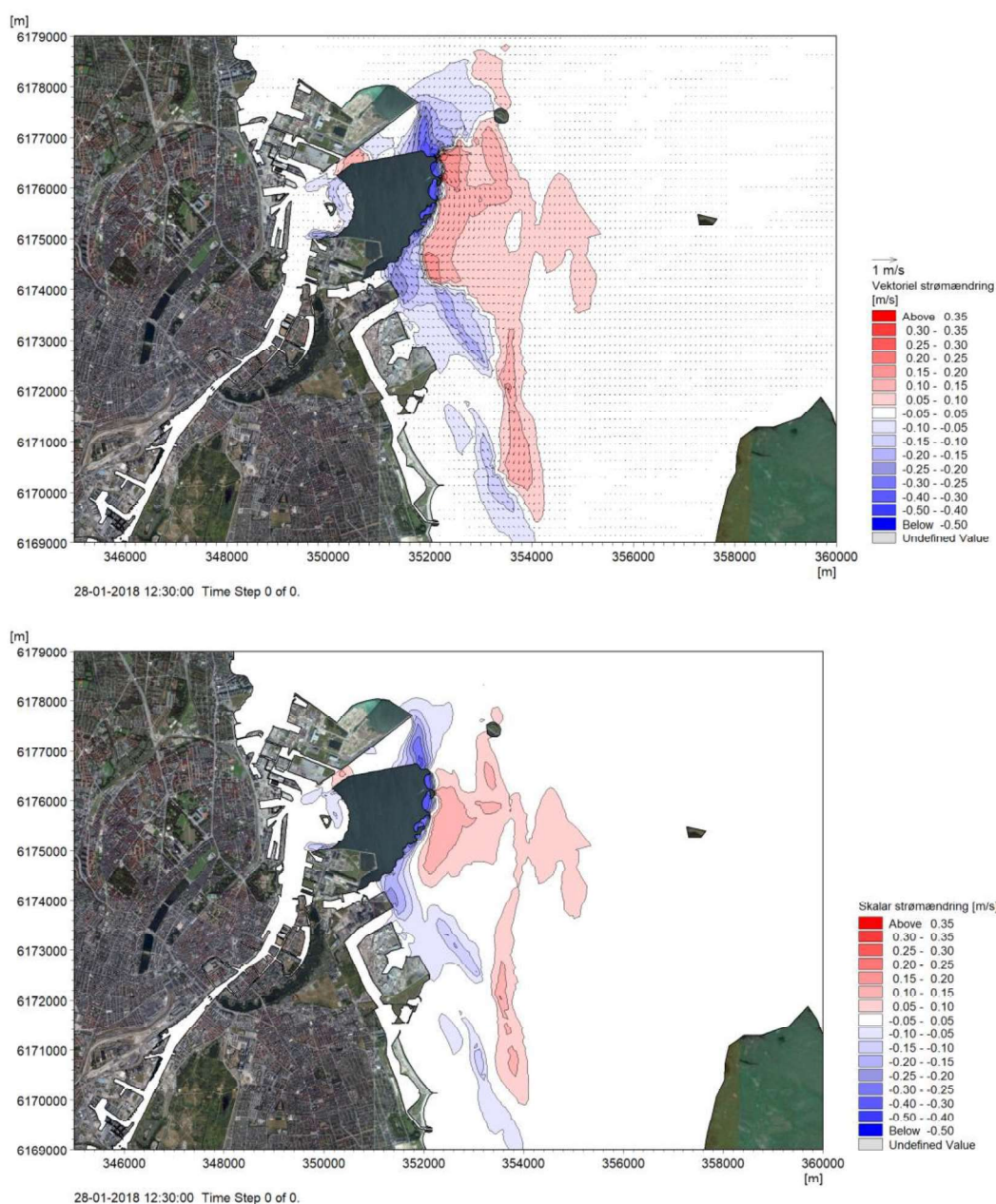


Figure 6-21 Vectorial (top) and scalar (bottom) calculated change of bottom current for conditions with strong southbound current and Lynetteholm reclamation with coastal landscape.

### 6.1.2.2 Conditions with a strong northbound current

The Lynetteholm reclamation affects the local flow conditions both with and without a coastal landscape along the eastern perimeter. This section highlights the impact of a situation with a solid northbound current. With the closure of Kongedybet, the current from Drogden will be forced further east so that the current weakens in the remaining part of Kongedybet and is reinforced along large parts of Lynetteholm's eastern perimeter as well as in the Hollænderdybet east of Middelgrunden.



