Consulting Port and Coastal Engineers

ESIA FOR EXPLORATION DRILLING IN BLOCKS 11B/12B OFFSHORE OF SOUTH AFRICA

Peer Review of Oil Spill Modelling Study

REV.01

08 October 2020

SLR Consulting / TOTAL E&P South Africa B.V.
South Africa

Consulting Port and Coastal Engineers

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1. INTRODUCTION

SLR Consulting is undertaking an Environmental and Social Impact Assessment (ESIA) for exploration drilling in Blocks 11B/12B offshore of South Africa for TOTAL E&P South Africa B.V. (TEPSA). SLR Consulting have appointed PRDW to undertake a peer review of the specialist Oil Spill and Drilling Discharges Modelling Studies undertaken by TEPSA for the ESIA. This report describes the peer review of the Oil Spill Modelling Studies, whilst the peer review of the Drilling Discharges Modelling Studies is described in a separate report.

2. PEER REVIEWER

The peer review was performed by Stephen Luger. He has 28 years of experience in the application of numerical models in the fields of coastal hydrodynamics, waves, oil spills, drill cuttings, tsunamis, sediment transport, outfalls, water quality, dredging, coastal flooding, climate change and underwater acoustics. He has undertaken 15 oil spill modelling studies in South Africa, Namibia, Mozambique and Chile. A detailed CV is provided in Annexure A.

3. APPROACH TO PEER REVIEW

The approach to the peer review is outlined below:

1. Kick-off meeting with SLR, TEPSA and TEPSA's modelling team on 8 April 2020.
2. Meeting to discuss the two discharge locations to be modelled with SLR, TEPSA and TEPSA's modelling team on 9 April 2020.
3. Review of the oil spill modelling methodology being applied by TEPSA, based on a review of the oil spill study performed previously by TEPSA for the Luiperd-1X well in Blocks 11B/12B. The review comments and TEPSA's responses are provided in Section 4.
4. Meeting on metocean data and model scenarios with SLR, TEPSA and TEPSA's modelling team on 25 May 2020.
5. Review of the draft oil spill reports. The review comments and TEPSA's responses are provided in Section 5 and have been incorporated into the final oil spill modelling reports.
6. Review of the final oil spill reports described in Section 6.

4. REVIEW OF OIL SPILL MODELLING METHODOLOGY

The oil spill study performed previously by TEPSA for the Luiperd-1X well in Blocks 11B/12B was reviewed. This allowed the reviewer to provide comments on the oil spill modelling methodology being applied by TEPSA including any changes recommended for the current study. The peer review comments and TEPSA's responses and actions are provided in Table 4-1. The report reviewed was:

- 191218 OSCAR_LUIPERD-1X_SOUTH_AFRICA_DETAILED_Draft_02.pdf.

Table 4-1: Peer review comments on oil spill modelling methodology and TEPSA's responses and actions.

Report Section	Items	Peer Comment	TEPSA Response	TEPSA Action
3.1	1	Please include a brief description of the near-field blowout module applied in OSCAR.	- OSCAR is a commercial software with limited access to information. - OSCAR is a well known tool used worldwide - Gas hydrates formation not really calculated into the model - Put extract of document received from Sintef + reference of the document/article.	- Ask Sintef for a brief description of the BO near-field module in OSCAR
	2	Please include a description of how the oil droplet sizes and associated rise velocities and gas hydrate formation are calculated in OSCAR, since these determine how long the oil will remain sub-surface and where the oil reaches the surface.		- Ask HES to get the oil surfacing location & time from deterministic scenarios - Ask Sintef information about oil droplets velocities & gas hydrate formation in OSCAR
	3	Please include the horizontal and vertical dispersion coefficients applied in the model + Wind drift factor & coriolis factor		- Ask Sintef the horizontal & vertical dispersion coefficient + Wind drift factor & coriolis factor
	4	Please summarise and reference validation studies where the results from OSCAR are compared to prototype oil spills.		- Ask Sintef any scientific study/paper validating OSCAR
3.2	1	Please include a justification for the two spill locations selected – refer to the meeting minutes from 9 April 2020. Please include the depths at these locations and the distances to the closest shoreline.	- Worst case approach to be explained in the modelling and ESIA report (closest to coastlines, closest to EBSA, etc.) - TEPSA can provide assistance in the wording of this justification	- Ensure that the justification of discharge locations appears in the modelling report
	2	Please include a justification for the oil characteristics modelled, e.g. based on an analysis of oil found at nearby wells. Any supporting documents (e.g. service request forms) should be included as an annexure to the oil spill report.	- TEPSA will include the input data in the modelling report, including the expected oil properties. - Mention should be added that these properties have been chosen by similarity to Luiperd-1X study - Important: Statement not true. Gas with condensate has been found in Brulpadda. Luiperd not drilled yet. Future modelling will be based on Luiperd expected crude oil - Nothing has been analyzed in lab. - Information should be included in the modelling and ESIA report - TEPSA can provide assistance in the wording of this justification	- Ensure that the justification & input data appear in the ESIA report
	3	Please include a justification for the oil blow-out flow rate, e.g. the most likely rate based on the pressure measured at the closest available well with similar geology.	- Same as above: similarities with closest well Luiperd-1X with the same geological formation. - Use of the Most likely blow-out flowrate study made for Luiperd-1X (crude oil scenario) - Information should be included in the modelling and ESIA report - TEPSA can provide assistance in the wording of this justification	- Ensure that the justification & input data appear in the ESIA report
	4	Please include a justification for deploying the capping stack within 20 days, e.g. timeline for deploying Saldanha Capping Stack and any other parts required. Note that in the Luiperd-1X study mention is also made of a relief well. Please clarify if a relief well is planned. If the justification relies on other studies, e.g. by the drilling department of TEPSA, please include these as an annexure to the oil spill report.	- There was apparently a mistake in the Luiperd report stating that the relief well would be completed in 20 days, which is actually the time to see the capping stack installation. - Capping stack justification can be added in the report - Drilling department will draft a paragraph to explain the strategy & back-up plans - Information should be included in the modelling and ESIA report	- Ask Drilling Dpt to develop a short paragraph explaining the well response strategy & share it to Elcio/SLR

