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AAWDCP – Summary of Rapid Assessment Plume dispersion modelling

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Plume dispersion modelling

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Conclusions

This document provides a summary of the rapid assessment modelling study, focusing exclusively on the cases selected by the Client from among several alternative layouts that were analysed.

Environmental criteria

General

- The excess salinity does not exceed 5% of background in the far-field simulations in all cases. Regarding the 2% of background salinity, a distinction is made between each of the modelled cases.

Case 1

- The highest excess salinity occurs south of the diffuser, where effluent from southern ports is partially transported back towards the diffuser area due to seabed gradients i.e., the southern ports discharge upslope. This re-entrainment reduces dilution efficiency.
- The maximum excess salinity at 100 m from the diffuser is very close to the criterion of maximum 2% of the background salinity. Whether the criterion is met or exceeded depends on the assumed near-field dilution. In case of the conservative approach followed in this study (based on a large range of experimental formulae) the criterion is exceeded. In case of the more optimistic approach following by HR Wallingford (2023), the criterion is *just* met.

Case 2

- Model results show that the adjustments made in the Case 2 diffuser result in the 2% of background threshold going beyond the 100m (distance contour) mixing zone by ~100m.
- With the fanned-out port configuration a large part of the effluent converges southwest of the diffuser, which hinders dilution.

Transboundary effects

- Results of all four modelled cases show similar concentrations at the boundaries with neighboring countries.
- At the border between Saudi Arabia and Jordan, the computed maximum excess salinity is about 0.1 – 0.15 PSU, which is about 0.25% - 0.35% of the background salinity. At the other borders with Israel and Egypt, the excess salinity is less than 0.02 PSU.

Recirculation

- The recirculation of salinity from the AAWDCP outfall towards the AAWDCP intake is very limited (<0.1 psu in all modelled cases and ambient conditions). This limited interaction between the outfall and intake is related to the horizontal and vertical separation between the intakes and the outfall diffuser area.

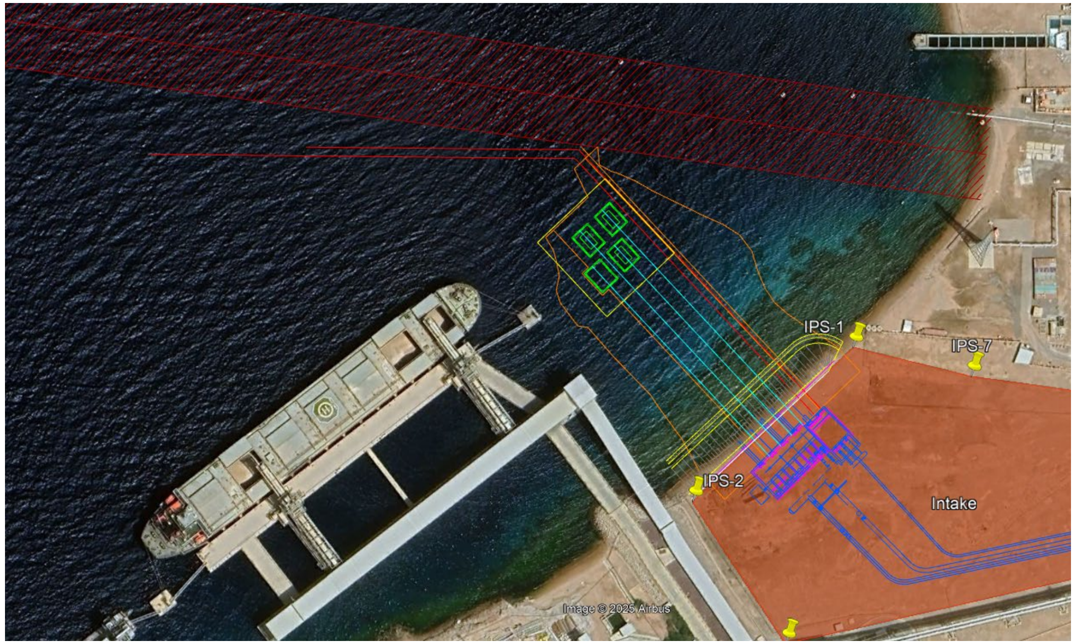
Project background and objective

The Government of the Hashemite Kingdom of Jordan has awarded a 30-year concession contract to a consortium led by Meridiam and Suez for the development of a strategic water infrastructure project. Under the leadership of the Ministry of Water and Irrigation (MWI), the Aqaba-Amman Water Desalination and Conveyance (AAWDC) project will deliver up to 300 million cubic meters of desalinated water annually to the capital, Amman, via a 438-kilometer pipeline.

Energies Group are involved in the Environmental Impact Assessment (EIA) studies for AAWDCP, and have commissioned Deltares to perform a rapid outfall plume dispersion and recirculation assessment of the currently proposed intake and outfall layout of the Sea Water Reverse Osmosis (SWRO) plant.

Study objective
The objective of the rapid assessment is to evaluate optimized locations of the seawater intake and outfall for the Plant in relation to the recirculation and environmental criteria (regulation and sensitive habitats). Next to the environmental regulations, also transboundary effects of the outfall plume are requested to be assessed.

Objective of this document
This document provides a summary of the rapid assessment modelling study, focusing exclusively on the cases selected by the Client from among several alternative layouts that were analysed.

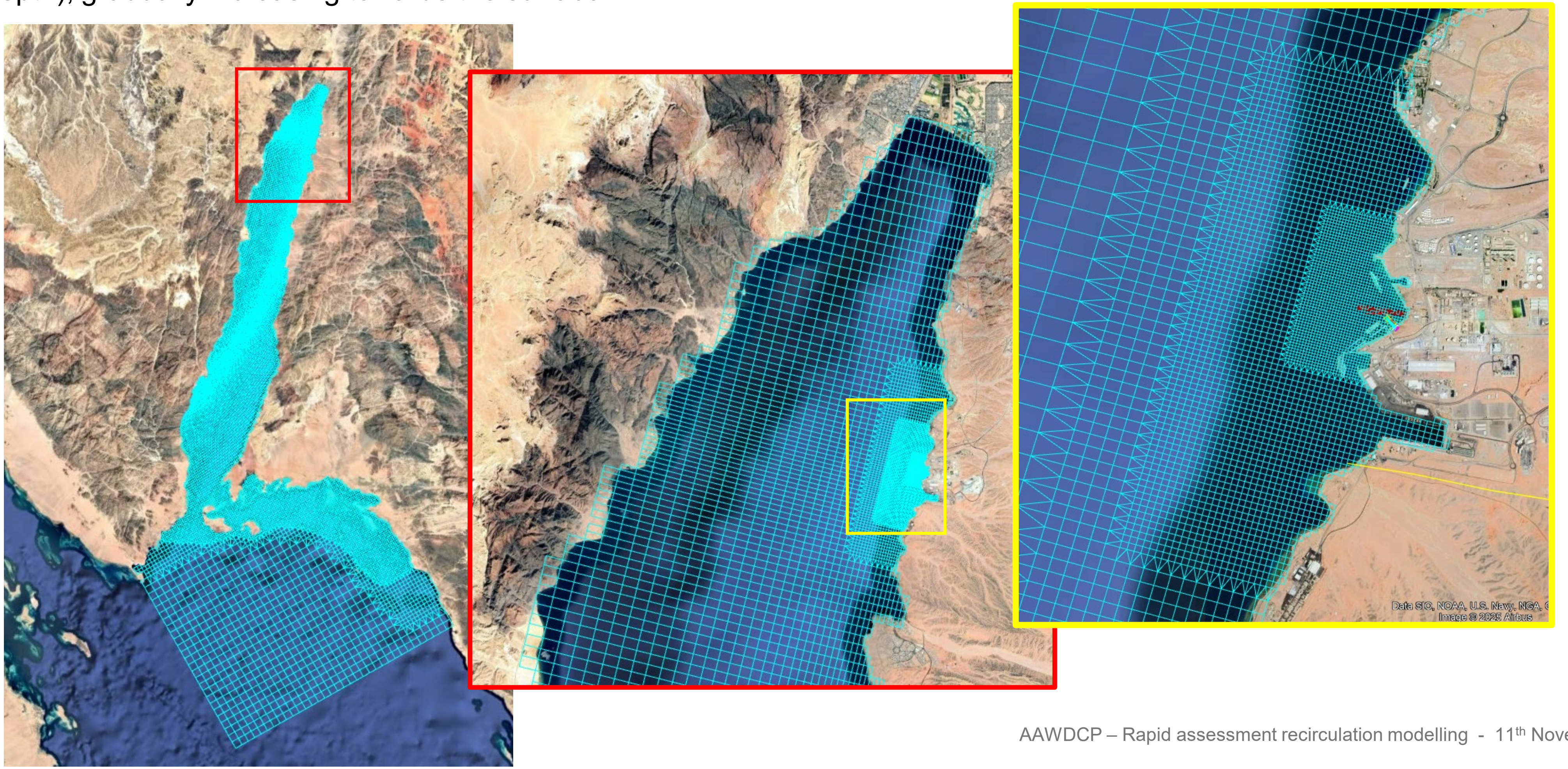


Study approach

- Review provided and available data.
- Update and review available baseline models to meet the needs of the present assessment.
    - Increase model resolution
    - Include discharges from existing plants
- Perform nearfield assessment for the provided Case layouts.
- Couple near-field results with far-field model to simulate the plume dispersion of all Cases.
- Simulate each Case for 5 different wind conditions (typical wind pattern and periods with persistent winds from different directions).
- Assessment of compliance with environmental criteria and recirculation potential (or criteria).

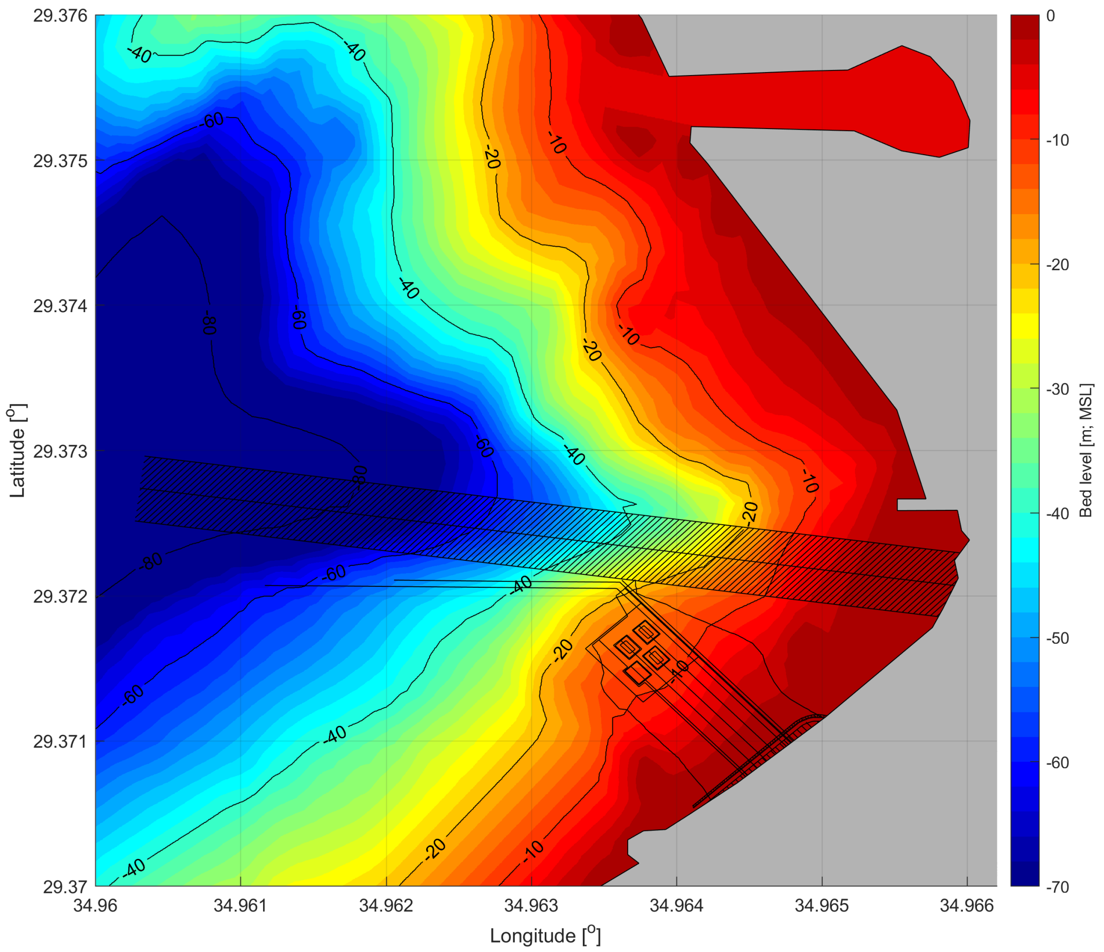
Delft3D-FM model setup: network

- An in-house Delft3D-FM model was customized for this project through local rotation and refinement. The figure below illustrates the model grid and its spatial extent. At the area of interest, the grid resolution is approximately 30 × 30 m
- The vertical grid consists of 45 sigma layers that follow both the seabed and the water surface. Layer thickness scales proportionally with local water depth. For this project, the vertical distribution was optimized by applying high resolution near the seabed (layer thickness ≈ 1% of water depth), gradually increasing towards the surface.



