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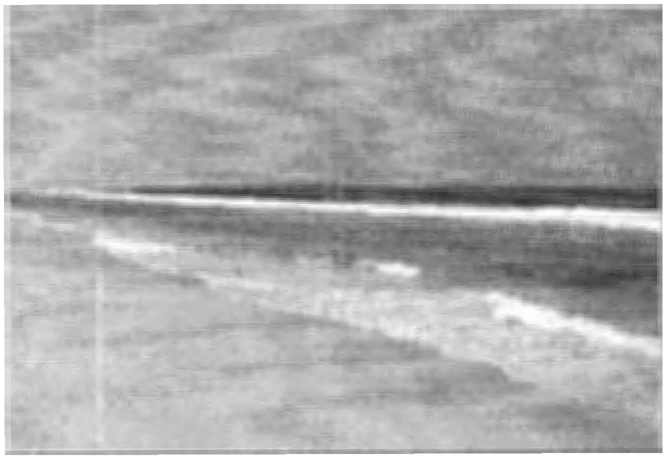

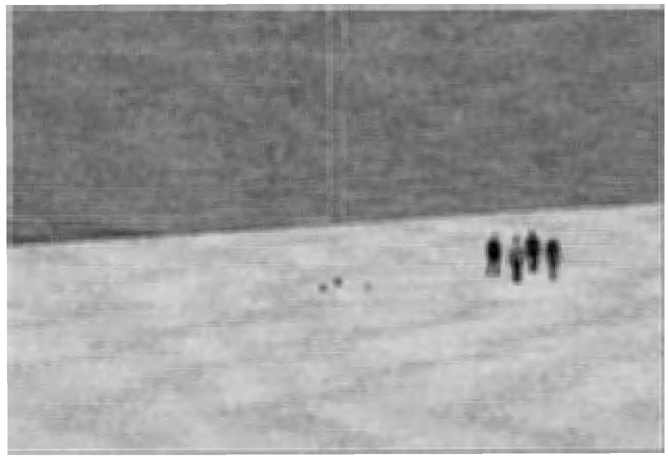

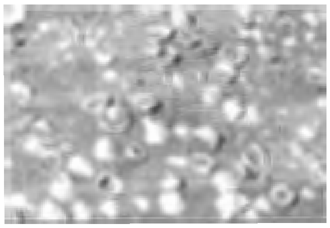

TULLOW OIL

## Appendices

# Banda Field Development - Gas Project

## Environmental Impact Assessment

May 2013

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| | |
|---|---|
| ***Date*** | Mardi 12 juin |
| ***Heure*** | 2.30 PM |
| ***Lieu*** | Ministère Délégué auprès du Premier Ministre Chargé de l'Environnement et du Développement Durable (MDEDD) |
| ***Institution rencontrée*** | Direction des Aires Protégées et du Littoral (DAPL) |
| ***Présents*** | Mohamed Lemine Ould Mohamed Moustapha (Chef de service, DAPL)<br>Moctar Ould Dadah (Cadre, DAPL)<br><br>Amadou Ba (Consultant Indépendant)<br>Mohamed Ould Mahfoudh (SCET-RIM)<br>Arnaud Uzabiaga (ERM) |
| ***Sujet*** | Sensibilités marines et côtières |
| ***Notes*** | Le Directeur des aires protégées et du littoral étant absent (en mission à Rio), la mission a eu une séance de travail avec son chef de service et un de ses collaborateurs.<br><br>La mission a présenté aux représentants de la DAPL une description du développement du champ de Banda et a précisé sa localisation par rapport aux différentes aires protégées du littoral.<br><br>Le chef de service a souhaité que le Projet prenne en compte la proximité et la sensibilité des aires protégées et a en particulier souligné la présence de conditions océanographiques (courant et vents) pouvant amener d'éventuelles pollutions au niveau de la Réserve de Biosphère Transfrontalière. Il a aussi attiré l'attention de la mission sur des populations d'alevins migrants à proximité des côtes et présentant une sensibilité majeure.<br><br>Il a ensuite précisé qu'Amadou Ba en tant qu'ancien directeur de la DAPL est en mesure de nous faire part de son expérience des sensibilités associées aux milieux marins et côtiers ainsi qu'aux différentes aires protégées mauritaniennes. |