	5	Please include a justification for surface dispersant response time of 24 hours and the SubSea Dispersant Injection system (SSDI) deployment time of 15 days. If this justification relies on other studies, e.g. by the drilling department of TEPSA, please include these as an annexure to the oil spill report.	- SSDI modelled only to assess the impact of subsea dispersion - SSDI would be mobilized but it is not the primary well response strategy as TEPSA is not confident to deploy it in such harsh environment - SSDI justification can be added in the report - Drilling department will draft a paragraph to explain the strategy & back-up plans - Information should be included in the modelling and ESIA report - Considering the uncertainties of deployment, one option can be to cancel the scenario with SSDI installation	- Ask Drilling Dpt to develop a short MEMO explaining the well response strategy & share it to Elcio/SLR
3.3	1	For Luiperd-1X the upper seawater temperature used in the model was 18°C, which seems low. Please change or justify.	- According to request forms for new modelling, suitable temperature will be choosen for each quarter - Further studies will be done involving Ph. Lattes to select the most representative temperature. - Study sent right after the meeting	- Include the sea surface temperature analysis in the modelling reports
	2	A single snapshot of wind and current fields is provided. This is insufficient to confirm that the wind and currents applied in the model are realistic. Please also include wind and current roses for the modelled period (e.g. 1 or 5years) on a 1° grid of the entire model domain, with the currents provided near the surface and at two sub-surface depths.	Current: Available (Surface + 1 subsurface only available) Wind: Available Stephen agreed to use only 1 subsurface (seabed level) instead of 2	- Include the wind & current roses in the modelling reports
	3	Please provide validation of the winds and currents against measurements in the area of interest. Should this validation be done by the metocean data provider, please provide their report as an annexure to the oil spill report. Validation can include a time-series comparison, a drifter comparison, a rose comparison, a speed exceedance comparison, etc.	- Metocean specialist provided a MEMO detailling the model used by SatOcean & the comparison & calibration strategy	- Include the MEMO for metocean model calibration in the modelling reports
	4	For Luiperd-1X only one year (2012) of metocean data was modelled. This is considered too short to robustly predict the probability of shoreline oiling which requires specific sequences of currents and winds. Since the simulations are 90 days this also excludes releases after 2 October 2012.	- Metocean data over 14 months to ensure modelling up to the 31st of December	
	5	Further, the 90 trajectories per quarter will have significant overlap in time and thus cannot be considered as 90 fully independent scenarios. It is recommended to use at least five years of metocean data. Please extend the dataset or justify the use of a shorter dataset.	- Remark involving significant impact: scope x 5, modelling time impact, financial impact. - A MEMO will be drafted to explain the rational for the use of one specific year over 10 years analyzed. - Stephen agreed on the principle - The MEMO will be circulated to Stephen for any comment before being included in the reports - When discussing the results in the modelling report explain that the results could be slightly different if another year had been modelled.	- Once drafted, include the MEMO for year selection in the modelling reports

3.4	1	Table 2.8 of the Luiperd-1X report gives a surface oil thickness threshold of 0.04 µm but the probability plots (e.g. Figure 3.1) use 5 µm. Please clarify which thickness will be used in the current study and justify this value in terms of ecological impact.	- HQ clarified the limits set: 5 µm for crude oil & 0,03 for condensate µm - Threshold of 10g/m2 on shoreline. - The rational should be explained in the modelling report	- Explain the rational of the threshold in the modelling report
	2	The probability plots (e.g. Figure 3.1) would benefit from a different colour scale that makes it easier to distinguish between the 10, 20 and 30% probabilities.		- Ask HES to use different colors for 10, 20 and 30%
	3	It is not clear how there can be a 100% probability of shoreline oiling at some locations (e.g. Figure 3.4) when the surface oil probability plot shows <20% near the shoreline (e.g. Figure 3.1). Presumably this is due to different thresholds applied for the surface and shoreline oil and that these need to be checked. Please note that is it essential that realistic shoreline probability plots from the stochastic model are included in the new report and that these plots not simply be left out.		- Clarify the issues with HES & request them consistencies in the results
	4	In order to facilitate a comparison to the probabilistic results and evaluate the effectiveness of the surface and subsurface dispersants, please additionally run the deterministic model without dispersants.	- Decision taken long time back to not play any scenario without oil spill response as it is not realistic at all - Significant impact: Additional time + Additional budget - After discussion, TEPSA agreed to run extra scenario without response	- Update the request form & launch the modelling scenario without response
	5	Please provide mass balance tables and plots for the deterministic model without dispersants, with surface mitigation and with SSDI.	- Decision taken long time back to not play any scenario without oil spill response as it is not realistic at all - Significant impact: Additional time + Additional budget - After discussion, TEPSA agreed to run extra scenario without response	- Provide the mass balance for the scenario without response
	6	The mass balance plots, e.g. Figure 3.11, indicate that the plume reaches the surface within hours. Please confirm the oil droplet sizes and rise velocities predicted by the model and whether gas hydrate solids are formed.	- Redundant with item 3.1 / 2.	
	7	For the deterministic model results, please include a plot showing where the sub-surface oil threshold of 70 ppb is exceeded.	- Agreement reached to display the Total Oil Concentration in the water column in the report	- Include the Total Oil Concentration in the water column in the report

Based on the oil spill modelling methodology review, TEPSA decided to increase the oil spill simulation period from one to five years, which addressed Items 4 and 5 in Section 3.3 of Table 4-1. TEPSA's response and actions thus addressed the peer review comments on the methodology and TEPSA proceeded to undertake the oil spill modelling for the current study on this basis.