Delft3D-FM model setup: bathymetry

The bathymetry of the original in-house model was based on publicly available data from GEBCO. In the vicinity of the project area, the bathymetry was updated from in-house bathymetry datasets as well as a bathymetry dataset provided by the Client. The resulting model bathymetry is visualized below.



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Ambient hydrodynamics

- In the assessment of the near-field behavior we assumed stagnant conditions, which is conservative for near-field dilution. Next to it being a conservative approach, it is also realistic given that the ambient flow is limited in this area.
- The effect of the tide is minor in the project area. The tidal range is typically about 50 cm during neap tide and about 70 cm during spring tide.
- The flow velocities are typically weak (< 0.2 m/s), especially near the bed.
- Furthermore, seasonal variations influence the sea surface temperature, however salinity experiences small periodical changes.
- During the peak summer months (July-September) surface temperatures reach around 31°C and drop to around 21°C by the late March[1]. The surface temperature is typically about 1 to 3 °C higher than the temperature at a depth of about 50 m.
- Salinity is rather constant year-around, oscillating around 40.7 psu.

1 *Based on E.U. Copernicus Marine Service Information:* [*https://doi.org/10.48670/moi-00016*](https://doi.org/10.48670/moi-00016)

Assessed ambient condition scenarios

Tide

All simulation consider a full spring-neap tidal cycle. The tidal variation in the project area is rather limited. The tide therefore only has a limited influence on the local flow conditions.

Wind conditions:

Different wind scenarios were selected based on a 10-year historic ERA5 wind data set. The selected wind conditions both cover typical wind conditions as well as persistent winds from other directions.

- Typical wind: Wind varying between NNW and NNE, with a daily variation in wind speed of typically 2 to 5 m/s.
- N wind: Relatively strong persistent northerly wind with wind speeds up to 8 m/s.
- NE wind: Persistent northeasterly wind with wind speeds up to 7 m/s.
- S wind: Persistent southerly wind with wind speeds up to 8 m/s.
- W wind: Westerly wind with wind speeds up to 8 m/s.

Seasons:

All wind conditions are modelled during winter conditions as the near-field dilution is lowest in winter and is expected to be normative. As part of the sensitivity analysis, summer simulations were run, confirming the conclusions drawn on the winter simulations.

Existing outfalls

Recent information on nearby industrial discharges was not available at time of modelling. Therefore, the following assumptions have been made in agreement with the Client:

- Based on Google Earth it seems there is at least one submerged outfall in the project area (see yellow circle below). The following assumptions have been made:
    - Type of plant: Power plant
    - Outfall location: Center of the yellow circle (see figure).
    - Outfall type: single port close to the seabed slightly inclined upwards, diameter of 1 m (based on photograph of Client and measured in Google Earth)
    - Discharge rate: An assumed velocity of about 2 m/s in the pipeline results in a discharge rate of about 1.5 m^3/s
    - Excess temperature: +8 °C (typical excess temperature)
    - Excess salinity: no excess salinity
    - Intake location: red circle (see figure), assume depth-averaged withdrawal
- Please note that the presence of this discharge will not significantly affect the outcomes of this rapid assessment. It is likely that this discharge slightly increases the water temperature at the AAWDCP intake. This will have a minor effect on the water density at the outfall, which in turn will only slightly affect the outfall plume behaviour (this effect is included in this modelling results). Furthermore, this power plant may discharge other substances (e.g. chlorine). In the modelling, a tracer is added to the power plant discharge to roughly assess the effluent dilution at the AAWDCP.
- The FSRU cold water discharge has been excluded from the modelling study. Deltares (2013) showed that the impact of the discharge on the local water temperature is very small (<0.5 °C at 100 m from the FSRU outfall).

Environmental and Operational Criteria

Environmental Criteria
The Client specified two different environmental criteria:

- Salinity increase at 100 m from the outfall should be less than 2% of the background salinity.
- Salinity increase at 100 m from the outfall should be less than 5% of the background salinity.

Since the 5% criterion was not exceeded in the far-field simulations, this study effectively applied only the stricter 2% criterion.

For these criteria, a typical background salinity of 40.7 psu was assumed.

Recirculation
Recirculation criteria are not available at this stage. The computed recirculation potential has been presented as average and maximum values, which allows for independent further use.

Definitions of near field and far field

The dispersion of an outfall plume covers different spatial scales and is often divided into a *near field* and a *far field* section of the plume.

The *near field* of a jet/plume is defined here as the region in which the initial (jet) momentum and/or its buoyancy governs the behavior (and initial mixing) of the plume. This typically takes place within the first 100m from the present types of outfall.

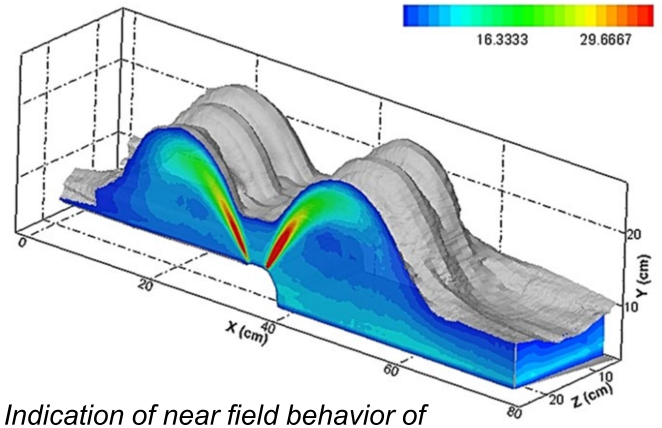
The *far field* is defined here as the region beyond the near field where the ambient conditions (e.g., ambient flows and atmospheric cooling) govern the behavior and dispersion of the plume. This is typically at a distance of 100m and further from the outfall.

To obtain an accurate assessment of the plume dispersion towards the intake or regulatory mixing zones, both the near field and far field were assessed and properly coupled.

Near-field assessment: approach

- The near-field assessments in this study are based on empirical formulae from a large selection of scientific publications (including Roberts et al (1997), Abessi and Roberts (2016), etc.).

- A near-field assessment assumes that there is no build-up of effluent in the diffuser area. However, it is often the case that part of the effluent will build up in the area or may be brought back into the diffuser area by tidal flows. Consequently, part of the effluent will be re-entrained into the plume instead of ‘pristine’ ambient water (as assumed in the near-field assessment). This build-up effect can only be assessed in the far-field modelling assessment with accurate coupling. The computed dilution in the far-field model is referred to as the ‘effective dilution’. The ‘effective dilution’ will be at best equal, but often lower than the ‘near-field dilution’



Indication of near field behavior of discharged brine through a diffuser

Presentation of results

The dispersion of the AAWDCP effluent is visualized as maximum (or actually 98th percentile)* excess salinity footprints and dilution footprints. The +2% excess salinity contour lines (i.e., above background salinity) is presented as red contour line.

The maximum excess salinity footprints present a summary of the maximum excess salinities that occur during the entire simulation and for all ambient conditions. This footprint does not occur at any given point in time i.e. not instantaneous (the plume dynamically moves and dilutes under the influence of varying flow conditions). During the simulations, the maximum at each location in the domain are recorded and presented in the footprint. The maximum excess salinity footprints are therefore a representation of the total extent of the outfall plume over time.

In addition, the recirculation towards the intake (i.e., salinity increase at the intake) is computed for the different scenarios.

* The computed 98th percentile footprints are presented to avoid numerical outliers in the modelling results. For the simulated period this means that the presented values occurred at least for a total of about 3 hours per week (but not necessarily consecutively, e.g., possibly as short peak events).

Discharge characteristics Case 1 and 2

AAWDCP Intake and outfall locations

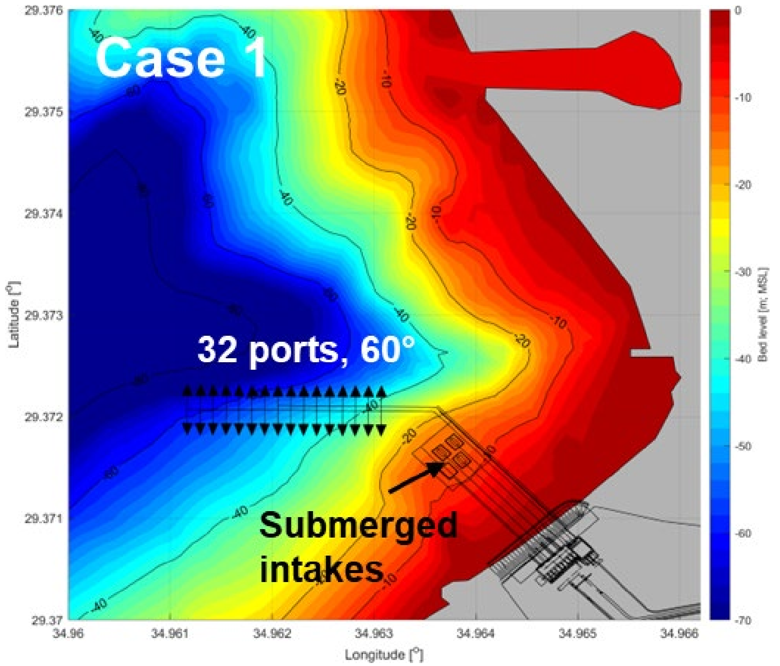
A number of intake and outfall layouts have been assessed in this study. This document only presents two cases selected by the Client. The below figures give a brief overview of the locations of the intake and outfall. The main differences are:

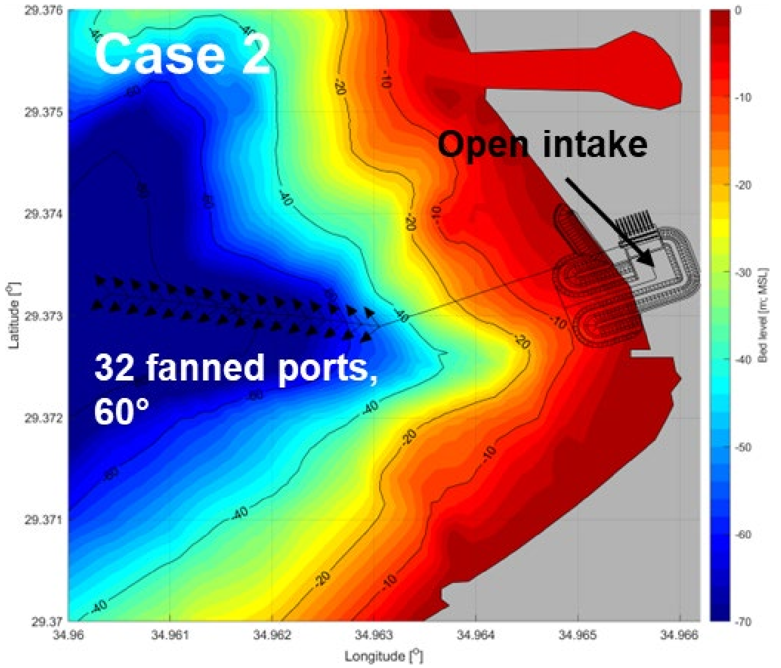
Case 1:

- Meridiam (2023) layout
- Submerged intakes
- Diffuser with 32 ports with a vertical angle of 60°

Case 2:

- Open intake
- Diffuser located at deeper water; ports are rotated by 45° in westward direction to reduce the amount of effluent flowing back towards the diffuser. Consequently, the length of the diffuser is increased by about 40%, to prevent merging of the individual jets in the near-field.





Discharge characteristics

		Case 1	Case 2
Outfall	**Flow rate**	11.7 m^3/s	
	Excess Salinity [psu]	+34.8 psu	
	Excess Temperature [°C]	+1 °C	
	Diffuser length [m]	185	261
	Outfall pipeline length (from coast to start of diffuser)	~230	~225
	Depth at diffuser	about -35 m MSL to -60 m MSL	about -50 m MSL to -80 m MSL
	Number of risers	16 (2 diffuser lines with 8 risers)	
	Number of ports per riser	2 ports per riser	
	Horizontal orientation of the ports	Perpendicular to diffuser pipe orientation	45° orientation in westward direction relative to the dffuser pipe
	Vertical orientation of the ports	60°	
	Port diameter	290 mm	
	Vertical position of the port w.r.t. seabed	5.4 m	
	Port spacing	12.3 m	17.4 m
Intake	**Flow rate**	21.8 m^3/s	
	Depth at intake locations	About -11 to -13 m MSL	
	Type of intake	Submerged	Open
	Intake height	Intake screen is located between 3 and 7 m from the seabed	

Near-field assessment
Case 1 and 2

Near-field assessment: results

The expected near-field behaviour is summarized in the below table for both winter (T = 21°C, S = 40.7 psu) and summer conditions (T = 31°C, S = 40.7 psu).