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|---|---|
| *Date* | Mercredi 13 juin |
| *Heure* | 8.30 AM |
| *Lieu* | Résidence Iman |
| *Institution rencontrée* | Projet Biodiversité Gaz Pétrole/GIZ |
| *Présents* | Frédéric Marret (Conseiller Technique Principal, GIZ)<br>Ahmed Ould Zein (Consultant, GIZ)<br><br>Baptiste Galmiche (Tullow Oil)<br><br>Amadou Ba (Consultant Indépendant)<br>Mohamed Ould Mahfoudh (SCET-RIM)<br>Arnaud Uzabiaga (ERM) |
| *Sujet* | Gouvernance environnementale du secteur pétrolier et gazier |
| *Notes* | Le conseiller technique principal du Projet Biodiversité Gaz et Pétrole, Frédéric Marret et le consultant, Ahmed Ould Zein, ont tour à tour présenté la démarche de leur Projet en ce qui concerne la gouvernance environnementale des activités pétrolières et gazières et les vulnérabilités d'un milieu marin et côtier déjà soumis à diverses pressions (pêches, trafic, secteur pétrolier).<br><br>Ils ont présenté des activités déjà entreprises telles que la consolidation des connaissances disponibles sur les milieux marins et côtiers en Mauritanie et la mise en place d'indicateurs de pollution et d'un dispositif d'alerte.<br><br>Le Projet BGP travaille également à l'élaboration d'un atlas des vulnérabilités environnementales dont une version préliminaire devrait être disponible pour l'automne.<br><br>Ces outils contribueront à rénover le cadre de gouvernance et à renforcer les capacités des institutions intervenant sur les activités pétrolières et gazières.<br><br>Les représentants du Projet BGP ont mis l'accent sur la nécessité d'une synergie entre les différents acteurs de la gouvernance environnementale du secteur pétrolier et sur le rôle que peut jouer la société civile en termes d'échange d'information et de sensibilisation dans le cadre de la protection de l'environnement marin. Ils ont en particulier souligné un atelier de sensibilisation organisé par un programme régional sur les hydrocarbures du WWF qui s'est tenu fin mai à Nouakchott et début juin à Nouadhibou. |

| | |
|---|---|
| ***Date*** | Mercredi 13 juin |
| ***Heure*** | 1 PM |
| ***Lieu*** | Bureau de l'UICN (Nouakchott) |
| ***Institution rencontrée*** | Représentation Mauritanienne de l'UICN |
| ***Présents*** | Mohamed Lamine Ould Baba (Coordinateur national, UICN)<br><br>Amadou Ba (Consultant Indépendant)<br>Mohamed Ould Mahfoudh (SCET-RIM)<br>Arnaud Uzabiaga (ERM) |
| ***Sujet*** | Conservation et vulnérabilité des espèces et habitats marins et côtiers |
| ***Notes*** | Le coordinateur national de l'UICN, Mr Mohamed Lemine Ould Baba a rappelé que l'organisme qu'il dirige intervient essentiellement sur quatre volets principaux :<br>(i) la planification côtière<br>(ii) le Projet Biodiversité Gaz Pétrole<br>(iii) l'appui à la RBT dont la façade maritime est potentiellement impactée par le Projet<br>(iv) l' appui à la élaboration de Plans d'aménagement des pêcheries des espèces migratrices (courbine, mulet et tessargal).<br><br>Le reste de la discussion a porté sur le Projet d'élaboration d'une liste rouge des écosystèmes pour lequel un atelier va se tenir à Dakar.<br><br>L'absence d'une liste rouge nationale ou régionale pour les espèces menacées et le degré de leurs vulnérabilités a aussi fait l'objet de discussion au cours de la rencontre.<br><br>Le coordinateur a enfin transmis aux membres de la mission le rapport final du panel scientifique indépendant sur les activités pétrolières et gazières en Mauritanie. Ce document dont la lecture avait été recommandée par la DCE lors de la réunion de la soumission est un outil précieux pour la réalisation de l'EIE. |