5. REVIEW OF DRAFT OIL SPILL REPORTS

TEPSA provided first and second draft reports. The peer review comments and TEPSA's responses to these comments are provided in Table 5-1. The Round 1 comments refer to the following two reports:

- 2020-09-02_Block 11B-12B OS Report_Point 1-East_Rev08_BLI.docx
- 2020-07-27_Block 11B-12B Oil Spill Report_Point 2-West_Rev02.docx.

The Round 2 comments refer to the following report:

- 2020-09-02_Block 11B-12B OS Report_Point 1-East_Rev08_BLI.docx.

Table 5-1: Peer review comments on oil spill modelling reports and TEPSA's response.

Report Section	Items	Peer Comment Round 1	TEPSA Response Round 1	Peer Comment Round 2	TEPSA Response Round 2
All	All	Grammatical and formatting issues have been noted but these are not detailed as this review is limited to technical issues.			
	All	The two reports have an identical format except for the discharge points and the associated results. These comments thus apply equally to both reports. Where the comments refer to specific numerical values, these are from the Point 1 report and TEPSA should insert the corresponding values for the Point 2 report.	Comments for point 2 report under implementation		
	All	Section 3 (Results) repeats the same format of plots and text for all 16 scenarios. Thus any review comment made here applies to the corresponding plot/text for all 16 scenarios.	Taken into account		
	All	Throughout the report the units mm and um; ppm and ppb; g/m2 and kg/m2 are used interchangeably. It would be preferable - particularly for non-technical readers - to use one unit consistently.	Modified accordingly	Table 2.7 still has 58 ppb although the values in the adjacent cell are changed to ppm. I have not checked any further whether the units have been modified throughout the report.	Modified accordingly
Identi-fication page	1	The disclaimer is in my opinion too extreme and leaves the reader wondering why this study was undertaken at all. The drilling discharge reports did not include such a disclaimer. The modellers need to take responsibility for the quality of the input data and have in fact done so, i.e. by validating the local winds and currents, by using a probabilistic approach to reflect the uncertainty in the spill timing, using most likely oil properties, etc. No-one expects the model to replicate an actual spill that may happen in the future, but there should be a high degree of confidence that it will lie within the modelled probabilities. My recommendation is to edit the disclaimer to reflect these considerations, otherwise the authorities and public can reasonably question whether this study provides any useful information.	Modified accordingly		
	2	"Model results indicate that impact to shoreline is possible". Change "possible" to "probable" (since the annual probability is 60%) and also add the seasonal probabilities of 22%, 87%, 87% and 42% from Table 4.1, and describe the regions most as risk. For Point 2 all these probabilities are higher.	Modified accordingly	Q4 should be 42% not 47% as given in the Abstract. Add a description of shoreline regions most at risk to the Abstract.	Modified accordingly
	3	Add a description of the drift distance and direction.	Drift direction already mentioned. But not clear what distance is to be mentioned, distance is already mentioned for each scenario.	Add to the Abstract an indication of the distance the surface oil is likely to travel before it drops below the threshold thickness. This is to inform on the scale of the impact, i.e. is it 10 km or 100 km or 1000 km?	Modified accordingly in the abstract and on each "B" scenario.
	4	Add a description of the maximum oil mass ashore, i.e. proposed row to be added to Table 4.1.	Row added in table 4.1	Add a summary of the mass ashore to the Abstract.	Modified accordingly

	5	The last sentence regarding the shoreline threshold applied is too detailed for an abstract and should be removed or replaced with a statement that the shoreline oiling threshold applied is considered to be conservative.	Modified accordingly		
1.3	1	Add a description of who the "affiliate" is.	Modified accordingly		
2.1.1	1	Please include the horizontal and vertical dispersion coefficients applied in the model, the wind drift factor and the Coriolis deflection angle.	Modified accordingly		
2.1.2	1	Please clarify whether the weathering is modelled in the same way in the stochastic simulations compared to the deterministic simulations	Modified accordingly		
2.2.1	1	"These oil properties have been chosen by similarity to the LUIPERD-1X study". Please provide additional justification, i.e. on what basis was the LUIPERD study oil chosen, is it based on oil found at nearby wells or in similar geology, etc.	Modified accordingly	Section 2.2.1 needs to be edited as the following two statements conflict: "In Brulpadda-1X, mainly gas with condensate with a thin oil rim were found" and "These oil properties have been chosen by similarity to Brulpadda-1X oil properties". Although it is explained that crude was modelled as a worst case, there are hundreds of different crude profiles and you need to explain why you selected the crude profile used in the model. The explanation previously given by TEPSA was "Future modelling will be based on Luiperd expected crude oil" but this in turn needs to be justified. If it is likely that the well will contain condensate, then please consider including a discussion in the conclusions on how the impacts would differ compared to crude.	Rephrased Crude oil based on the crude oil encountered at Brulpadda-1X Discussion included in Oil Profile + Appendix 4
2.2.2	1	"The release discharge rate defined for the study scenarios considers the maximum blowout rate from past studies made on the block." Please provide additional justification, i.e. on what basis was the rate from past studies determined, is this based on measured pressures, etc. during previous drilling in this area or in similar geologies?	Modified accordingly		
2.2.3	1	Appendix 2 does not include justification for 15 vessels deployed within 3 days. Please confirm that this number of suitable vessels is available in South Africa.	Appendix 2 is more about subsea response. A sentence has been added in 2.2.3		
2.2.5	1	Table 2.3: The "A" and "B" scenarios are called "No response" but the spill duration of 20 days is due to the Capping Stack being installed, otherwise the duration would be longer than 20 days. Thus either rename the "A" and "B" scenarios to "Capping only", or remove "Capping" as a response from scenarios "C" and "D" and state that Capping applies to all scenarios "A" to "D". Also explain why the spill duration is 20 days but Capping is deployed after 19 days.	"No Response" renamed to "Capping only". In oil spill modelling capping stack is deployed at the end of the 20th day (with consideration of 1 day margin compared to BOCP).		

