MEMO

TO: Olivia Allen, Helen Crosby

FROM: Roy van Ballegooyen

SUBJECT: Final review of the SINTEF Drilling Discharge Modelling Study

DATE: September 15, 2023

1 INTRODUCTION

I have undertaken a final review of the view of the SINTEF Report:

- SINTEF (2023). Simulations of spreading and deposition from drilling discharges from Block 11B/12B offshore South Africa, SINTEF *Report No: 2023:00870 (Restricted)*, 170pp + 71pp Appendices.

This final review is the culmination of a review process comprising a reviewer comment and response cycle within which a number of issues have been addressed (see Section 4 of this memo for the detail).

TotalEnergies EP South Africa B.V. (TEEPSA), has specific requirements as to the content and presentation of the model results in the reporting. Initially, the primarily goal was to ensure consistency with the reporting for similar studies most recently undertaken in South African waters (HES, 2022). However, as two prior Drilling Discharge modelling studies (HES, 2020a, 2020b) also form part of the Drilling Discharge modelling reporting for the present ESIA, the focus now is on ensuring consistency between the three Drilling Discharges modelling reports (HES, 2020a, 2020b and SINTEF, 2023) informing the present ESIA.

The context within which the review needs to take place is provided in Section 2 (Reporting Requirements), which outlines the "*high-level", best practise reporting requirements* for the ESIA.

The *detailed scope of work* and reporting requirements for the Drilling Discharges modelling study is contained in the service level request form:

- 221128_ZA_11B-12B_Discharge4-5_PARTRACK Modelling SRF.pdf (2 Dec 2022)

The above document has been reviewed to ensure that the SINTEF Drilling Discharges modelling report meets the stated requirements. Note that this service request form in included as an appendix in the SINTEF Drilling Discharges modelling report under review.

The review comprises "high-level" comment in Section 3 (Review Summary) as well as a more detailed review of specific aspects of the study as outlined in Section 4 ("Specific Issues addressed during the Review").

The marine ecologist specialist, the primary user of the oil spill modelling reports, has also been consulted to ensure that the SINTEF Drilling Discharges modelling report (SINTEF, 2023) meets the information requirements of the marine ecology specialist study being undertaken for the ESIA.

2 REPORT REQUIREMENTS

The reporting of the SINTEF Drilling Discharges modelling undertaken needs to both:

- be accessible to a wide range of readership and yet;
- contain sufficient detail to withstand a technical specialist review.

This requires that it is written simply, yet contain all core technical information relevant to the study. Whilst sufficient information should be included for the general reader, there are additional reporting requirements for more the specialist reader / technical reviewer. Thus, some more deeply technical information (*e.g.*, validation of the metocean study, model parameterisations, *etc*.) may need to be included in the reporting, ideally as appendices or, if more substantive, as referenced material. An added complexity is that *a sufficient degree of consistency is required with the earlier reporting for Drilling Discharge modelling undertaken for drill cutting and drilling mud discharges at Locations 1 and Location 2 (HES (2020a,2020 b) in the Exploratory Priority Area of Block 11B/12B.* This necessarily is the context within which the present SINTEF reporting for proposed drill discharges from drilling operations at Locations 4 and 5 in the Project Development Area of Block 11B/12B, needs to take place.

Generic requirements for SINTEF Drilling Discharges modelling reporting include:

- **Modelling software:** The modelling software utilised needs to include all relevant processes that determine the transport and fate of the drill cutting and drilling mud discharges under investigation. The model capabilities need to be clearly described in the report, including any assumptions and limitations of relevance to the study.
- **Metocean Data:** The robustness of the metocean conditions used in the study needs to be demonstrated. This typically would require evidence of adequate calibration and validation of the metocean database used in the study.
- **Model scenarios – Environmental conditions:** The approach to developing the environmental conditions need to be consistent with the earlier Drilling Discharge modelling studies for Location 1 and 2 in the Exploration Priority Area of Block 11B/12B (HES, 2020a, 2020b) and should include all relevant variability in currents, water quality and associated water column mixing processes. It should be noted that, whilst the Agulhas Current shows little evidence of seasonality, it is subject to substantive episodic perturbations.
- **Discharge Location(s):** There needs to be adequate motivation for the selection of the discharge location(s) used in the modelling. The selection of spill locations needs to provide a sufficiently conservative assessment of the Drilling Discharge risks for the proposed drilling in the Project Development Area of Block 11B/12B. The previous Drilling Discharge studies in the Exploration Priority Area of Block 11B/12B (HES, 2020a, 2020b) selected the discharge locations on the following basis:
    - The need to assess different (rather shallower) water depths,
    - Proximity (shorter distance) to the shoreline,
    - Proximity to sensitive areas.
- **Model scenarios – Drilling Discharge scenarios**: The modelled scenarios need to be motivated in terms of the nature of drilling operations. This needs to include specification of the hole sections and the associated drilling schedule, volumes of drill cuttings being discharged for each section, the type of drilling muds used and the nature of the resulting discharges of both drill cuttings and muds for each section.
- **Consistency with prior reporting:** There needs to be adequate degree of consistency with earlier reporting to facilitate the reading and interpretation of the three Drilling Discharge modelling specialist studies included in the present ESIA study.

3 REVIEW SUMMARY

High level review comments on the SINTEF Drilling Discharges modelling study (SINTEF, 2023) are summarised below.

3.1 MODELLING SOFTWARE

The model capabilities are clearly described in the report, including assumptions and limitations of relevance to the study.

The SINTEF model is the same Dose-related Risk and Effects Assessment Model (DREAM) used in the earlier Drilling Discharge modelling studies (HES, 2020a, 2020b) undertaken for the Exploratory Priority Area. *It is a "state of the art" model widely utilised in the oil and gas industry and therefore is deemed adequate for the present study*. Sufficient detail of the model capabilities has been provided in the SINTEF Drilling Discharge modelling report (SINTEF, 2023) under review here, to allow the reader to understand the concepts utilised and the rigour of the study.

The assumptions and limitations around the parameterisations and processes included in the model are deemed appropriate, as is the spatial resolution in the model.

The following observations are relevant in this regard:

- The concept of an Environmental Impact Factor (EIF) is used in the DREAM Model. The EIF method is based on a PEC/PNEC approach, in which the predicted environmental concentration (PEC) for each discharged compound or stressor is compared to a predicted no-effect concentration (PNEC) for that same compound.

  The risk probability is the probability that a randomly selected species in the environment is exposed to concentrations exceeding its chronic no-effect concentration (NOEC). A risk probability of 5% is often used as a cut-off criterion assuming that risk is unacceptable if more than 5% of the species are exposed above their chronic NOEC. Therefore, it has been suggested that the concentration at which the risk probability is 5% corresponds to the PNEC. This implies that when the PEC/PNEC equals 1, the risk probability equals 5%.

  The EIF is reported as the volume or area where the overall impact probability exceeds 5% (where the ratio PEC/PNEC > 1), *i.e.*, where the probability that more than 5% of the species selected are exposed to concentrations above their chronic no-effect concentration. In the SINTEF Drill Cutting Disposal modelling study under review (SINTEF, 2023), the unit EIF is reported as a volume (100m x 100m x 10 m = 100 000 m^3) in the water column and an area (100m x 100m = 10 000 m^3) on the sea floor.

  Note that, while the method takes into account cumulative effects, it does not include synergistic effects.

- It is stated that the process of re-suspension of sediments after their initial settling onto the seabed, was not included in the DREAM model. Further, it was stated that this constituted a conservative approach. In terms of the persistence of impacts this is true. However, given the strong flows near the seabed in the vicinity of the drilling locations, a significant mobility of sediments is expected. Thus, the results of the modelling study are likely to be possibly overly conservative in terms of the persistence of the impacts in the sediments.