## 2.1 OFFSHORE COMPONENT STAKEHOLDERS CONSULTATIONS

### 2.1.1 Introduction

In July 2012 a series of 18 consultation meetings was held with stakeholder groups or organisations from Nouakchott and coastal communities (including three camps South of Nouakchott and four villages North of Nouakchott). Stakeholders consulted included government authorities, cooperation programs, fishermen associations, private investors, representatives of villagers and traditional leadership.

The objectives these consultations were to share Project information, collect baseline data and understand key stakeholder concerns for the offshore component of the Project. The consultation guide presented in *Table 2.1* (in French) was used during these meetings.

*Table 2.1* ***Consultation guide (in French)***

| Partie prenante | Questions type |
|---|---|
| Direction de la Pêche Artisanale et Côtière | • Explication du but de la visite et des consultations<br>• Disponibilités de données bibliographiques<br>• Localisation des principaux foyers de pêcheurs le long du littoral<br>• Projets en prévisions<br>• Types de conflits sociaux et environnementaux préexistants<br>• Conseil sur d'autres personnes à rencontrer |
| Direction Pêche Industrielle | • Explication du but de la visite et des consultations<br>• Nombre de sociétés Mauritaniennes travaillant dans la pêche industrielle<br>• Chiffre d'affaire national / Tendance<br>• Nombre d'emplois concernés en Mauritanie / Tendance<br>• Projets en prévision pour la pêche industrielle (nationale)<br>• Problèmes actuels environnementaux et sociaux (conflits etc.) dans le secteur de la pêche industrielle<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Fédération Libre de la Pêche artisanale (FLPA) / Fédération Nationale de Pêche (FNP) | • Explication du but de la visite et des consultations<br>• Présentation de l'organisation :<br>o rôles,<br>o nombre de membres,<br>o organisation hiérarchique,<br>o statuts,<br>o historique<br>o Couverture du territoire / du secteur<br>• Projets et perspectives actuels (aménagement, organisation etc.)<br>• Quantité de produits revendus, destination et provenance<br>• Difficultés actuellement rencontrées (y compris environnementaux et sociaux, conflits etc.)<br>• Conflits actuels avec le trafic maritime et le secteur pétrolier<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Fédération des Mareyeurs Mauritaniens (FMM) | • Explication du but de la visite et des consultations<br>• Présentation de l'organisation :<br>o rôles,<br>o nombre de membres,<br>o organisation hiérarchique,<br>o statuts,<br>o historique<br>o Couverture du territoire / du secteur<br>• Quantité de produits revendus, destination et provenance |