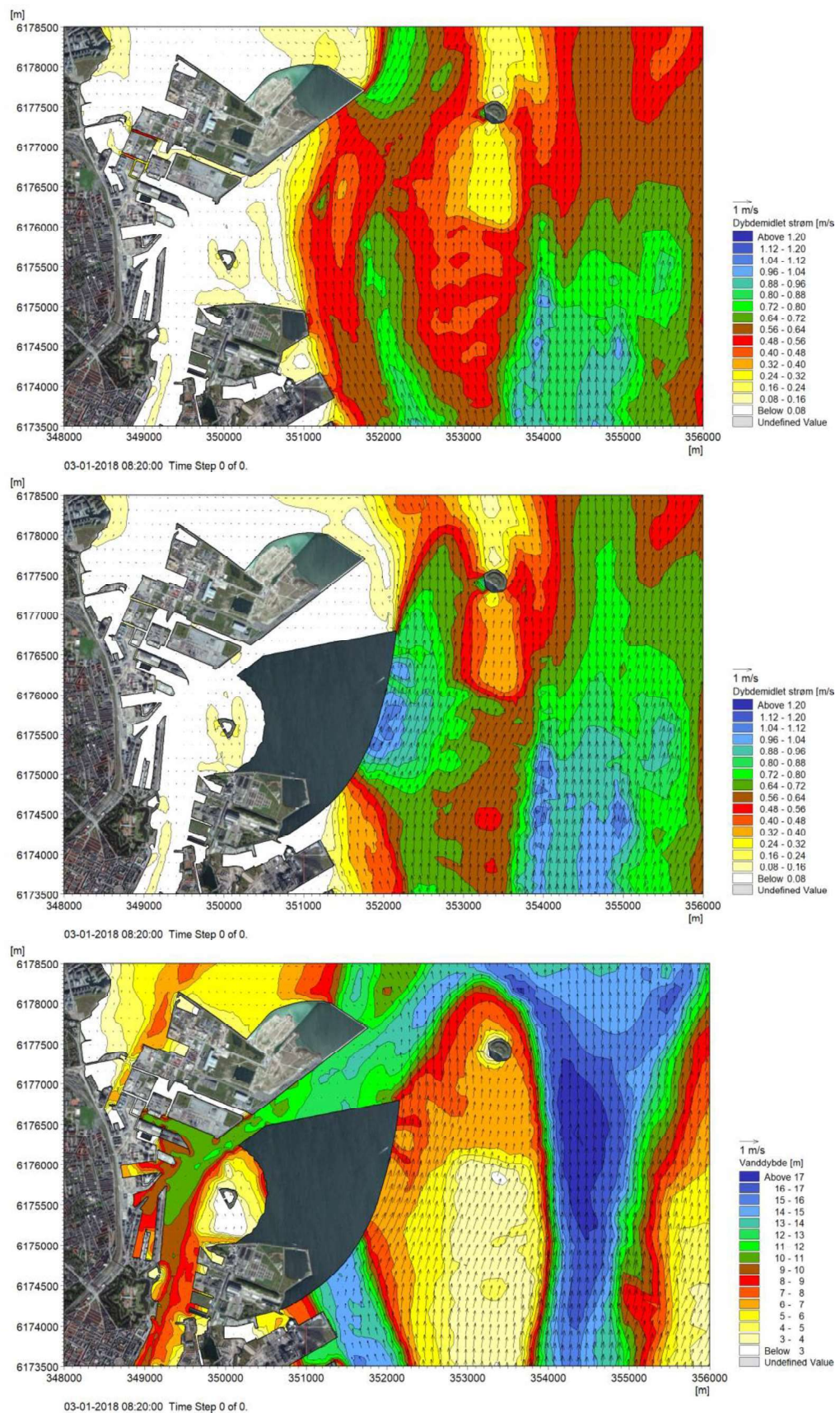


Figure 6-22 Depth-averaged current speed and water depths for conditions with strong northbound currents on 3 January 2018. Top: Existing conditions, Middle: Lynetteholm without coastal landscape, Bottom: Water depths superimposed with current vectors.