  Note that the assumption of no re-suspension and re-distribution of sediments remains spatially conservative only if the sediments are resuspended a rate that preclude a growing impact footprint on the seabed, *i.e.*, the sediments are re-suspended at a rate slow enough to allow the re-suspended sediments to be sufficiently dispersed by prevailing currents to prevent impacts when they re-settle onto to the seabed. This is likely to be the case at the drilling locations. *Consequently, it is accepted that the exclusion of resuspension effects is likely to result in a conservative assessment of risk in the sediments, particularly in terms of their persistence,*

3.2 METOCEAN DATA

It is important that the reporting demonstrate that:

- the Metocean database used in the modelling study is both appropriate and sufficiently accurate, and;
- the environmental conditions considered in the oil spill modelling study are sufficiently representative of the prevailing conditions in the area of interest.

The environmental conditions have been summarised in the main body of the SINTEF Drilling Discharges modelling report, based on the Metocean data summary and the validation study for the SATOCEAN data (that have been included as an appendix to the report). The appendix contains a reference to Russo *et al*. (2022) that provides a detailed validation of global models in South African waters, albeit focussed on large-scale oceanographic features.

The information contained in the Appendix to the SINTEF Drilling Discharge modelling report under review, provides adequate confirmation that the SATOCEAN data comprises a sufficiently accurate hydrodynamic database for the execution of the SINTEF Drilling Discharges modelling study.

3.3 ENVIRONMENTAL SCENARIOS MODELLED

It is important that the Drilling Discharge scenarios, as a minimum, are simulated a range of "worst-case" environmental conditions leading to a conservative impact assessment.

The \SINTEF Drilling Discharge modelling study focussed on the minimum distance between the drilling discharge locations and the closest sensitive receptor sites. The closest such sensitive site is a Marine Protected Area to the southwest of Location 4. Thus, the environmental conditions comprising the dominant and most regular flow conditions (*i.e.*, the strongest south-westerly flows), were targeted for the simulation undertaken for each season.

This does mean that other less common flows such as major perturbations of the Agulhas Current (*i.e.*, Natal Pulses) are not simulated. The drill cuttings dispersal for such flows are likely to result in similar impact outcomes (EIF factors). However, it is only the leading-edge flows of such large-scale perturbation of the Agulhas Current (that are likely to persist at a particular location for no more than one to 2 weeks at a time), that would have a significant onshore component. The resultant impacted areas for such flows i) are likely to be in closer proximity to the drilling and discharge location and ii) also not extend shoreward into other sensitive areas. *Thus, it can be concluded that the Drilling Discharge simulations have been undertaken in a manner that is likely to produce conservative impact scenarios.*

The water quality data used in the simulations are those provided by TEEPSA in the service request form. These data seem reasonable, however the ambient total suspended sediment concentration assumed, although expected to be low, seemingly are too much so. Conversely, the reported ambinet dissolved oxygen concentrations in the deeper waters near the seabed (2000 m) seem a bit higher than is expected. *However, these minor inaccuracies are unlikely to materially affect the model results and therefore will not change the conclusions of the study.*

3.4 DISCHARGE LOCATIONS

Drilling discharges have been assessed for two locations, namely Location 4 and 5. These two locations are deemed representative of proposed drilling operations in the Production Development Area within Block 11B/12B. Discharge location 5 was selected as a representative location for drilling possibly occurring both to the east and the west of this location, i.e., location 5 represents a central location within the proposed Production Development Area. Location is in close proximity to the previously drilled explorations well

Luiperd-1X upon which the oil spill characteristics and description of drilling activities for the SINTEF Drilling Discharge modelling study are based. Drilling location 4 has been selected due to its close proximity to a marine protected area and critical biodiversity areas located immediately to the southwest of location 4.

Based on the above, the discharge locations used in the study will provide an adequate characterisation of the impacts associated with drilling discharges from likely drilling operations in the Production Development Area within Block 11B/12B.

3.5 DRILLING DISCHARGE SCENARIOS

The drill cutting discharge scenarios are those provided by TEEPSA for proposed drilling operations in the Priority Development Area of Block 11B/12B. These descriptions presumably are based on experience gained in the drilling of the Luiperd and Brulpadda wells), The specifications underlying the drill cutting discharge scenarios as provided in the Service Request form included as an appendix in the SINTEF report. The information provided includes:

- the hole section dimensions and the associated drilling schedule for the various hole sections;
- the volumes of drill cuttings being discharged for each section;
- the type of drilling muds used (all water-based), including a detailed inventory of their constituents; and
- the nature of the resulting discharges of drill cuttings and muds for each hole section.