2.3.3	1	Figure 5 and associated text: Explain why you are presenting results from the CMEMS3D model when the simulations were done with SATOCEAN. Explain why you are using the Luiperd and Blasoop locations instead of the spill location considered in this study. Indicate the spill location for this study relative to Luiperd and Kloofpadda. The text is too small - increase font and resolution, or rotate image to fill a full landscape page.	Rephrased. Removed Blasoop and Kloofpada (which is the name of discharge point). Position of Luiperd vs: discharge point is on figure 2. Comparison at Luiperd because it is a common point between the 2 studies. Figure reformatted and font increased		
	2	Figure 6 and 7 and associated text: Since you are comparing Figs 6 and 7 to Fig 5, you need to use the same current colour scales, specifically for the bottom currents. Explain why you present Kloofpadda in Fig 6 and 7 and Blasoop in Fig 5. The text is too small - increase font and resolution, or rotate image to fill a full landscape page.	Not possible to change the colour scales: 2 different reports from different contractors. Removed Blassop and Kloofpada + reformatted the figures		
	3	Add two new figures similar to Figure 6 and 7, but showing the full 5 year period 2012 - 2016 that was modelled (not 2012 only) at the actual spill location (not Luiperd and Kloofpadda). This is necessary to confirm that the model inputs are reliable.	The statistical analysis for the full 5-year dataset is not available, but using a 5-year dataset implies a good representativity of the variability of metocean conditions over time.	This request is not related to representivity, but rather to prove there are no errors in the model input data.	Quotation sent to TEPSA
	4	Add a new figure similar to Figure 9, but showing the full 5 year period 2012 - 2016 that was modelled (not 2012 only) at the actual spill location. This is necessary to confirm that the model inputs are reliable.	The statistical analysis for the full 5-year dataset is not available, but using a 5-year dataset implies a good represntativity of the variability of metocean conditions over time.	This request is not related to representivity, but rather to prove there are no errors in the model input data.	Quotation sent to TEPSA
2.4.2	1	Table 2.7: The surface oil thickness needs to be justified on ecological rather than response considerations. The Marine Ecology Specialist should be consulted.	Modified accordingly		
	2	Table 2.7: Explain how the shoreline oiling is calculated, e.g. assumed shoreline slope and associated cross-shore distance to get the square metres.	Modified accordingly		
2.5	1	Refer to the previous comment on the disclaimer. The phrase "...they do not represent what could happen in case of a real oil spill" should be changed to "...they do not represent what will happen in case of a real oil spill".	Modified accordingly		
	2	Figure 15: this is the same zoom as Figure 14.	Updated		
3.2	1	Figure 16: please add an explanation of the plot, i.e. is the main plot showing the plan view of the oil drops at all depths and the oil concentrations at the worst depth?, which plot shows the droplet diameter and which shows the thickness? What is "Thickness bonn"?	Separated Figures for a more simple reading. Bonn thickness was just thickness - legend corrected		
	2	Text above Fig 16: "with a thickness of 0.950 mm" - is this the maximum surface oil thickness at this time?	Modified accordingly		

	3	Text below Fig 16: Add a sentence that the maximum oil concentration in the water column of 460 ppb exceeds the ecological threshold of 58 ppb. This should also be mentioned in the conclusions and the Marine Ecology Specialist should indicate whether she requires any additional analysis of these concetrations, e.g. distance where value exceeds threshold.	Sentence added for all the scenarios. Complicated to give distances with values > threshold because it is deterministic case, and it changes for every time step. Possible to give just the max. distance.		
	4	Text below Fig 16: "termination depth is around 1050 m" - please define termination depth.	Termination depth is the depth where the plume stabilizes (asked by Peer-Reviewer before the study)		
	5	Text below Fig 16: change "Figure 15" to "Figure 16"	Modified accordingly		
	6	Figure 17: Confirm that the squares represent all the Lagranian particles in the model and comment on whther there are sufficient particles to simulate the slick.	It is grid cells impacted by oil - comment added on the Figure		
3.4	1	Figure 23: please include the results at days 20 and 30 in order to show the maximum oil on the surface and the impact of the SSD in reducing the oil reaching the shore. For comparison purposes it will be necessary to include these days in the other drift plots as well.	Original idea of the illustration is to show the drift of the slick until it reaches the coast(The last day presented on each map corresponds to the moment when the oil reached shoreline.). There is almost nothing at day 30 because of evaporation, stranding and dispersion.		
3.7	1	Figure 36: what is the physical explanation for the black squares clumping together?	It was a problem of resolution of the picture. Updated in the entire report.		
4	1	"Model results indicate that impact to shoreline is possible". Change "possible" to "probable" and (since the annual probability is 60%) and refer to Table 4.1	Modified accordingly		
	2	"Therefore, shoreline protection of sensitive sites and/or organization of cleanup plans shall be forestalled": change "forestalled" to "put in place".	Modified accordingly		
	3	Table 4.1: Add a row showing the maximum mass of oil ashore for each Scenario and response type.	Done.		
	4	The last sentence regarding the shoreline threshold applied is too detailed for a conclusion and should be removed or replaced with a statement that the shoreline oiling threshold applied is considered to be conservative.	Modified accordingly		
	5	Figure 86 - the legend cannot be read, please increase the image quality or show a single large legend.	Modified accordingly		

6. REVIEW OF FINAL OIL SPILL REPORTS

The final oil spill modelling reports provided for review were:

- 2020-09-16_Block 11B-12B OS Report_Point 1-East_Rev09_BLI.docx
- 2020-09-16_Block 11B-12B Oil Spill Report_Point 2-West_Rev05_BLI.docx.

These final reports adequately address all the peer review comments on the draft reports in Table 5-1, except for Items 3 and 4 in Section 2.3.3. These comments requested current and wind rose plots of the full 5-year period modelled (2012 – 2016) rather than only 2012, in order to demonstrate that there were no errors in the model input data. This is considered to be a minor issue as the roses for 2012 do not show any errors and the probabilistic oil spill trajectories for the full 5 years are as expected.