Winter (summer) near field behaviour	**Case 1 and Case 2**
Distance to terminal rise height (X_t) [m]	10 (11)
Vertical extent of terminal rise height (Y_t) [m], relative to the seabed	18.0 (18.4)
Distance to impact point (X_i) [m]	17 (17)
Dilution at impact point (S_i) [-]	31 (31)
Horizontal distance to the end of near-field [m]	58 (60)
Dilution at the end of near-field [-]	43.5 (44.5)

The focus of the far-field assessment has been on winter conditions given that this is slightly more normative in terms of near-field dilution (see last row of table).

Near-field assessment: Case 1 vs previous studies

In previous studies, also near-field assessments have been performed by HR Wallingford (2021) and Tetratech (2021), albeit with different outfall designs and effluent characteristics. The below table compares the present near-field results to these previous studies.

		HR Wallingford (2021)	Tetratech (2021) – Case 1 (42% recovery)	Tetratech (2021) – Case 2 (45% recovery)	Case 1 diffuser
Discharge characteristics	Discharge rate [m^3/s]	14.4	13.6	12.0	11.7
	Excess salinity [°C]	+45	+29.55	+33.38	+34.8
Diffuser configuration	Number of ports [-]	32	30	30	32
	Vertical port angle [°]	60	60	60	60
	Port diameter [m]	0.3	0.3	0.3	0.29
	Velocity at port [m/s]	6.4	6.4	5.65	5.5
Near-field results	Froude number [-]	20.5	25.1	20.8	20.8
	Distance to impact point [m]	17	28	23	17
	Dilution at impact point [-]	33.8	35.8	29.7	31
	Distance to end of near-field [m]	58	69	57	58-60
	Dilution at end of near-field [-]	53.2	69	56.9	43.5 - 44.5
	Excess salinity at the end of near-field [psu]	0.85	0.43	0.59	0.80 - 0.82
	Near-field assessment method	Abessi and Roberts (2016)	brIHne		Large selection of formulae from literature, see introductory slide

The near-field dilution estimated in this study is lower than in previous studies because a more conservative methodology was applied. For example, HR Wallingford (2021) used empirical relationships from Abessi and Roberts (2016). While their application was correct and consistent, the dilution values reported in that paper are relatively high/optimistic compared to other experimental results. To address this, also laboratory data from additional publications were incorporated in this study, resulting in a more solid and conservative estimates. As shown in the lower table row, even with this conservative approach, the predicted near-field dilution remains sufficient to reduce the effluent to approximately 2% of the background salinity (+0.81 psu).

Maximum excess salinity footprints near diffuser area

Case 1 and 2

All cases

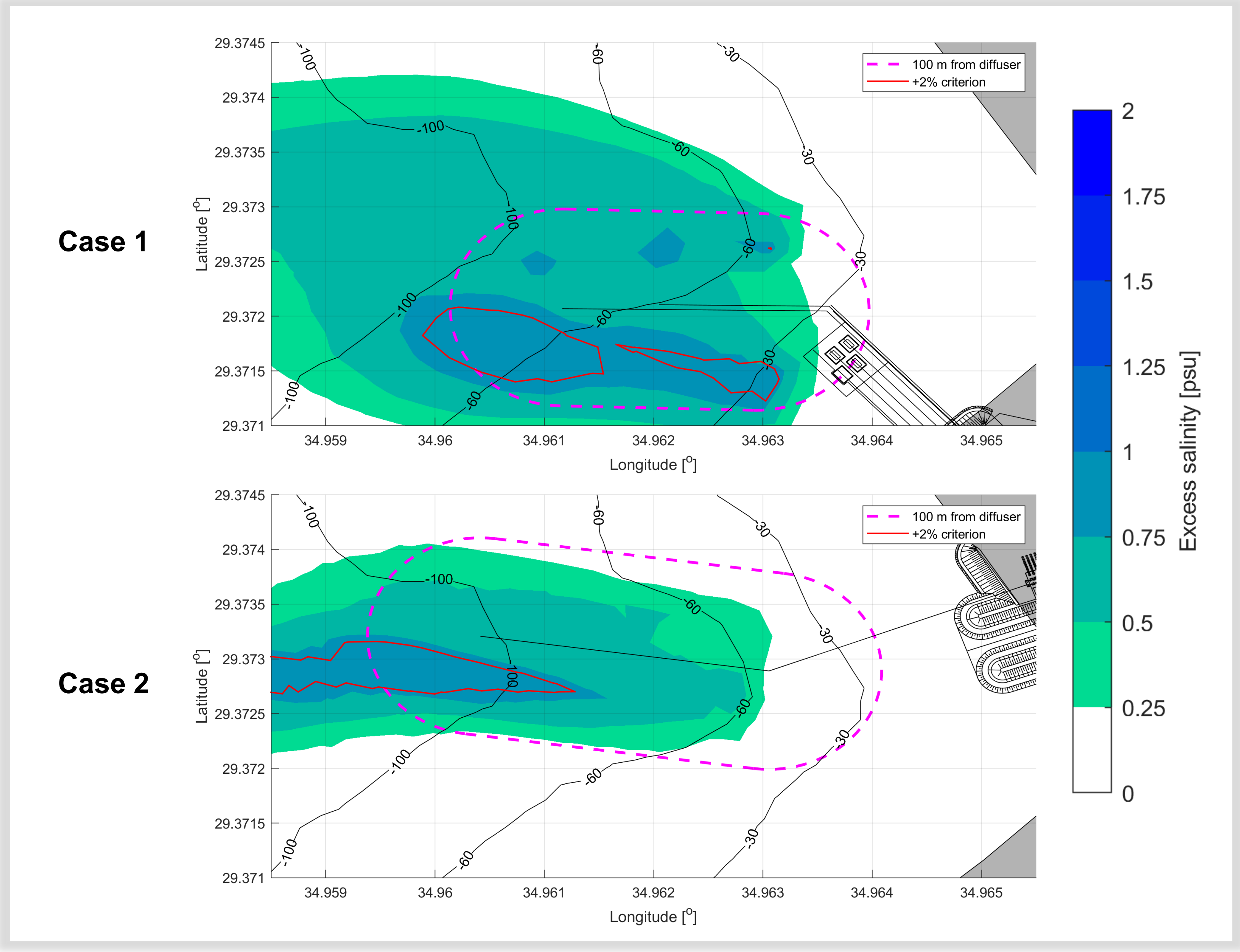
Season: Winter
Wind condition: Typical

- Note that the excess salinity does not exceed +5% in the far-field simulations in all cases.
- Note that the excess salinity between the impact point and the end of the near-field zone is not shown in this figure, as Delft3D-FM only models far-field dispersion.
- The cases are presented separately in the following slides.

Main observations

- The maximum excess salinity at 100 m from the diffuser is slightly higher than 2% of the background salinity (40.7 psu) for both cases.
- The higher concentration south of the Case 1 and southwest of the Case 2 diffusers is related to the unfavorable bed slope, which brings the effluent partially back towards the diffuser area. The subsequent re-entrainment reduces dilution efficiency. This effect is strongest in Case 2, where a large part of the effluent converges southwest of the diffuser.

98th percentile excess salinity footprint near the bed



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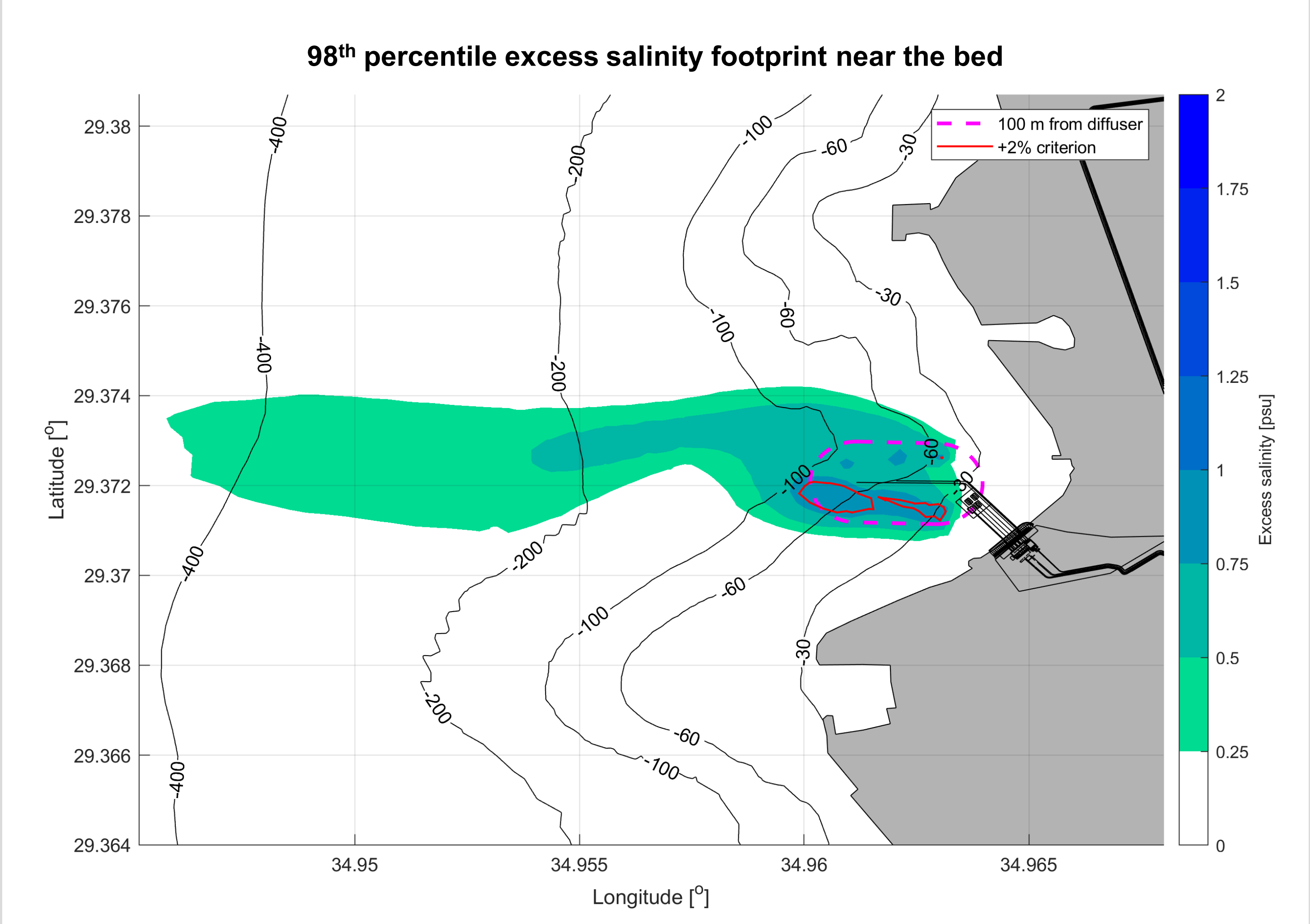
Case 1
Season: Winter
Wind condition: Typical

- Note that the excess salinity does not exceed +5% in the far-field simulations
- Note that the excess salinity between the impact point and the end of the near-field zone is not shown in this figure, as Delft3D-FM only models far-field dispersion.

Observations

- Beyond the near-field zone, the effluent primarily follows seabed gradients as a density current.
- Ambient current velocities have little effect on effluent dispersion in the visualized area because the ambient flow is weak and the seabed slope is steep
- At 100 m from the diffusers, the maximum excess salinity slightly exceeds the 2% criterion; however, this exceedance is within the model's accuracy margin and should therefore be interpreted that it is on the edge of compliance.
- The highest excess salinity occurs south of the diffuser, where effluent from southern ports is partially transported back toward the diffuser area due to seabed gradients. This re-entrainment reduces dilution efficiency.
- The salinity footprint in the shown area is very similar for all modelled wind conditions, as the wind-driven currents are very weak near the bed. The brine effluent therefore mainly follows the bed gradient. The footprints for the other ambient conditions are therefore included in the appendix.