The only information not provided in the Service Request Forms is the grain size distribution of the drill cuttings. SINTEF has provided the necessary grain size distribution information based on available literature.

The model simulations were undertaken as follows,

- The DREAM model first simulated the drilling discharges and their fate in the water column, *i.e.,* the dissolution and degradation of the drill cuttings and muds in the water column and settling on the sea floor. This simulation is run for a 35-day duration.
- This was then followed a simulation using the sediments module that simulates the longer-term restitution processes in the sediment compartment (toxicity, oxygen change, grain size change and burial). This simulation is run for a 10-year duration.

Based on the above, the drilling schedule and the composition of the drill cuttings and muds are deemed appropriate for the proposed drilling operations and locations. Furthermore, the modelling approach, model assumptions and duration of the model simulations all are deemed appropriate to ensure a sufficiently rigorous assessment of the risks associated with the discharge drill cuttings and muds from the proposed drilling activities in Priority Development Area in Black 11B/12B.

3.6 MODEL RESULTS

The model results are largely reported in a similar manner to those reported for the earlier Location 1 and Location 2 Drill Cutting Disposal modelling studies (HES, 2020a, 2020b).

Initially, only the instantaneous plot of the risk in the water column at the time of maximum EIF was reported. This does not provide a conservative assessment of the spatial area of impact, that could occur at any time during the drill cutting disposal simulations. Accordingly, it was requested that plots be presented of the maximum cumulative risk in the water column throughout the drilling discharge simulations. These plots, however, are a very conservative estimate of impact as the spatial risk indicated in such plots include all areas risk even if of very short duration (*e.g.*, minutes to hours).

The inclusion of these plots ensured consistency with the risk levels reported in the earlier Drilling Discharge modelling studies (HES, 2020a, 2020b). More recent Drilling Discharge modelling studies (HES,2022) have provided a more nuanced way of presenting such results, namely spatial plots of the percentage of time a location is at significant risk during the model simulations. While this provides an integrated view of the extent and duration of impacts, *the SINTEF reporting provide a more conservative view of impacts with additional time series that provide insight as to the limited duration of the impacts. This approach is consistent with the earlier Drilling Discharge modelling reports (HES 20230a, 2020b) that*.

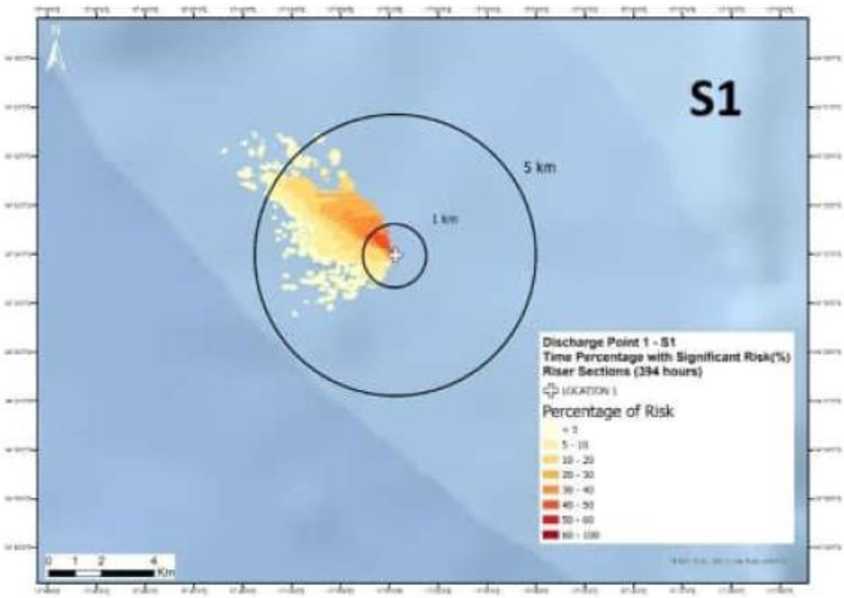

Figure 1: An example of a plot presenting the percentage of time where there exists a significant risk associated with drilling discharges (Source: HES, 2022).