7. CONCLUSIONS

The oil spill modelling studies undertaken by TEPSA for Blocks 11B/12B have 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.

ANNEXURE A | CV FOR STEPHEN LUGER

PRDW
Consulting Port and Coastal Engineers

Curriculum Vitae
25-02-2020

STEPHEN LUGER
Technical Director

OFFICE LOCATION	Cape Town, South Africa
NATIONALITY	South African
DATE OF BIRTH	12 January 1967
SPECIALISATION	Numerical modelling of coastal hydrodynamics, waves, tsunamis, sediment transport, outfalls, water quality, dredging, oil spills and flooding
QUALIFICATIONS	Registered Professional Engineer, South Africa (1998) (Number: 980442) BSc(Eng) Civil Engineering, University of Cape Town (1988) MSc(Eng) Civil Engineering, University of Cape Town (1991)
PROFESSIONAL SOCIETIES	Member, South African Institution of Civil Engineers (1991)
LANGUAGES	English, Afrikaans

SUMMARY

Stephen Luger received an MSc in Civil Engineering from the University of Cape Town in 1991. He was then employed by the Council for Scientific and Industrial Research (CSIR) for 16 years as a coastal modelling specialist. For the past 14 years he has been employed by PRDW Consulting Port and Coastal Engineers as a coastal modelling specialist and currently holds the post of Technical Director. He has 28 years of experience in the application of numerical models in the fields of coastal hydrodynamics, waves, tsunamis, sediment transport, outfalls, water quality, dredging, oil spills, coastal flooding, climate change and underwater acoustics. These modelling studies have been conducted for feasibility studies, environmental impacts studies, nuclear safety studies and detailed engineering design. The countries where the studies have been conducted include South Africa, Namibia, Gabon, Nigeria, Kenya, Mauritius, Seychelles, Guinea, Mozambique, Madagascar, Cameroon, Angola, Egypt, Bahrain, Qatar, United Arab Emirates, Jordan, Israel, Ireland, Chile, Peru, Brazil, St Helena, Timor and Australia. He is the author or co-author of over 20 articles in scientific journals, chapters in books and conference proceedings, over 100 technical reports for external contract clients, and has presented over 20 papers at local and international conferences.

RELEVANT PROFESSIONAL EXPERIENCE

WAVES

- Spectral wave modelling for sediment transport at Big Bay, Cape Town (2018)
- Spectral wave modelling to establish design waves at Small Bay, Cape Town (2018)
- Boussinesq and refraction modelling for a new port at Chancay, Peru (2018)
- Modelling waves and run-up in evaporation dams at the Olympic Dam mine, Australia (2018)
- Boussinesq and refraction modelling for LNG berth in Saldanha, Ngqura and Richards Bay (2016)
- Refraction modelling for LPG mooring in Saldanha Bay (2015)
- Wave refraction modelling and vessel downtime assessment in Walvis Bay (2013)
- Boussinesq and refraction modelling for Port of Durban (2013)
- Boussinesq and refraction modelling for proposed port at Valparaiso, Chile (2013)
- Boussinesq and refraction modelling for proposed port at Micaune, Mozambique (2013)

- Refraction modelling for LPG berth in Saldanha Bay (2012)
- Refraction modelling at Inhambane (2011)
- Refraction modelling for Matola terminal in Maputo (2011)
- Refraction modelling for PetroSA SPM at Ngqura (2010)
- Boussinesq wave modelling for dig-out port, Durban (2010)
- Boussinesq wave modelling for Port of Ngqura (2009)
- Boussinesq wave modelling for Eden Island, Seychelles (2008)
- Wave refraction study for SBM in Algoa Bay (2008)
- Refraction and Boussinesq wave modelling for proposed Eskom Nuclear power stations (2008)
- Wave refraction study for St Helena Bay SBM (2007)
- Boussinesq wave modelling for proposed dig-out port, Durban (2007)
- Wave refraction modelling for Cape Town Container Terminal expansion (2006)
- Modelling of proposed harbour extensions in Saldanha Bay: wave resonance (1997)

HYDRODYNAMICS

- Impact of tidal pool on coastal hydrodynamics at Port St Johns, South Africa (2016)
- Impact of tidal pool on coastal hydrodynamics at Tinley Manor, South Africa (2016)
- Impact of reclamation on 3D currents at Valparaiso, Chile (2015)
- Current and wave modelling to establish design conditions in Abu Dhabi (2014)
- Cyclone modelling for proposed port at Micaune, Mozambique (2013)
- Modelling sediment, stormwater and brine plumes for Anadarko LNG plant, Mozambique (2012)
- Cyclone modelling for Matola terminal in Maputo (2011)
- Cyclone modelling for export jetty neat Inhambane, Mozambique (2011)
- Modelling cross-currents at the Port of San Antonio, Chile (2010)
- Hydrodynamic modelling of the currents in the entrance channel of San Antonio Port, Chile (2010)
- Tidal propagation in the Port of Durban (2009)
- Wave and current modelling for a proposed Eskom nuclear power station (2008-09)
- Wave, current and sediment transport modelling for Cape Town Container Terminal expansion (2006)
- Hydrodynamic modelling at Beira and Nacala for the proposed Moatize Coal Terminal (2005)
- Hydrodynamic modelling of the Victoria and Alfred Canal, Cape Town (2005)
- Hydrodynamic modelling of Northern Irish Loughs for sustainable mariculture project (2005)
- Hydrodynamic modelling of Maputo Bay for catchment to coast project (2004)
- Hydrodynamics and water quality for Bahrain Financial Harbour (2003)
- Hydrodynamic decision support system for Namdeb inshore diamond mining (2002)
- Modelling hydrodynamics and water quality in the Gabon Estuary (2001)
- Modelling of proposed harbour extensions in Saldanha Bay (1997)
- Simulation of current patterns due to geometric changes to East London breakwater (1996)