| | |
|---|---|
| | • Difficultés actuellement rencontrées (y compris environnementaux et sociaux, conflits etc.)<br>• Conflits actuels avec le trafic maritime et le secteur pétrolier<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Chef de Port Commercial | • Explication du but de la visite et des consultations<br>• Organisation des autorités portuaires<br>• Trafic portuaire actuel : fréquence, destination, tonnage, type de navires<br>• Importance économique du port dans le pays (vs Nouhadibou)<br>• Aménagements et Projets en cours<br>• Conflits actuels avec la pêche et le secteur pétrolier<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Autorité du port de pêche / Marché de poisson (NKC) | • Explication du but de la visite et des consultations<br>• Type d'autorité (traditionnelle/étatique/associative autre)<br>• Nombre de pêcheurs utilisant le port (permanent/saisonnier)<br>• Provenance des pêcheurs (nationale et étrangère)<br>• Aménagements et Projets en cours<br>• Problèmes actuels environnementaux et sociaux (conflits etc.)<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Chef de village | • Nom du village<br>• Date de fondation<br>• Nombre d'habitants<br>• Taille moyenne des familles<br>• Occupation permanente / temporaire<br>• Nombre de famille de pêcheurs<br>• Nombre d'agropasteurs, description de leurs habitudes<br>• Occupation principale / secondaire des habitants<br>• Origine géographique/ethnique des habitants<br>• Structures présentes : autorité communale, centre de santé, école, eau potable, autres |
| Chef de pêche (niveau village – si différent de chef du village) | • Rôles de l'autorité de pêche<br>• Mode de désignation de l'autorité de pêche<br>• Lieux de pêche selon saison (direction, distance, aire)<br>• Fréquence des sorties de pêche<br>• Moyens et équipements disponible (bateaux, filets autres)<br>• Prix d'achat du matériel<br>• Prix des permis le cas échéant<br>• Techniques utilisées<br>• Type de produits péchés<br>• Quantités de produits pêchés (utiliser un calendrier saisonnier)<br>• Tendance des quantités pêchées<br>• Destination de la pêche : vente vs consommation<br>• Filières de vente : modalités, lieux, acheteurs<br>• Prix de vente y compris variations saisonnière<br>• Mode d'attribution des lieux de pêche<br>• Qui d'autre pêche dans la zone ?<br>• Conflits existants avec d'autres utilisateurs<br>• Problèmes environnementaux (climat, pollutions, maladies)<br>• Interaction avec le secteur pétrolier<br>• Interaction avec la pêche industrielle<br>• Interaction avec le trafic maritime<br>• Autres activités liées à la zone côtière ? |
| Individus (le cas échéant) | • Taille du foyer<br>• Année d'installation dans le village / Village d'origine<br>• Fréquence des sorties de pêche<br>• Revenus liés à la pêche au niveau de son foyer<br>• Autres revenus (agriculture, élevage, commerce) |

### 2.1.2 *Summary*

The key issues that were raised during the consultations are summarized in this section.

*The development of the O&G sector has a direct impact on fisheries*

- "Since the beginning of O&G Projects in 2005 populations of fishes have started to decline" (artisanal fishermen)
- "populations of cephalopods have declined in the vicinity of oil drilling wells" (Vocational Center - CASAMPAC)
- "O&G Projects generate pollutions which give bad taste to the fish" (artisanal fishermen)

*The development of the O&G sector presents a high risk of pollution*

- "Concerns about the pollution generated by chemicals used during the drilling phase" (industrial fisherman)
- "Risks linked with drilling waste and solid waste management" (NGO)
- "High risk of large oil spills" (industrial fisherman)
- "Are the emergency response adapted to all threats to the population, fish resources and biodiversity?" (NGO)

*The O&G sector is seen as an opportunity for development of communities*

- Employment opportunities (local communities)
- "Which kind of infrastructures (paved roads, water supply) can Tullow provide to the communities?" (Vocational Center - CASAMPAC)
- "Concerns about the involvement of civil society in the O&G sector" (NGO)
- "What kind of support to artisanal fishermen can be provided by Tullow?" (artisanal fishermen)

*Spatial competition with industrial fisheries*

- "Will the pipeline route be restricted for trawling?" (Industrial fishermen)

Generally the concerns of the stakeholders were more questions and assumptions based on rumors than concrete and rational issues. Therefore awareness raising and communication activities with all stakeholders could be relevant activities to be implemented.

When asking for their concern about the Project, artisanal fishermen always first raised concerns about competition with industrial fishing before concerns about O&G.