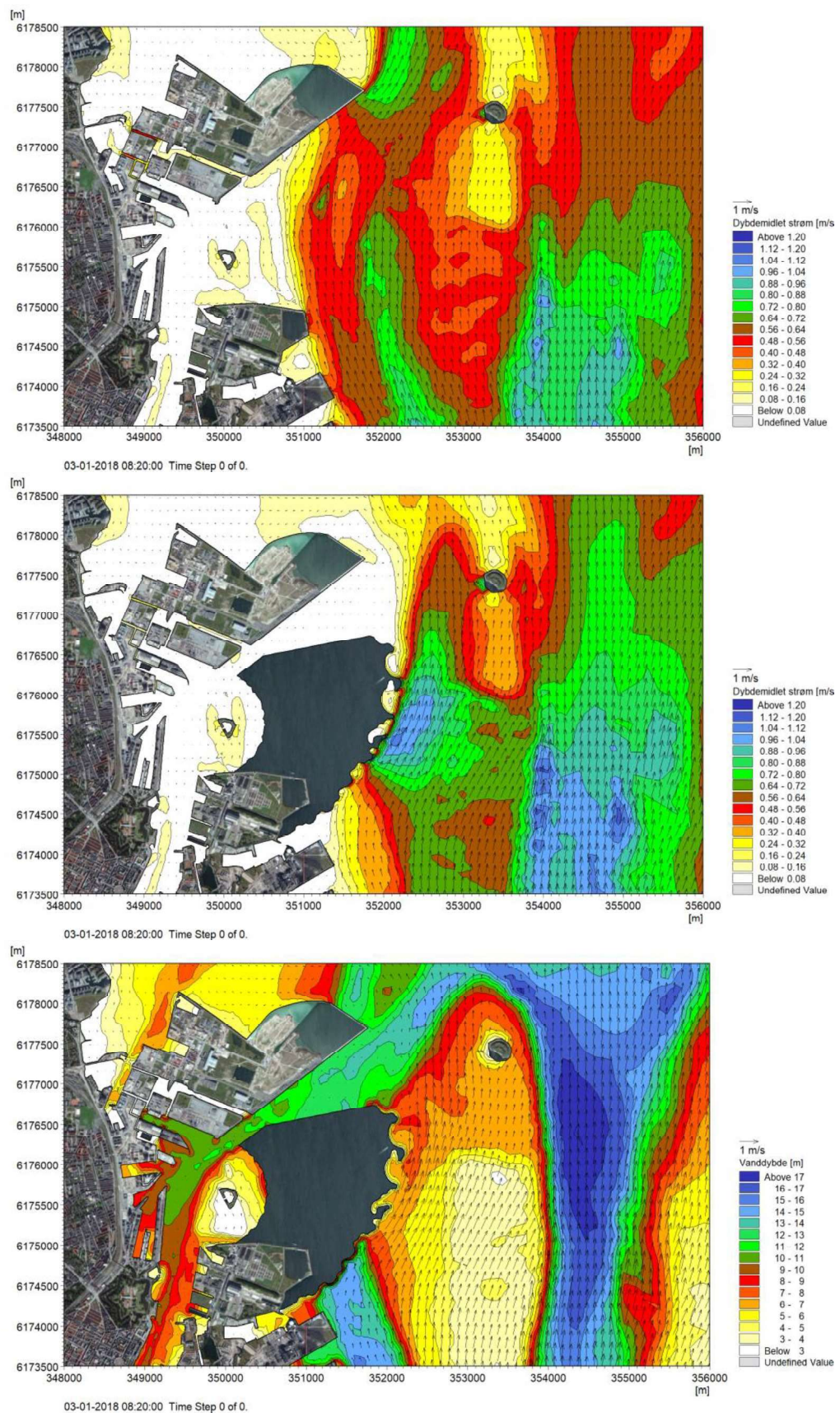


Figure 6-23 Depth-averaged current speed and water depths for conditions with strong northbound currents on 3 January 2018. Top: Existing conditions, Middle Lynetteholm with coastal landscape, Bottom: Water depths superimposed with current vectors.



Based on existing conditions Figure 6-22 (top) shows a depth-averaged current field for a situation of a strong northbound current (3 January 2018). The corresponding situation with Lynetteholm without a coastal landscape is shown at the bottom of the figure. Similarly, Figure 6-23 shows the current conditions with a coastal landscape. The current velocities during this northbound event are somewhat higher than during the southbound event described above.