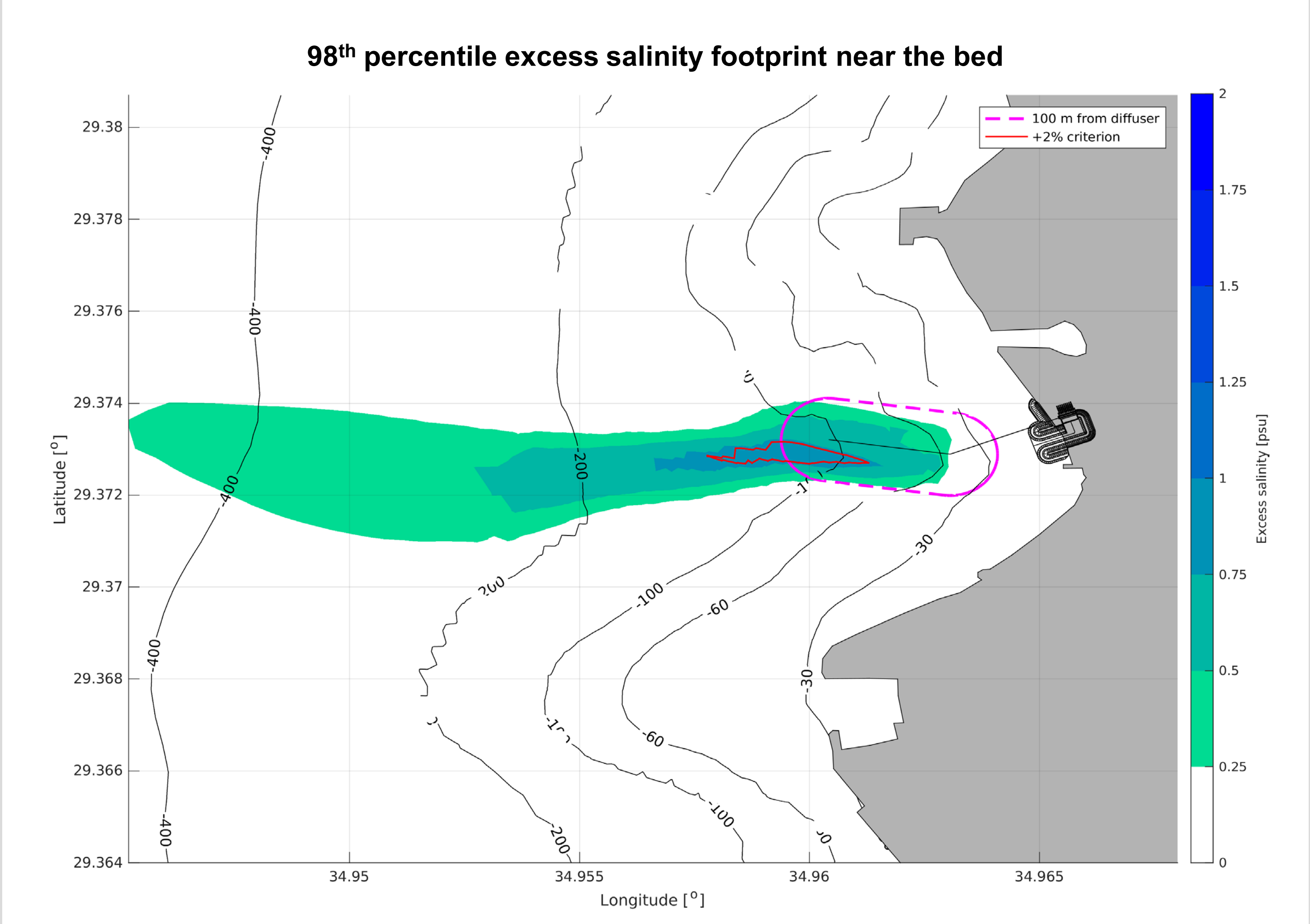


Case 2
Season: Winter
Wind condition: Typical

- Note that the excess salinity exceeds the +2% in the far-field simulations
- Note that the excess salinity between the impact point and the end of the near-field zone is not shown in this figure, as Delft3D-FM only models far-field dispersion.

Observations

- The combination between outwards-fanned ports and the bathymetry gradients around the diffuser prove to be unfavorable with regards to effective effluent dilution.
- Model results show that the criterion of 2% above background salinity is exceeded within the 100m mark to the West of the diffuser, as it does into an additional 100 m in the offshore direction.
- This diffuser configuration therefore exceeds the environmental criteria.



Achieved dilution near diffuser (input required for Xodus)

Case 1 and 2

Dilution and plume shape close to diffuser (requested information by Xodus)

- The following information is based on combined results for all modelled ambient conditions

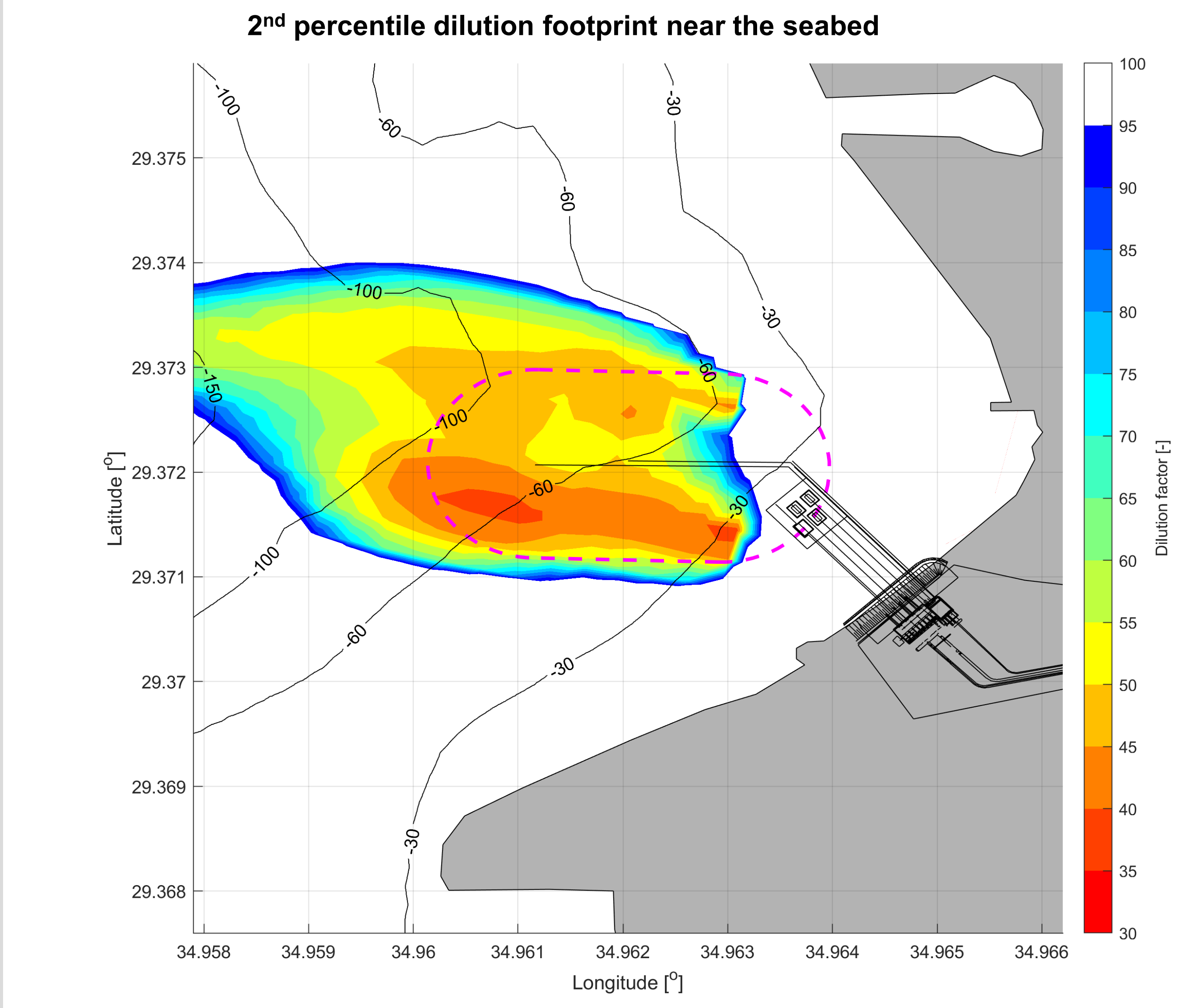
	Case 1	Case 2
Horizontal distance to terminal rise height	10	10
Vertical extent of the terminal rise height (relative to the seabed) [m]	18	18
Horizontal distance to impact point (touchdown) [m]	17	17
Dilution at touchdown [-]	31	31
Horizontal distance to end of near-field [m]	58	58
Dilution at end of near-field [-]	South side: 38 (due to re-entrainment), north side: 43.5	37 (due to re-entrainment)
Minimum dilution at 50 m from diffuser [-]	Similar to the row above	Similar to the row above
Minimum dilution at 100 m from diffuser [-]	south side: 40 north side: 48	39

Case 1
Season: Winter
Wind condition: Typical

- Note that dilution between the impact point and the end of the near-field zone is not shown in this figure, as Delft3D-FM only models far-field dispersion.

Observations

- These maps show the 2nd percentile dilution footprint near the seabed. Dilution expresses how much the original effluent concentration has been reduced. For example, a dilution of 50 means the concentration is 50 times lower than the original effluent concentration.
- This figure is basically showing the inverse of the earlier shown excess salinity plots
- The lower dilution occurs south of the diffuser, where effluent from southern ports is partially transported back toward the diffuser area due to seabed gradients. This re-entrainment reduces dilution efficiency.

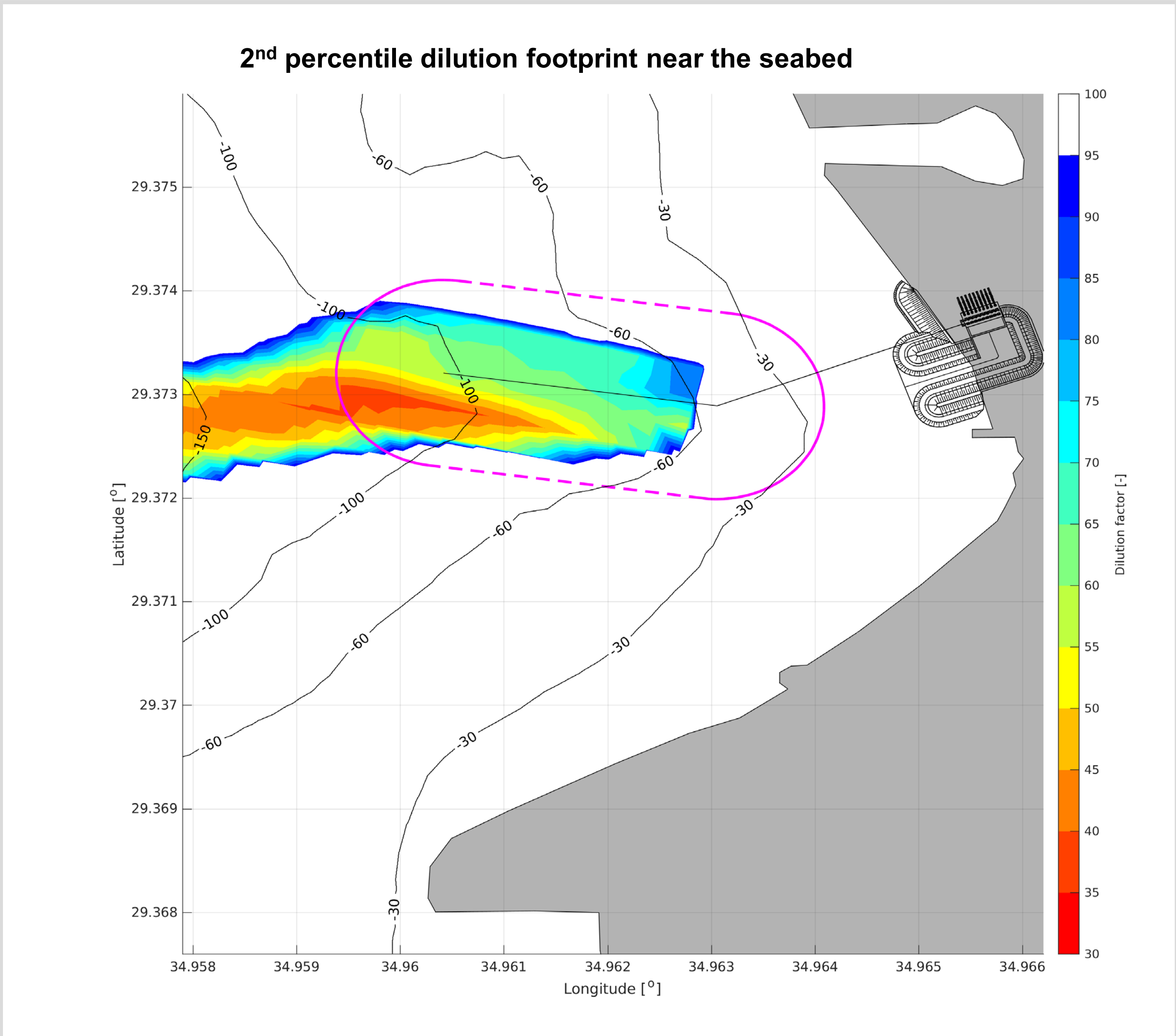


Case 2
Season: Winter
Wind condition: Typical

- Note that dilution between the impact point and the end of the near-field zone is not shown in this figure, as Delft3D-FM only models far-field dispersion.