### 2.1.3 *Consultation records (in French)*

| | |
|---|---|
| ***Date*** | Jeudi 12 Juillet 2012 |
| ***Heure*** | 12h |
| ***Lieu*** | Bureau Tullow (Nouakchott) |
| ***Institution rencontrée*** | Fédération Nationale de Pêche |
| ***Présents*** | Cheikh Mohamed Cheikh, secrétaire général de la section sud<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Arnaud Uzabiaga (ERM) |
| ***Sujet*** | Consultation |
| ***Notes*** | Crée depuis environ 30 ans la FNP regroupe toutes les activités de pêche et représente le patronat et les activités associées.<br><br>Organisée en 2 secteurs : pêche artisanale et pêche industrielle (y compris congélations et usines de transformation)<br><br>La section sud (Nouakchott) ne comprend que la pêche artisanale et 2500 propriétaires de pirogues en sont membres. La section sud concerne 7000 embarcations réparties en pirogues plastique et aluminium pour la pêche au poulpe et les pirogues en bois pour la pêche au filet et à la ligne.<br><br>Il existe 4 usines de congélation d'une capacité de 150 T/j ainsi que 2 usines de farine de poisson à PK28. La demande est plus forte que l'offre et ces usines sont en surcapacité.<br><br>La FNP collabore avec la fédération sénégalaise qui a obtenu l'octroi de 300 licences (150 filets tournants) pour pêche pélagique en échange d'un débarquement de 15% à Nkc et du paiement des licences.<br><br>Le marché de poisson est une société publique gérée par l'état. Un conseil d'administration gère toutes les activités de pêche : débarquement, installations, contrôle sanitaire.<br><br>Parmi les Projets prévus, le développement du port de pêche sur le marché de poissons ainsi qu'au PK 144.<br><br>L'organisation est en conflit avec la FMM et n'a pas voulu parler de la FLPA.<br><br>La personne interrogée a déclaré que la FNP est consultée pour la première fois dans le cadre d'un Projet pétrolier ou gazier et n'a pas connaissance d'un quelconque impact lié au développement du secteur pétrolier et gazier off-shore. |

| | |
|---|---|
| *Date* | Samedi 14 Juillet 2012 |
| *Heure* | 16h |
| *Lieu* | FLPA, Port de Pêche (Nouakchott) |
| *Institution rencontrée* | Fédération Libre de la Pêche Artisanale – FLPA<br>Union des Coopératives de Pêche Artisanale (Le Moole) |
| *Présents* | Ibrahima Sarr (Président Section Sud)<br>Ibrahima Gueye (Vice-Président Le Moole) – 46 50 46 09<br>Amadou Ba (Consultant indépendant)<br>Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM) |
| *Sujet* | Consultation |
| *Notes* | Organisation fondée en 2006 par des membres de la FNP qui lui reprochent d'avoir des visées à court terme et de ne pas défendre suffisamment le métier de pêcheur. Aujourd'hui la FLPA compte 2718 membres : pêcheurs, propriétaires de pirogues, usiniers et mareyeurs (collecteurs, distributeurs et exportateurs). Elle entretient une bonne relation avec la FMM.<br><br>La FLPA est organisée en 2 sections sud (Diago – Nouhadibou) et nord (Nouhadibou – frontière marocaine) sur le modèle de la FNP et couvre l'ensemble du littoral mauritanien ainsi que la pêche continentale. Elle a des représentations à Ndiago et PK93 au sud.<br><br>La FLPA est enregistrée officiellement mais ne reçoit aucune subvention de l'Etat.<br><br>5 coopératives de pêcheurs (4 masculines et une féminine) sont regroupées en tant que UCPA – Le Moole, elle-même membre de la FLPA. Son président est Yali Ndiaye (46 41 99 88) et elle compte actuellement 178 membres. Site Web : www.lemoole.blogspot.com<br><br>Les actions récentes du Moole comprennent l'aide sociale (notamment pour pertes de matériel ou accidents – remboursement de 60% des frais), le nettoyage d'épaves échouées au port de pêche et des actions de lobbying contre l'utilisation du mono-filament. Les droits d'adhésion par pirogue sont de 5000 UM + 1000 UM/mois.<br><br>De nombreux pêcheurs refusent d'adhérer à une fédération à cause de mauvaises expériences passées mais ils utilisent la FLPA pour le renouvellement de leurs immatriculations et permis.<br><br>Pas de statistiques disponibles à leur niveau concernant les tonnages de poissons pêchés.<br><br>Les difficultés actuellement rencontrées par les pêcheurs artisanaux sont :<br>- L'utilisation – bien qu'illégale – par certains pêcheurs des filets mono-filaments qui cassent et créent des pêches fantômes et ont une incidence sur la raréfaction de la ressource halieutique (pollution)<br>- L'intrusion illégale des bateaux de pêche industrielle dans la zone réservée à la pêche artisanale et côtière<br>- L'encombrement de la plage du port de pêche par des carcasses de pirogues entraine un risque d'endommagement lors des marées hautes<br><br>La FLPA a été sensibilisée par l'ONISPA aux problèmes potentiels liés à l'activité pétrolière (empoisonnement de la ressource par les rejets, risques liés aux études sismiques) mais reste consciente que le problème principal est la pêche industrielle incontrôlée.<br><br>Autres informations sur les pratiques de pêche : |