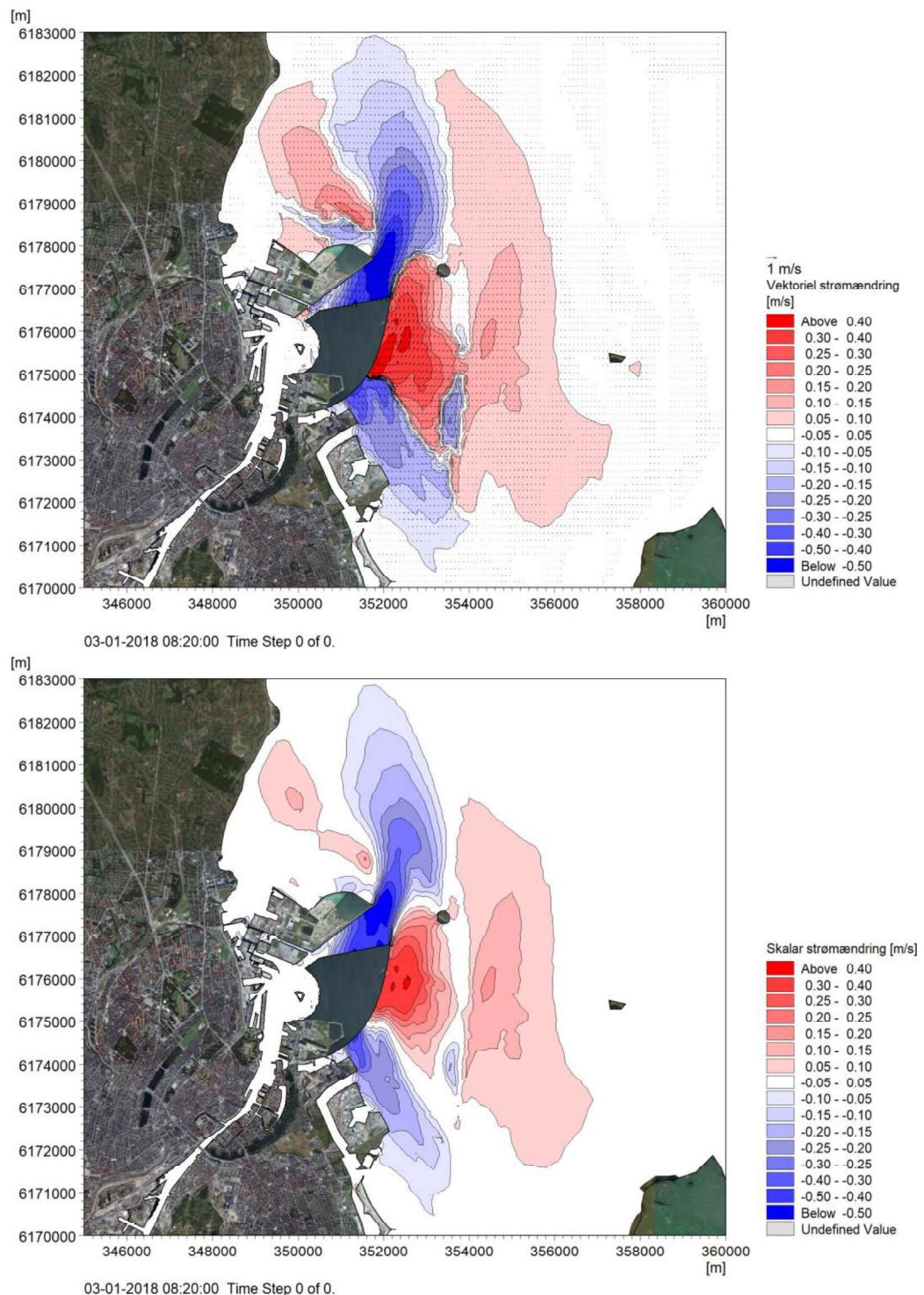


Figure 6-24 Vectorial (top) and scalar (bottom) calculated change of depth-averaged current for conditions of strong northbound current and reclamation coastal landscape.

It can be seen that a current increase occurs along with large parts of the eastern perimeter, but that the current weakens east of the Nordhavn tip and in Kongedybet off Amager power station as well as the Prøvestenen south of Lynetteholm. There is a current shelter in the concave pockets where beaches are established in the layout with a coastal landscape. The pockets with current shelters ensure safe bathing conditions. Outside the pockets, on the other hand, the current will often be strong, and bathing must therefore be discouraged in these areas. A plot of the water depths has been inserted at the bottom to better understand the current image at the time in question.