4 SPECIFIC ISSUES ADDRESSED DURING THE REVIEW

The following specific issues were addressed during the review process.

- There was a seeming disconnect in the time serious and pie graphs indicating the % contribution of the various drilling discharge constituents to risk in the water column. However, this issue was resolved as it was due to a misunderstanding of the nature of the risk being reported in the time series. Text was added in Section 2.5 of the report providing guidance on how the time series and associated risks should be interpreted, thus providing the consistency between pie chart and time series being reported.
- A threshold of concern of 100 ppm (~ 100 mg/L) was specified for the DREAM model. The implication is that only suspended sediment concentration > 100 mg/L will generate an impact in the water column. Given that i) drill cuttings themselves are

deemed non-toxic, ii) the very short duration of such impacts related to elevated suspended sediments in the water column and iii) that such impacts are deemed modest compared to the toxicity impacts of other drilling discharge constituents; _the use of such a relatively high value threshold of concern is unlikely to significantly change the overall magnitude of the assessed impacts, certainly not to the extent that it would change conclusions of the study._

- Initially only the top-hole discharge impacts in the sediments were plotted and tabulated. However, this led to queries around whether the drilling discharges near the sea surface had indeed been assessed in terms of potential impacts in the sediments. The reporting was changed to include the impacts of near surface discharges on the sediments to demonstrate that these impacts had been correctly modelled. In reality, it is only impact related to the changes in grain size that result from the near surface drilling discharges, as any other impacts are either minimal or non-existent due to the high degree of dispersion and dilution of the drilling discharges as they settle through the water column before reaching the seabed.
- Initially there was concern that some of the top-hole discharges directly onto the seabed seemed to generate “midwater” plumes (i.e.,where the ration PNEC/PEC > 1). In reality, such plumes occurred at the same water depths as the those at which the top-hole material was being discharged onto the seabed. The absence of visible slope topography / bathymetry in the plots, is due to the fact that once the constituents entered the water column from these top-hole discharges on the seabed, they are advected into deeper waters giving the effect of their being a midwater column plume.
- Initially it was not clear that both compounds logPow <3 (high solubility) and logPow > 3 (generally attached to particulates and having a low solubility) are considered when assessing potential impacts in the water column both compounds. SINTEF confirmed that constituents with a logPOW $\geq$ 3 having a high solubility, indeed were included in the assessment of risk in the water column.

5 CONCLUSION

The Drilling Discharges modelling study (SINTEF, 2023) undertaken for the Project Development Area in Blocks 11B/12B T by SINTEF for TEEPSA has been peer reviewed and are considered to follow best international practise. _The results can therefore be considered reliable and can be used to inform the ESIA._

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REFERENCES

SINTEF (2023). Simulations of spreading and deposition from drilling discharges from Block 11B/12B offshore South Africa, SINTEF Report No: 2023:00870 (Restricted), 170pp + 71pp Appendices.

HES (2020a). TEP SA – Block 11B/12B – Discharge nº01: Drilling Discharges at Sea Modelling Study V04, HES Report No: DG/PSR/HSE/EP/ENV/OPS (Nº 2020-30), September 2020, 140 pp + 22 pp Appendices.

HES (2020b). TEP SA – Block 11B/12B – Discharge nº02: Drilling Discharges at Sea Modelling Study V06, HES Report No: DG/PSR/HSE/EP/ENV/OPS (Nº 2020-44), September 2020, 138 pp + 20 pp Appendices.

HES (2022). Total Energies E&P South Africa: Block 5/6/7 – Discharge Points 1 & 2: Drill discharge modelling Technical report, H-ES Projects References: P-2021-05-0124 and P-2021-05-0121, 127 pp + 61 pp Appendices.