TSUNAMIS

- Modelling tsunamis at Mejillones, Chile (2010)
- Tsunami modelling for a proposed Eskom nuclear power station (2008-2009)
- Modelling tsunamis at Mejillones, Chile (2008)
- Modelling tsunamis at Bayovar, Peru (2006)

SEDIMENT TRANSPORT

- Modelling of shoreline morphology and sediment bypass at Chancay, Peru (2019)
- Modelling of 2D sediment transport at Big Bay, Cape Town (2018)
- Beach planar and cross-shore stability modelling at Jalmudah, Saudi Arabia (2018)

- Beach planar and cross-shore stability modelling at Al Sahel, Bahrain (2017)
- Beach planar stability modelling at Al Mirfa, UAE (2017)
- 2D sediment transport at the port of Punta Arenas, Chile (2017)
- 2D sediment transport at the port of San Antonio, Chile (2016)
- 2D sediment transport in Bushmans River Estuary, Kenton-on-Sea, South Africa (2016)
- 2D sediment transport for maintenance dredging requirements in entrance channel to Port of Maputo, Mozambique (2016)
- Modelling 2D sediment transport for VIP development at Swakopmund, Namibia (2015)
- Mauritius Turtle Bay Beach Restoration Study (2015)
- Modelling sedimentation for proposed southern channel in Maputo Bay, Mozambique (2014)
- Modelling waves and sediment transport at Emu Point, Australia (2013)
- Modelling 2D sediment transport in Rupert's Bay, St Helena Island (2013)
- Shoreline and 2D modelling of sediment transport for proposed port at Micaune, Mozambique (2013)
- Shoreline modelling for Pampa de Pongo jetty, Peru (2013)
- Modelling sedimentation for Bauxite Export Port in Guinea (2012)
- Modelling impact of port reclamation and dredging on stability of Table Bay coastline (2012)
- Modelling sedimentation at Barquito jetty, Chile (2011)
- Modelling fate of sediment disposed offshore for proposed Eskom nuclear power station (2011)
- Sediment transport modelling for intake basins for proposed Eskom nuclear power station (2008 - 2009)
- Sediment transport modelling for proposed a fixed sand bypass system at Richards Bay (2008)
- Morphodynamic modelling for a fixed sand bypass system at Durban (2007)
- Morphodynamic modelling for the Durban Small Craft Harbour (2006)
- Dredging impacts in Table Bay: hydrodynamics, waves, shoreline stability and dredge plumes (2003)
- Morphodynamic modelling of beach erosion at Langebaan (2003 - 2004)
- Modelling morphodynamics on Egypt’s northshore (2002)
- Modelling morphodynamics (beach protection measures) at Bar Beach, Lagos, Nigeria (2000)
- Modelling diamond distributions on West Coast for De Beers (2000)

OUTFALLS / DISPERSION

- Brine dispersion modelling in the Victoria &Alfred Waterfront, South Africa (2019)
- Dispersion of fish factory effluent for CWDP compliance at West Point Processors in St Helena Bay (2018)
- Mining effluent dispersion from an outfall at the Ambatovy mine in Madagascar (2018)
- Aquaculture, brine, thermal and sewage effluent dispersion from proposed pipeline servitude at Coega (2017)
- Dispersion modelling for proposed finfish farming in Saldanha Bay (2017)
- Thermal plume modelling for Department of Energy and Transnet’s proposed gas to power projects at Saldanha Bay, Coega and Richards Bay (2016)
- Temperature, chemical and radionuclide dispersion at Koeberg, South Africa (2015)
- Heating water dispersion from FSRU vessel in Walvis Bay (2015)
- Brine dispersion modelling at Volwaterbaai, South Africa (2014)
- Brine dispersion modelling at Cabo Delgado, Mozambique (2012)
- Brine dispersion modeling at Nacala, Mozambique (2010)
- Brine dispersion modelling for Swartkops desalination plant, Port Elizabeth (2010)

- Thermal plume modelling for a proposed Eskom nuclear power station (2008 - 2009)
- Modelling desalination brine dispersion for proposed Eskom nuclear power station (2008)
- Thermal plume modelling for Nampower power station, Walvis Bay (2008)
- Brine dispersion modeling at Cannon Rocks, South Africa (2007)
- Modelling of brine dispersion in Durban Port (2007)
- Near-field modelling for Huntsman Tioxide pipeline, Durban (2003)
- Modelling marine impacts of discharges into the Port of Ngqura for Aluminium Pechiney (2002)
- Modelling impacts of effluents and runoff from the Mozal site on the Matola River (1999)
- Design of a sewage outfall monitoring program using predictive modelling of hydrodynamics and water quality for East London (1999)
- Second Mombasa and coastal water supply, engineering and rehabilitation project: three-dimensional numerical modelling of plume from marine outfall (1997)
- South Dunes Coal Terminal EIA: specialist study on stormwater discharge into Richards Bay Harbour (1997)
- Assessment of effluent surfacing and design of diffuser for AOS and Tioxide marine pipelines (1997)
- Southern Metro Wastewater Disposal Study: modelling of marine disposal options for Durban (1997)
- Dispersion modelling for extension of the Sappi Saiccor pipeline near Durban (1997)
- Three-dimensional modelling of thermal plume in Saldanha Bay due to proposed seawater cooling system (1997)
- Southern Metro Wastewater Disposal Study: Preliminary numerical modelling of currents and dispersion of effluents (1997)
- Dispersion of zinc and fluoride in Richards Bay harbour (1996)
- Baie du Tombeau Sewerage Project, Mauritius: Numerical modelling of currents and effluents (1996)