Observations

- These maps show the 2nd percentile dilution footprint near the seabed. Dilution expresses how much the original effluent concentration has been reduced. For example, a dilution of 50 means the concentration is 50 times lower than the original effluent concentration.
- This figure is basically showing the inverse of the earlier shown excess salinity plots



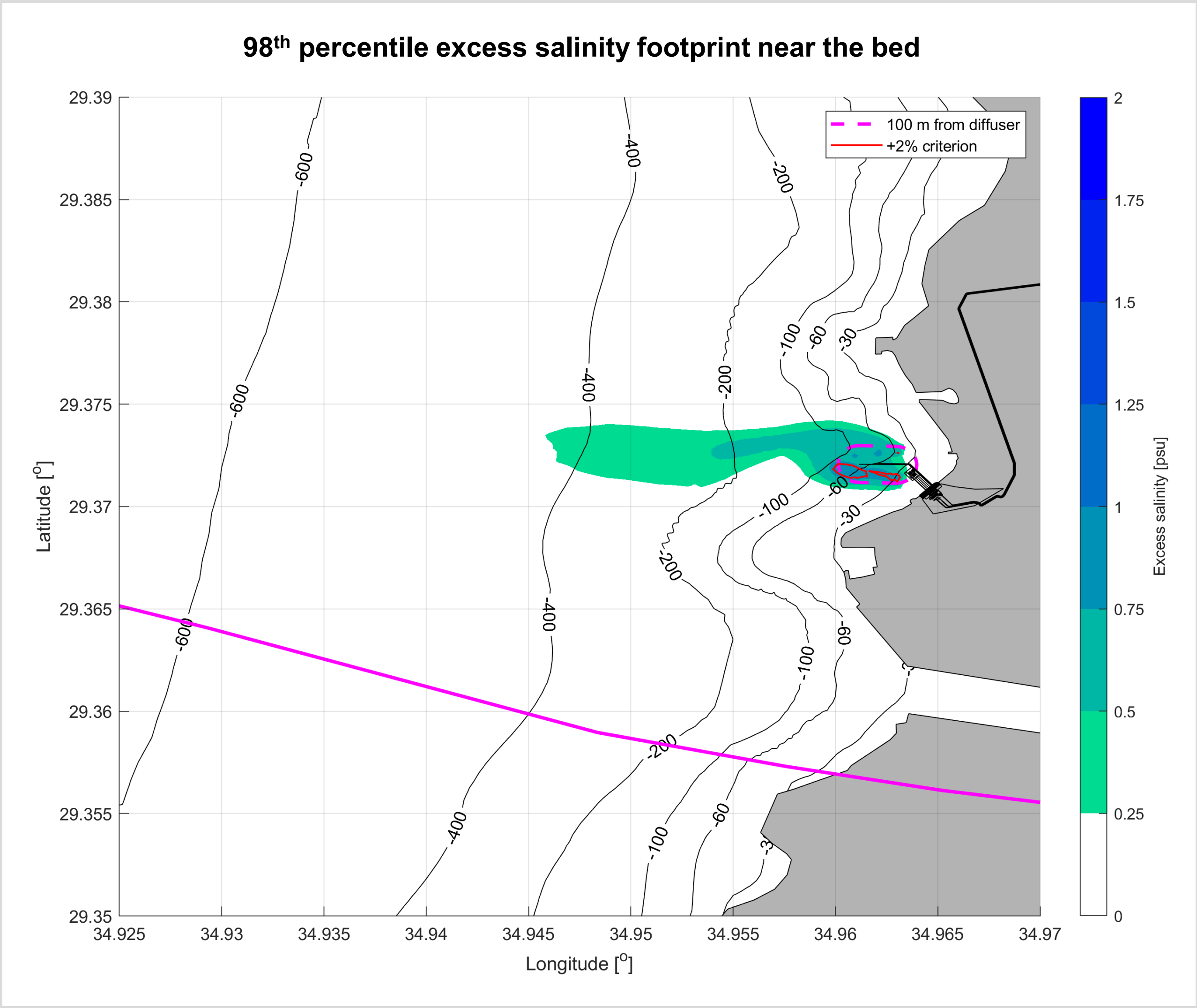
Transboundary effects

Case 1 and 2

Case 1
Season: Winter
Wind condition: Typical

Observations

- As previously shown: the effluent initially travels as a density current, following the bed slope i.e.to deeper areas.
- During traveling downslope, ambient water is entrained into the plume, reducing its density.
- At a certain point, the density difference between the plume and the ambient water becomes insignificant after which the weak ambient flow determines the subsequent transport to the north and south. This occurs when the excess salinity is less than 0.25 psu, which is therefore not visible in the figure.
- At the Saudi-Jordan border, the effluent plume is typically located at depths between -100 to -500 m MSL. At certain times the plume touches the seabed, while at other moments, the plume is separated from the seabed. The actual depth of the effluent plume mainly depends on the ambient stratification and the local (weak) flow patterns (which will bring the plume closer or further from shore).
- At the border between Saudi Arabia and Jordan, the computed maximum excess salinity is about 0.1 – 0.15 psu, which is about 0.25% to 0.35% of the background salinity.
- At the borders with Israel and Egypt, the excess salinity is less than 0.02 psu.
- The conclusions are similar for the other modelled wind conditions..



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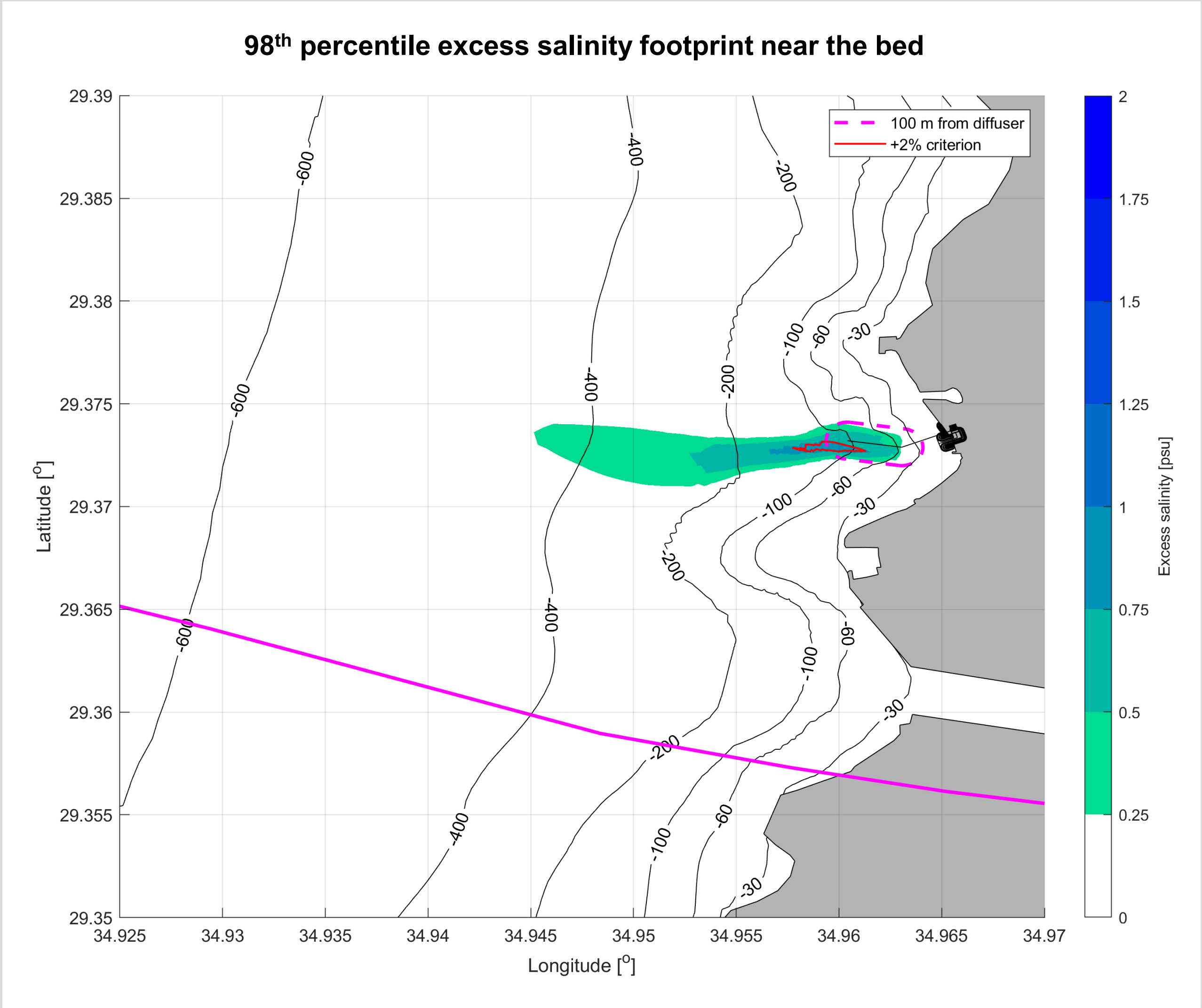
Case 2
Season: Winter
Wind condition: Typical

Observations

- The plume extent modelled in the Case 2 configuration is comparable to the plume described in Case 1. No additional observations are added for this case.



Recirculation towards the intake structure

Case 1 and 2

Recirculation results | Case 1 - 2

- For each modelled Case, the excess salinity is recorded at the corresponding intake structure during the complete production period.
- The excess salinity at the various AAWDCP intakes structures (Case-dependent) is less than 0.1 psu in all modelled wind conditions.
- Recirculation is limited due to horizontal and vertical separation of the intakes from the diffuser area:
  - Horizontally, the discharged effluent mainly flows towards the west (away from the intakes/coastline), following the bathymetric features.
  - Vertically, the effluent is released near the bed, whereas the intake structures extract water either at +3m to +7m from the bed (Case 1) or at an open intakes at the coastline (Case 2). Furthermore, all modelled intake structures are placed at a location that is up-slope from the diffuser area. Given the denser (heavier) characteristic of the brine, it will typically flow down-slope if undisturbed.

Effect of existing outfall

Case 1 and 2

Effect of existing outfall | Case 1 - 2

- Impact of the existing industrial discharge on the modelled intake Cases is minor (see below), but values vary per modelled case.
- Given the buoyant characteristic of this effluent and that the intake structures (whether submerged or open) occupy a given height in the water column, this analysis is performed on the uppermost section of each intake. It is in this uppermost section where the highest impact can be expected.
- Across all modelled cases, the highest recirculation is observed during the Westerly wind scenario. This is expected, as the buoyant plume reaches the surface and is more susceptible to wind forces acting in the area. This effluent is expected to be “pushed” towards the East, where the intakes are located.
- Note: no impact is expected on the AAWDCP discharge.

- Dilution (factor) ranges of the industrial effluent recorded *at the intake structures*, per Case:

Case 1: effluent dilutes by an average of 90, and a minimum of 36.

Case 2: effluent dilutes by an average of 75, and a minimum of 45.

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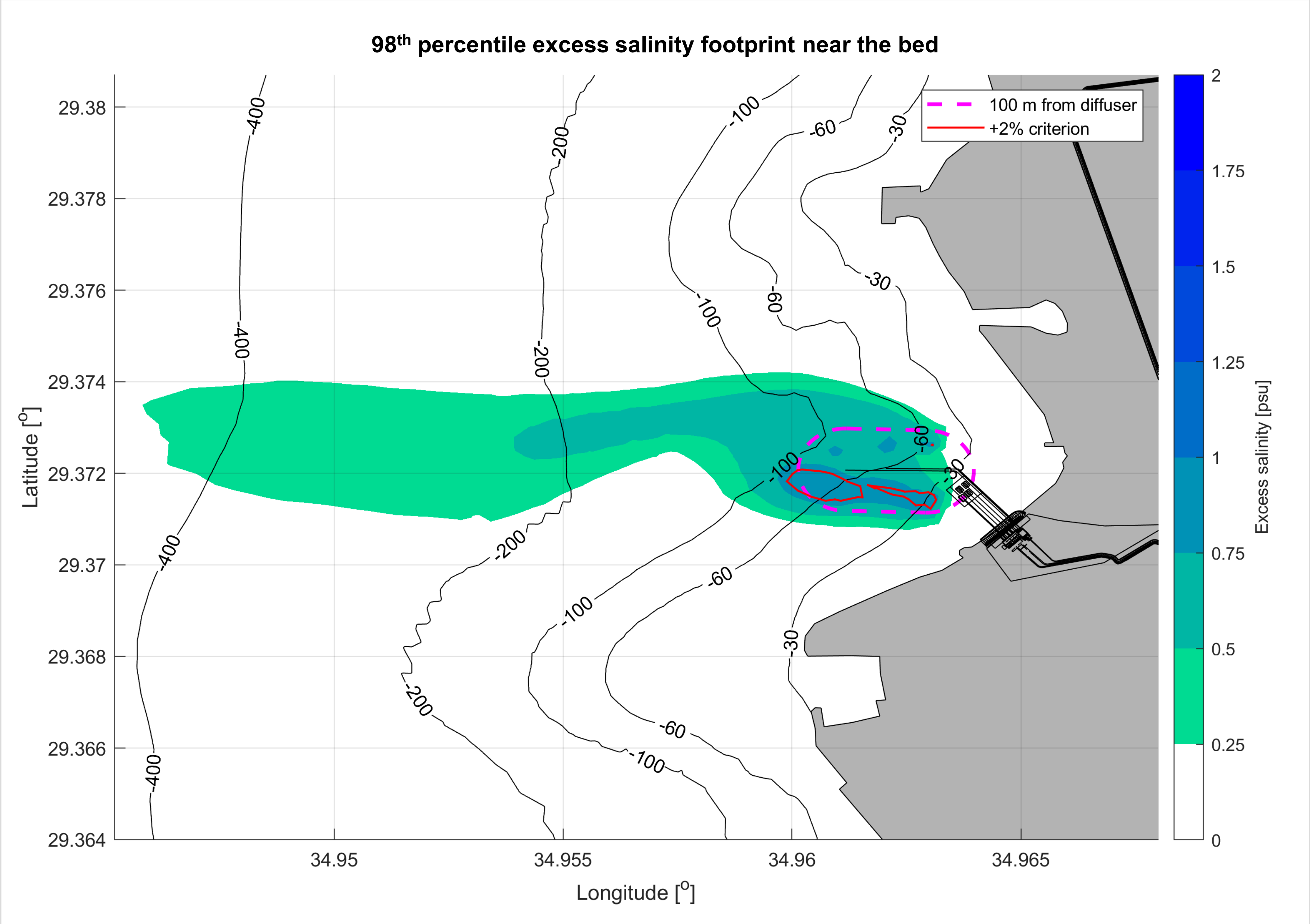
Appendix A