DREDGING

- Dredge plume modelling for Matola port expansion, Mozambique (2016)
- Dredge plume modelling for oil export pipeline at Temane, Mozambique (2016)
- Modelling fate and dispersion of dredge plumes in Maputo Bay, Mozambique (2012)
- Modelling fate and dispersion of dredge plumes at Cabo Delgado, Mozambique (2012)
- Modelling fate and dispersion of excavation spoil for a proposed Eskom nuclear power station (2009)
- Modelling fate and dispersion of dredge spoil for new offshore dumpsite at Durban (2007)
- Modelling of dredge plumes at Luanda (2007)
- Dredging impacts in Table Bay: hydrodynamics, waves, shoreline stability and dredge plumes (2003)
- Modelling fate of coal dust particles in Richards Bay (2000)
- Modelling plume from proposed dredging of Berth 306 in Richards Bay (1999)
- Simulation of tailings from exploration oil drilling off Angola (1997)
- Numerical modelling of hydrodynamics and dredging-induced turbidity in Saldanha Bay (1996)

OIL SPILLS AND DRILL CUTTINGS

- Oil spill modelling for Debmarine Namibia’s Diamond Mining in Atlantic 1, Namibia (2020)
- Oil spill modelling for Anadarko’s LNG Project in Palma Bay, Mozambique (2020)
- Modelling oil spills and drill cuttings for GALP’s proposed offshore exploration well drilling in PEL82 and PEL83, Namibia (2019)
- Independent reviewer for oil spill modelling by ERM/eni offshore Durban, South Africa (2018)

- Oil spill modelling for petroSA's proposed condensate import SBM in Mossel Bay (2017)
- Oil spill modelling for Sasol's proposed oil export pipeline at Temane, Mozambique (2016)
- Oil spill modelling for Department of Energy and Transnet's proposed gas to power projects at Saldanha Bay, Coega and Richards Bay (2016)
- Oil spill modelling in Totoralillo Bay, Chile (2015)
- Modelling oil spills and drill cuttings for Murphy's proposed exploration drilling in Block 2613 off the coast of Namibia (2015)
- Modelling oil spills and drill cuttings for Cairn's proposed exploration drilling in Block 1 off the west coast of South Africa (2014)
- Modelling oil spills and drill cuttings for Thombo's proposed exploration drilling in Block 2B off the west coast of South Africa (2014)
- Modelling oil spills and drill cuttings for Shell's proposed exploration drilling in the Orange Basin deep water licence area off the west coast of South Africa (2013)
- Oil spill risk assessment for Nacala-a-Velha Port Development (2010)
- Oil spill modelling for PetroSA SPM at Ngqura (2009)
- Hydrodynamic and oil spill modelling at Temane, Mozambique (2004)

MARINAS

- Eutrophication modelling for Ayla Oasis, Jordan (2010)
- Water quality modelling for Eden Island, Seychelles (2010)
- Hydrodynamic and water quality modelling for Durban Port expansion (2007)
- Water quality modelling for Roche Noir marina, Mauritius (2007)
- Hydrodynamic and water quality modelling for Luanda Waterfront (2006)
- Hydrodynamic modelling of the Victoria and Alfred Canal, Cape Town (2005)
- Water quality modelling for marina at Al Khawr, Qatar (2004)
- Water quality modelling for Arabian Peninsula Project at Jiddah, Saudi Arabia (2004)
- Water quality modelling for marina at Aqaba, Jordan (2004)

TROPICAL CYCLONES

- Modelling tropical cyclones for pipeline stability at Ambatovy, Madagascar (2018).
- Modelling tropical cyclones for coastal protection in Mauritius (2017).
- Modelling tropical cyclones for pipeline stability at Ambatovy, Mozambique (2016-17).

COASTAL ZONE MANAGEMENT

- Assessment and design of solutions for beach erosion at Milnerton, Cape Town (2018)
- Modelling impact of climate change on beach erosion at Big Bay, Cape Town (2018)
- Beach and dune erosion assessment at Big Bay, Cape Town (2016)
- Coastal protection studies for 13 sites in in Mauritius (2017-18).
- Flood hazard assessment along the South African coastline (2011-14)
- Impact of climate change on flooding at the Salt River mouth, Cape Town (2010)
- Flood line assessment for Eskom nuclear power stations (2009)
- Assessment of climate change effects on coastal engineering design for a proposed Eskom nuclear power station (2008-18)
- Determining wave run-up levels for a proposed Eskom nuclear power station (2008-18)
- Modelling beach protection measures at Langebaan (2003-2004)
- Modelling beach protection measures at Bar Beach, Lagos, Nigeria, (2000)

DATA MANAGEMENT

- Processing, analysis and archiving of water level, wave, current, wind, seawater temperature, bathymetry, beach profile and satellite data for Nuclear Site Safety Studies (2008-18)

UNDERWATER ACOUSTICS

- Case study: sound propagation from Trailing Suction Hopper Dredger in Palma Bay, Mozambique (2016)

- Case study: sound propagation from seismic air canon offshore Swakopmund, Namibia (2016)

PUBLICATIONS

Numerical Modelling to Understand the Causes of the Beach Erosion at Big Bay, Bloubergstrand. SAICE Civil Engineering Magazine, May 2019 Issue. (co-author: Hugo, P). 2019.

Morphological modelling of the response to a shipwreck – a case study at Cape Town. 33rd Int Conf. Coastal Engineering, Santander, Spain. (co-authors: Kristensen, SE; Deigaard, R; Fredsoe, J). 2012.

Potential Impact of Climate Change on Coastal Flooding: A Case Study of the Salt River, Cape Town. In: Cartwright, A; Parnell, S; Oelofse, G and Ward, S (eds). Climate Change at the City Scale. Impacts, Mitigation and Adaptation in Cape Town. Routledge. ISBN 978-0-415-52758-3. (co-authors: Harris, R; Sutherland, C and Tadross, M). 2012.

Modelling tsunamis generated by earthquakes and submarine slumps using MIKE 21. International MIKE by DHI Conference 2010, Copenhagen. (co-author: Harris, RL). 2010.