Maximum excess salinity footprints near diffuser area

Case 1 and 2, all wind conditions

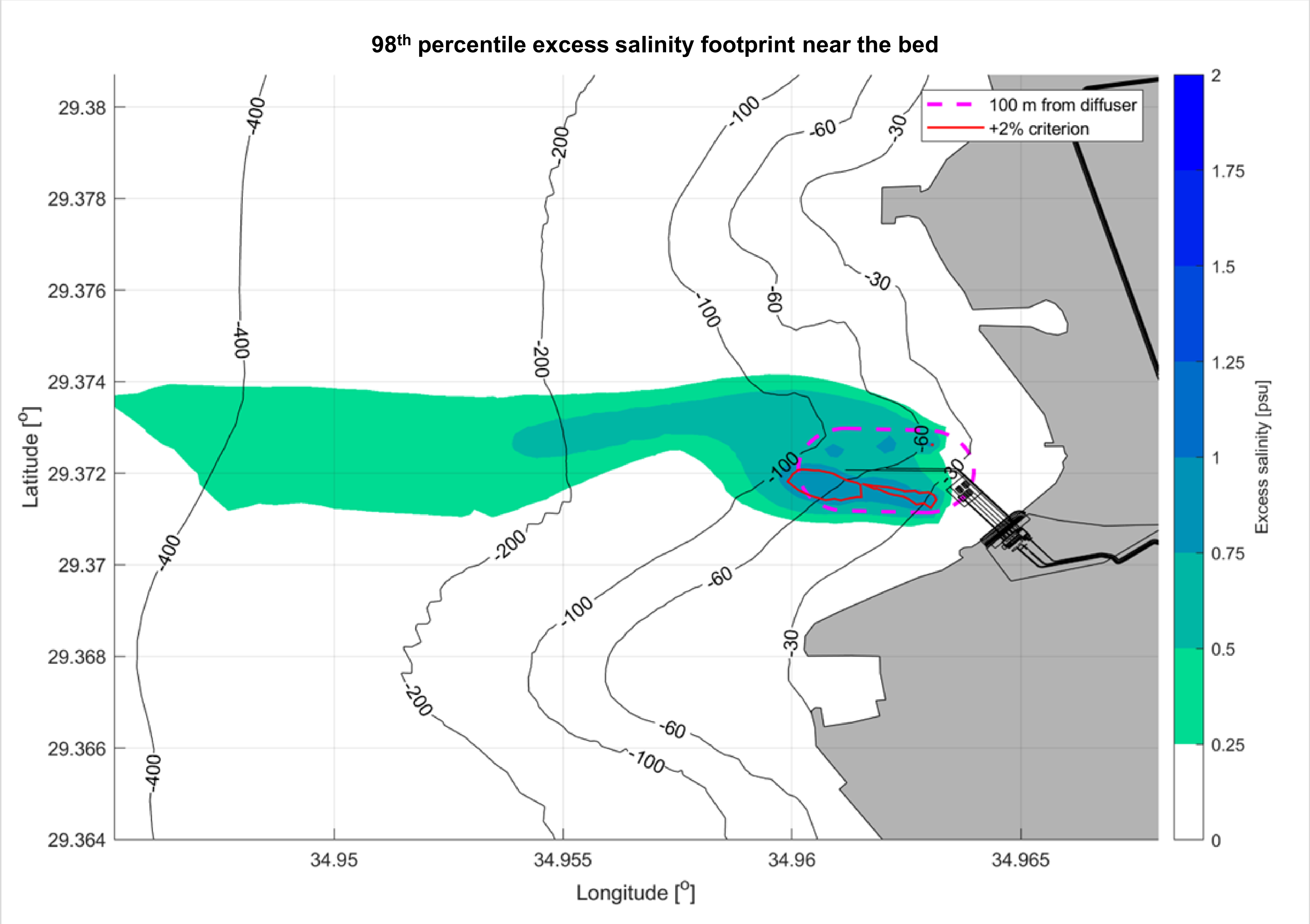
Case 1

Season: Winter
Wind: Typical



Deltares

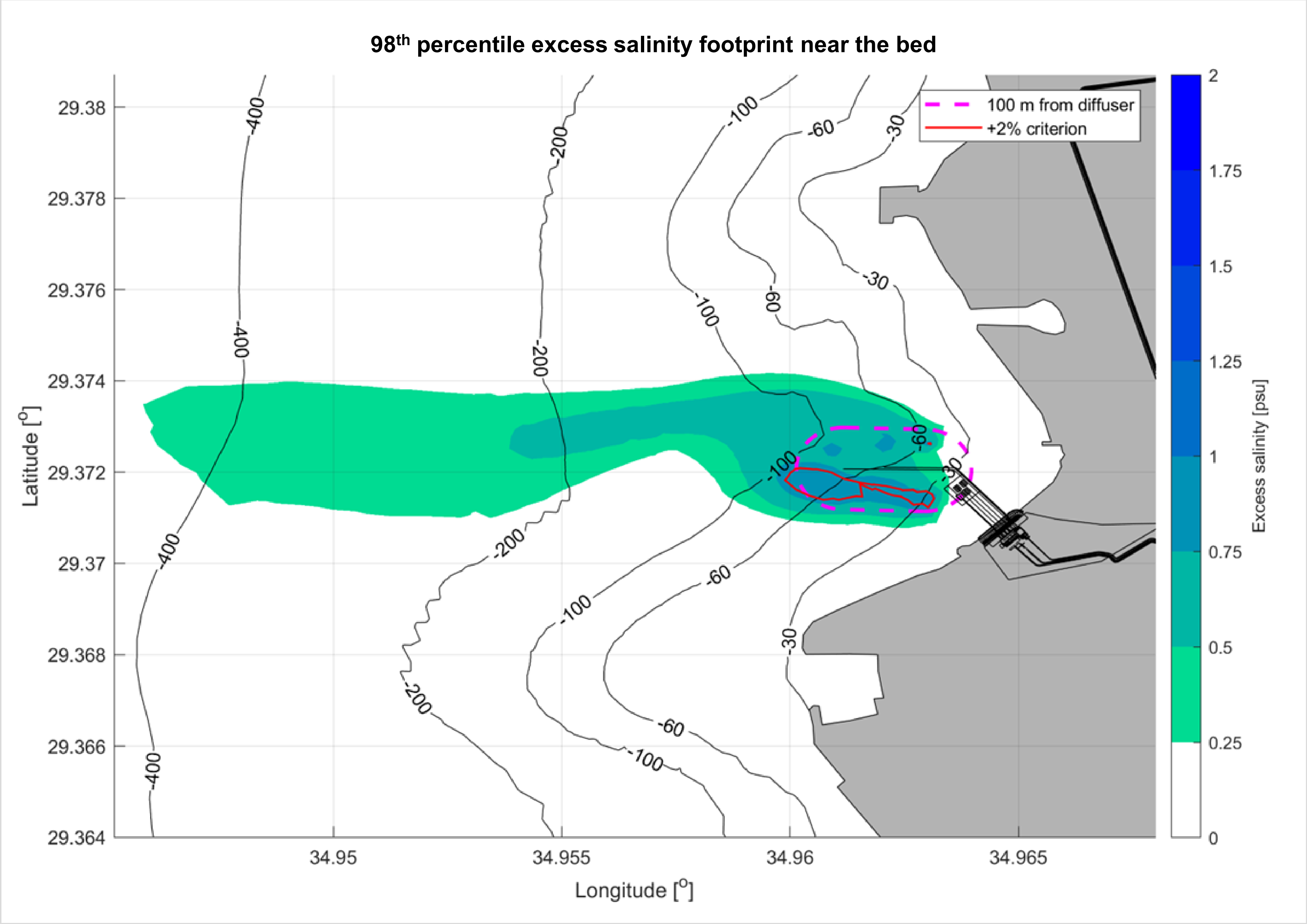
Case 1
Season: Winter
Wind: Northerly



Deltares

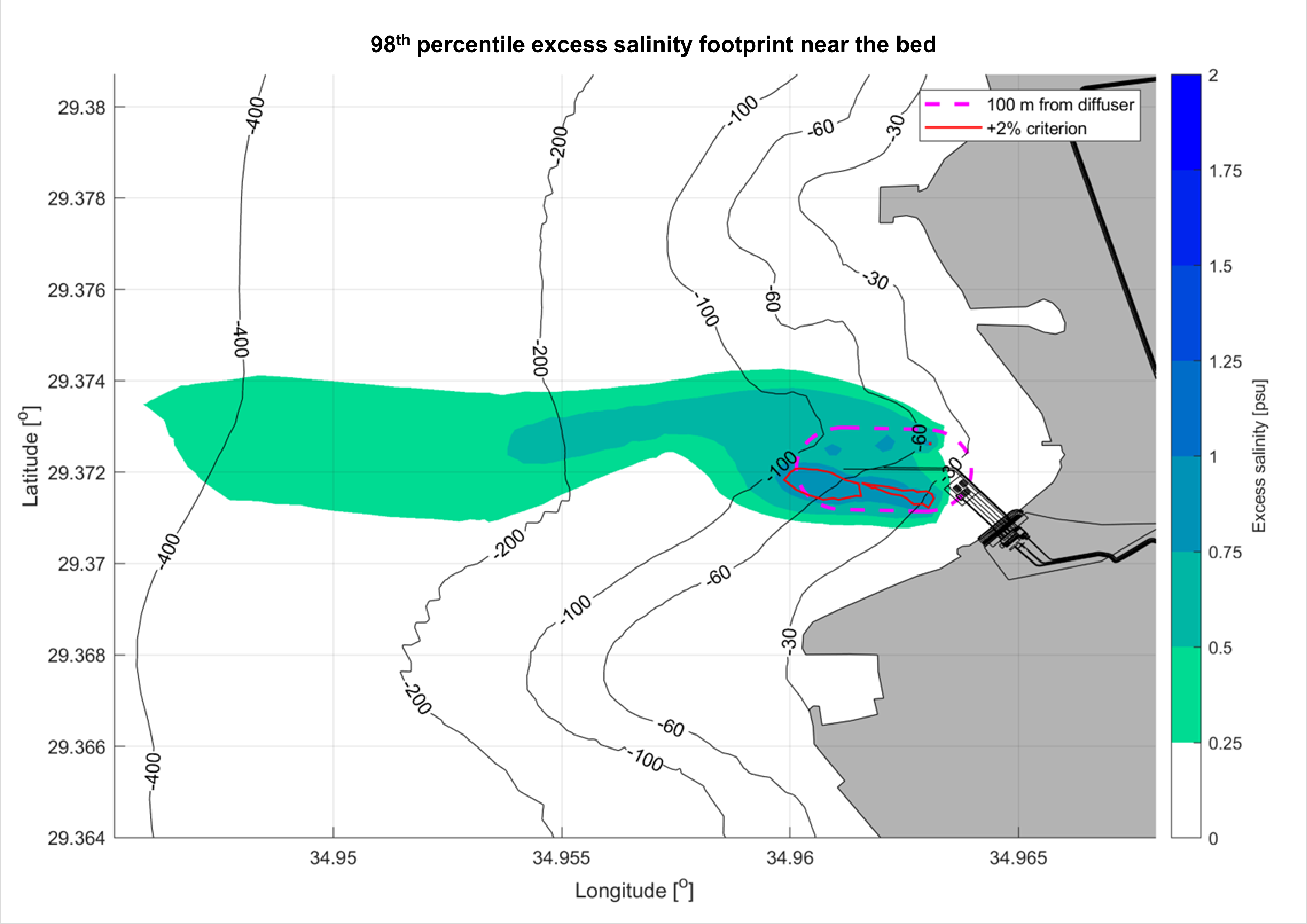
Case 1

Season: Winter
Wind: North-easterly



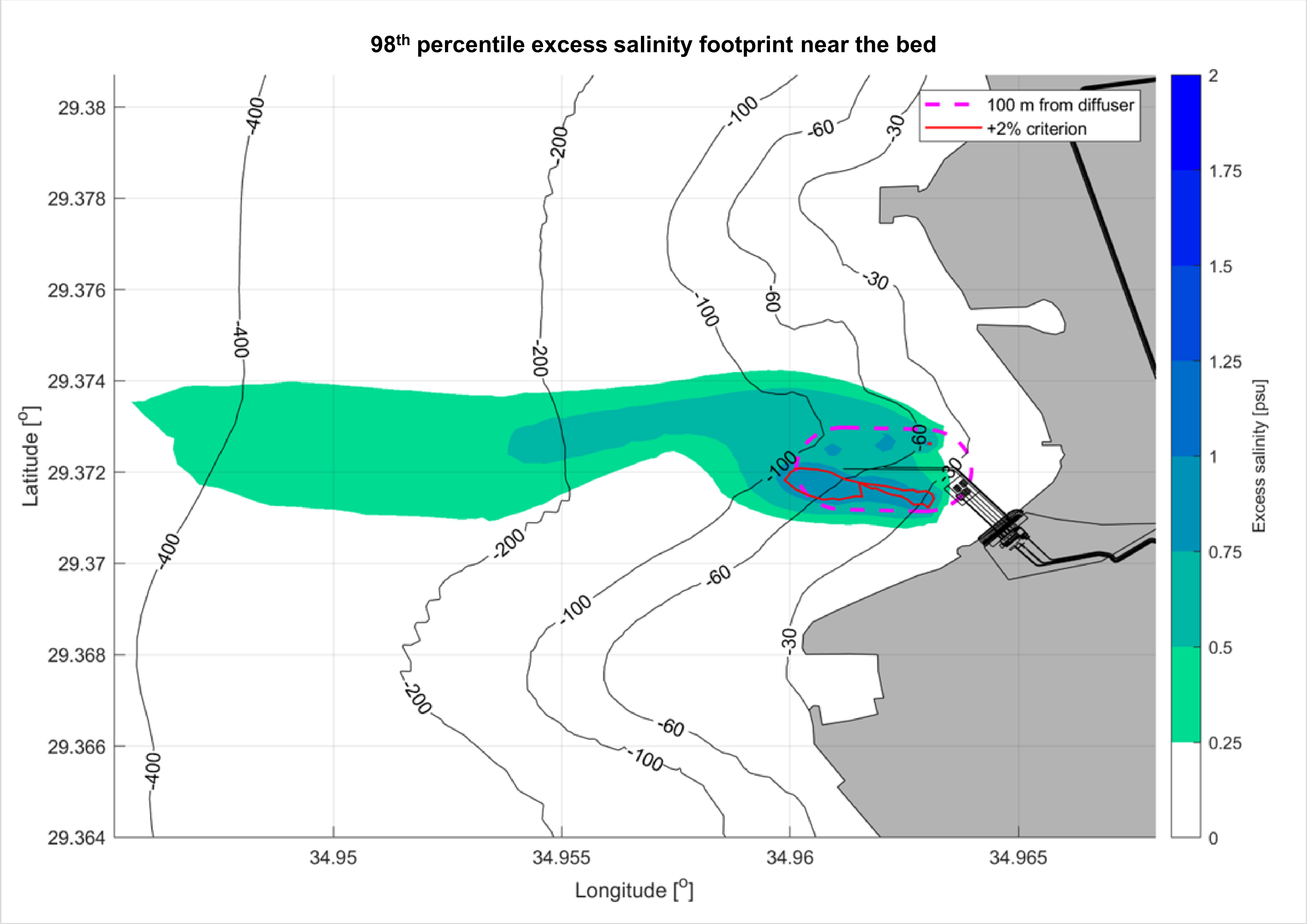
Deltares

Case 1
Season: Winter
Wind: Southerly



Case 1

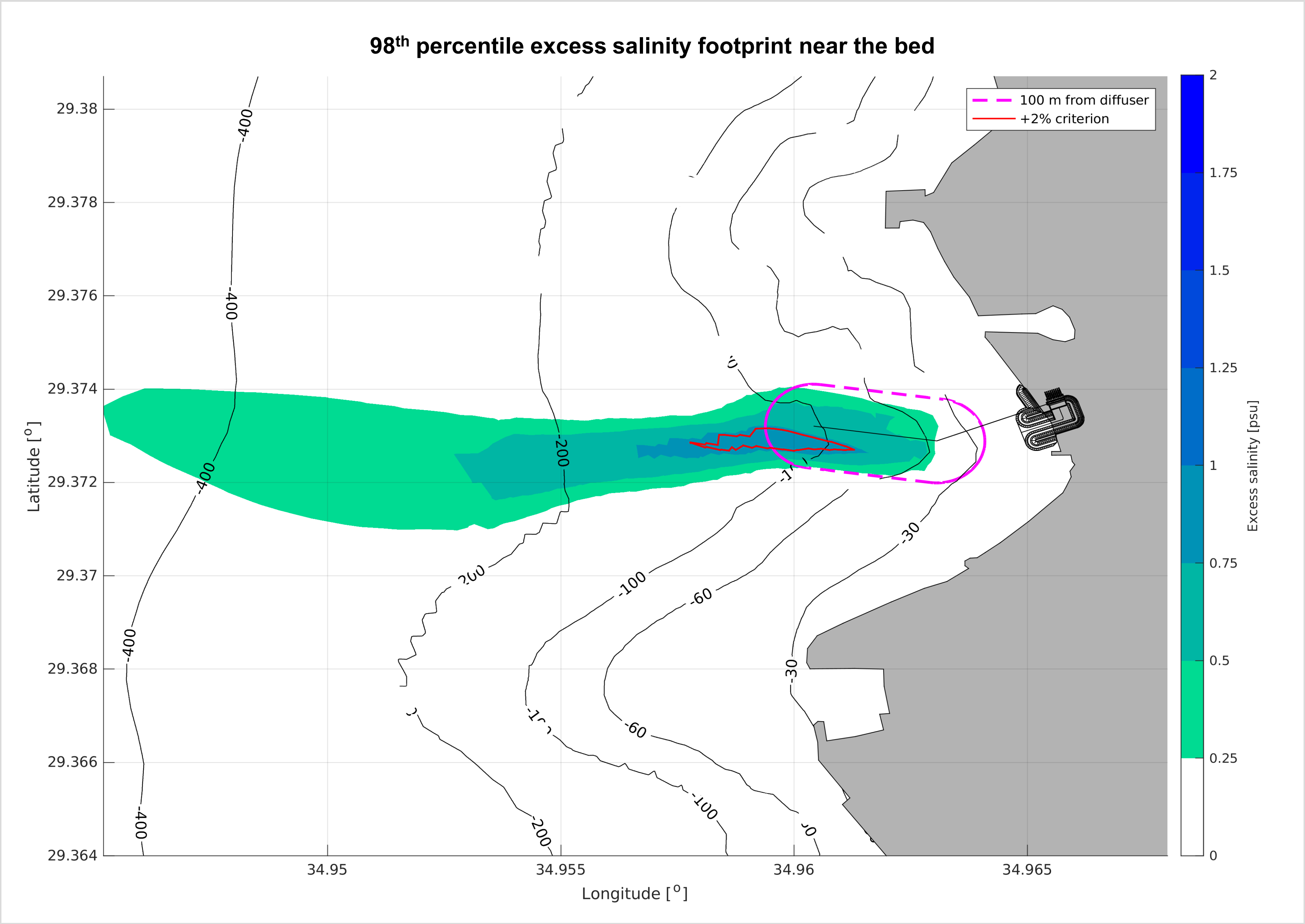
Season: Winter
Wind: Westerly



Deltares

Case 2

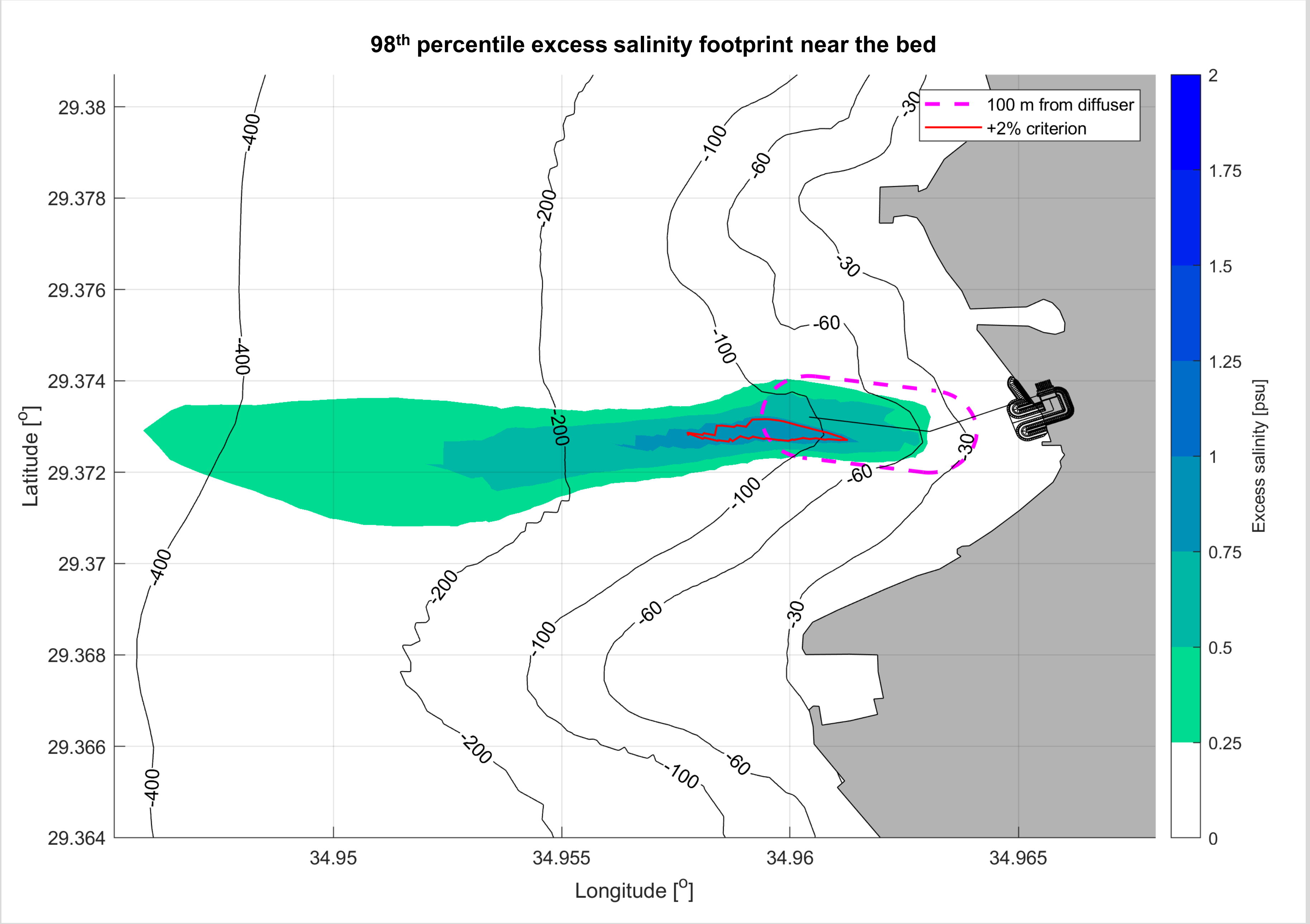
Season: Winter
Wind: Typical



Deltares

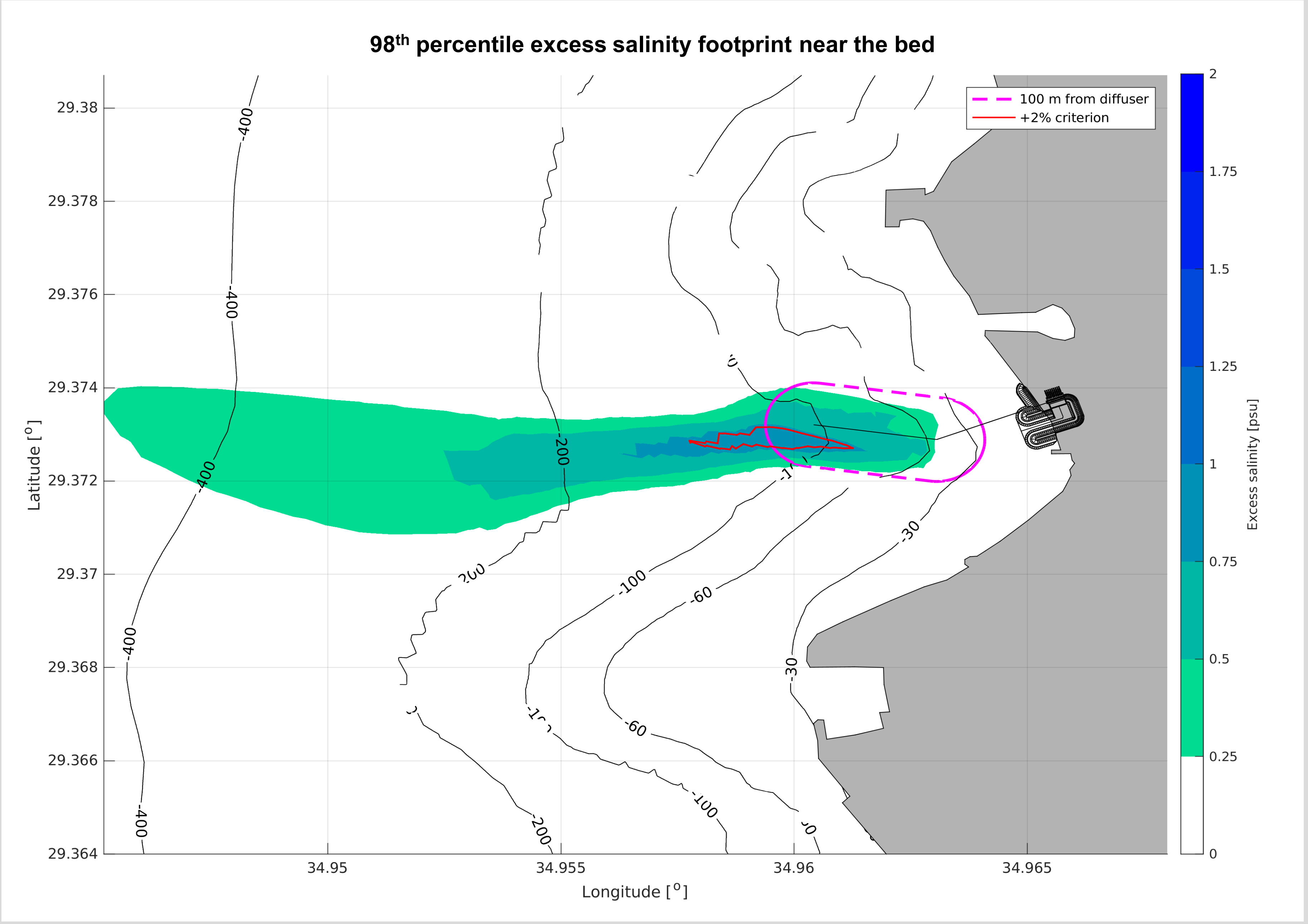
Case 2

Season: Winter
Wind: Northerly

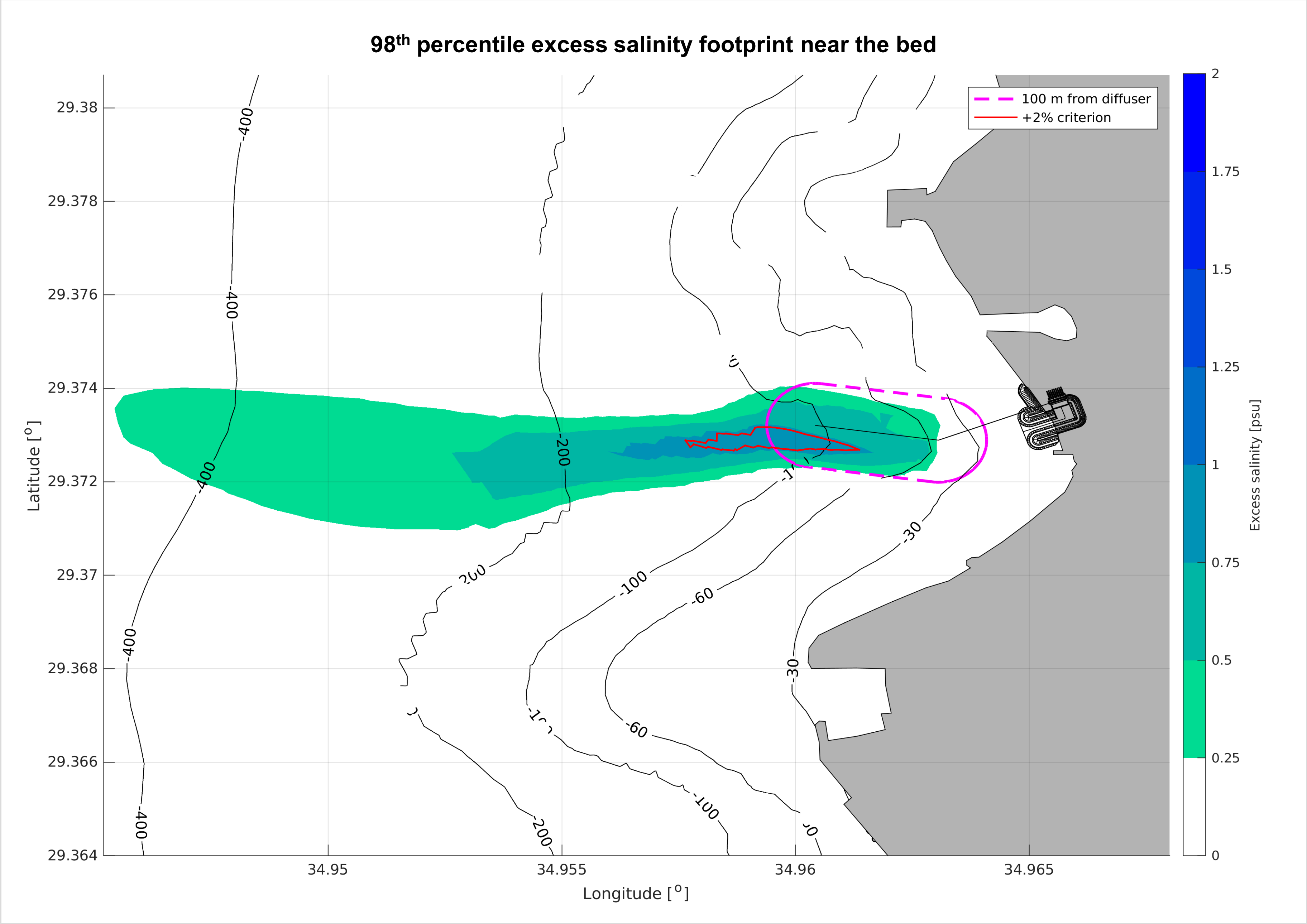


Deltares

Case 2
Season: Winter
Wind: North-easterly

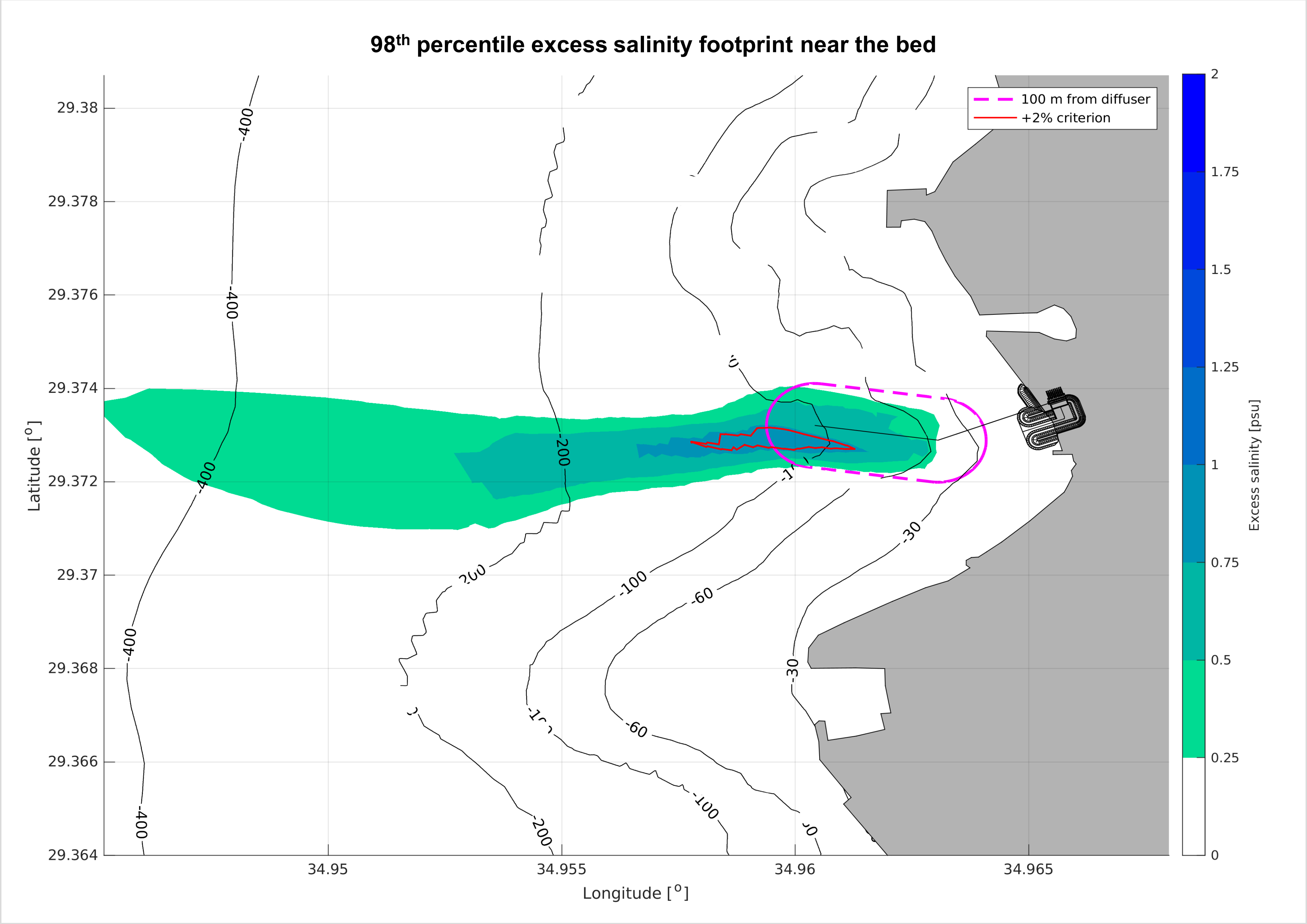


Case 2
Season: Winter
Wind: Southerly



Deltares

Case 2
Season: Winter
Wind: Westerly



Appendix B

Maximum excess salinity footprints near diffuser area

Sensitivity analysis (Case 1)

Near field dilution – sensitivity analysis Case 1

Season: Winter, Wind condition: Typical

- As discussed in Slide 22: The near-field dilution computed in this study is lower than in other studies because a more conservative methodology was applied. For example, HR Wallingford (2021) used empirical relationships from Abessi and Roberts (2016). While their application was correct and consistent, the dilution values reported in that paper are relatively high/optimistic compared to other experimental results. To address this, laboratory data from additional publications was incorporated in this study, resulting in a more solid and conservative estimate.

- Using the approach described above, the near-field dilution factor for the Case 1 layout is about 43.5 (in winter), see upper figure.

- Sensitivity simulations were performed with a near-field dilution factor of 54 (highest end of the empirical formulae, similar to the approach undertaken by HR Wallingford (2021)) and with a factor of 48. The resulting excess salinity footprints are shown in the middle and lower figures.

- The difference between a near-field dilution factor of 43.5 and 48 is limited in relation to compliance with the +2% criterion at 100m. Only when using the upper end of the dilution range (54), the excess salinity at 100 m is lower than +2% of the ambient salinity.

- Based on these figures it can be concluded that the 2% salinity increase compared to background criterion is at or just beyond the 100 m distance line.
  To ensure that the +2% criterion is met at 100m from the outfall, it is recommended to optimise the Case 1 diffuser configuration (number of ports, orientation with respect to the bed gradients, etc.).