Maputo Bay hydrodynamics. In: P.M.S Monteiro and M. Marchand (eds.) Catchment2Coast: A Systems Approach to Coupled River-Coastal Ecosystem Science and Management. Vol 2. (1) pp 28-35. Amsterdam: Deltares Selected Series. IOS Press. ISBN 978-1-60750-030-8. (co-authors: Simpson, J; Lencart, J; Monteiro, P; Harcourt-Baldwin, J and Hoguane, A). 2009.

Fate of fine sediment from dredger-based mining in a wave-dominated environment at Chameis Bay, Namibia. Journal of Coastal Research, 23(6). (co-authors: Smith, GG; Weitz, N; Soltau, C; Viljoen, A and Maartens, L). 2008.

Morphological modelling for design of a beach restoration project, Proc. 30th Int Conf Coastal Engineering, San Diego, USA. (co-authors: Prestedge, GK; McClarty, AA; Soltau, C; Schoonees, JS and Fleming, C). 2006.

Morphological modelling under an event-driven wave climate. Proc. 29th Int Conf. Coastal Engineering, Lisbon, Spain. (co-authors: Diedericks, GPJ; Smith, GG). 2004.

Minimising the impacts of reclamation dredging at Cape Town. Proc. 29th Int. Conf. Coastal Engineering, Lisbon, Spain. (co-authors: Smith, GG and Schoonees, JS). 2004.

A Decision Support System for Optimising Engineering and Operational Design of Nearshore Mining Operations Based on Numerical Simulations of Nearshore Waves, Currents and Water Levels. 8th Int. Conf. Estuarine and Coastal Modeling, Monterey, California, United States. (co-authors: Van Ballegooyen, RC; Smith, GG; van der Westhuysen, A and Patel, SR). 2003.

Solving a harbour-induced erosion problem at Bar Beach, Lagos, Nigeria. Proc. 28th Int. Conf. Coastal Engineering, Cardiff, United Kingdom. (co-authors: Van Tonder, A; Smith, G; Bartels, A and Kapp, F). (2002).

Optimising the disposal of dredge spoil using numerical modelling. Proc. 28th Int. Conf. Coastal Engineering, Cardiff, United Kingdom. (co-authors: Schoonees, JS and Theron, A). (2002).

Hydrodynamic and sediment transport modelling to address erosion problems at Bar Beach, Nigeria. Delft3D User Conference, Delft, The Netherlands. (2001).

Application of DELFT3D for optimising the disposal of dredge spoil. Delft3D User Conference, Delft, The Netherlands, 2000.

Assessment of a potential thermal discharge in a coastal embayment using a three dimensional hydrodynamic model. Proc. 5th In.t Conf. on Coastal and Port Engineering in Developing Countries, Cape Town, South Africa, Vol. 3, pp2018-2027. (co-author: van Ballegooyen, RC). 1999.

Predictive modelling of hydrodynamics and marine water quality: Three applications along the South African coastline. 3rd Int. Conf. on Environmental Problems in Coastal Regions III, pp 281-290. (co-author: van Ballegooyen, RC). 1999.

Delft3D as an integrated system for port design based on hydrodynamic, water quality, sediment transport and wave resonance considerations. Delft3D User Conference, Delft, The Netherlands. (co-author: van Ballegooyen, RC and Monteiro, P). 1999.

Predictive modelling of marine water quality. IAIA SA 98, pp 198-207. (co-authors: Monteiro, PMS; Van Ballegooyen, RC and Pretorius, PJ). 1998.

Predicting and evaluating turbidity caused by dredging in the environmentally sensitive Saldanha Bay. Proc. 26th Int Conf Coastal Engineering, Copenhagen, Denmark, pp 3561-3572. (co-authors: Schoonees, JS; Mocke, GP and Smit, F). 1998.

Results of extensive field monitoring of dolos breakwaters. Proc. 24th Int Conf Coastal Engineering, Kobe, Japan, pp1511-1525. (co-authors: Phelp, D; Holzthausen, AH). 1994.

Increased dolos strength by shape modification. Proc. 24th Int. Conf. Coastal Engineering, Kobe, Japan, pp 1388-1396. (co-authors: Phelp, DT, Van Tonder, A and Holzthausen, AH). 1994.

ACADEMIC

FEBRUARY 2012	Impact of climate change on Salt River (Cape Town) and an offshore jetty design (Mozambique). Presented at Short Course & Seminar on Coastal Engineering within Climate Change, University of Stellenbosch, February 2012.
FEBRUARY 2011	Numerical Modelling for Port Design. Presented at Short Course & Seminar on Port Engineering, University of Stellenbosch, February 2011.
OCTOBER 2010	Wave Overtopping at Seawalls and Impacts on Setback Lines. Presented at Setback Lines for Coastal Developments, University of Stellenbosch, October 2010.
FEBRUARY 2010	Numerical Modelling in the Coastal Environment. Presented at Short Course & Seminar on Coastal Engineering, University of Stellenbosch, February 2010.
FEBRUARY 2009	Numerical Modelling of Waves, Currents, Sediment Transport and Water Quality. Presented at Short Course & Seminar on Port Engineering, University of Stellenbosch, February 2009.
FEBRUARY 2008	Numerical Modelling of Waves, Currents, Sediment Transport and Water Quality. Presented at Short Course on Port and Coastal Engineering, University of Stellenbosch, February 2008.
FEBRUARY 2007	Numerical Modelling of Waves, Currents, Sediment Transport and Water Quality. Presented at Short Course on Port and Coastal Engineering, University of Stellenbosch, February 2007.

APPOINTMENTS

2010 TO PRESENT	Technical Director, PRDW, Cape Town, South Africa
2008 - 2009	Associate, Prestedge Retief Dresner Wijnberg (Pty) Ltd, Cape Town, South Africa
2006 - 2007	Engineer, Prestedge Retief Dresner Wijnberg (Pty) Ltd, Cape Town, South Africa
1990 - 2006	Engineer, Council for Scientific and Industrial Research (CSIR), Stellenbosch, South Africa