- La pêche du poulpe est pratiquée par des capitaines mauritaniens avec du personnel malien
- De nombreux pêcheurs originaires du sud sont redescendus de Nouhadibou pour aller pêcher dans la zone de Ndiago
- La pêche artisanale ne concerne que les pirogues solitaires d'une taille inférieure à 14m. Les droits d'immatriculation sont de 10 000 UM/an
- La pêche côtière concerne les embarcations de 14 á 26 m. Les droits d'immatriculation varient de 300 000 UM à 1 000 000 UM/an
- La pêche industrielle concerne les embarcations d'une taille supérieure à 26m

| | |
|---|---|
| ***Date*** | Lundi 16 Juillet 2012 |
| ***Heure*** | 14h |
| ***Lieu*** | PK144 |
| ***Institution rencontrée*** | Abderrahman ould El Mouvid, Armateur membre de la FNP |
| ***Présents*** | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| ***Sujet*** | Consultation |
| ***Notes*** | Il est pêcheur depuis 2002, originaire de Nouakchott et membre de la FNP. |

Le camp de pêcheur est constitué de 30 baraques permanentes. Environ 15 familles vivent autour du camp.

Les saisons de pêche sont :

- Mai à octobre : pêche à la ligne de thiof, daurade, mérou, thiof noir
- Octobre à février : pêche au filet : mulet noir, mulet jaune, langouste
- Février à avril : sole longue, sole tigrée

La majorité des pêcheurs sont sénégalais. 12 employés (pêcheurs, mareyeurs) sont permanents et 80 pêcheurs sont payés à la récolte.

Il ne note pas d'incidents particuliers avec la pêche industrielle mais les quantités de poisson ont diminué entre 2007 et 2012.

Il exprime son inquiétude sur la dégradation de l'environnement avec le développement de Projets pétroliers : effets négatifs des produits utilisés lors de l'extraction du pétrole et le risque de marées noires.

| | |
|---|---|
| *Date* | Lundi 16 Juillet 2012 |
| *Heure* | 12h |
| *Lieu* | PK144 |
| *Institution rencontrée* | Aliou Ba, responsable du CASEMPAC PK144 ainsi qu'une demi douzaines de formateurs et employés du centre |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| *Sujet* | Consultation |
| *Notes* | Les centres de formation CASAMPAC sont localisés à Belawakh, Nouakchott Marché Poisson, PK28, PK 93, PK 144. |

Le centre PK144 est un pôle de développement créé pour attirer les populations de pêcheurs à s'installer. Il a été inauguré en 2009.

Le centre forme des jeunes en déperdition scolaire recrutés sur concours. La formation dure 6 mois au centre plus 3 mois en stage dans les usines de transformation (entreprises privées) et donne droit à une attestation de formation.
52 apprentis pêcheurs et 29 femmes pour la transformation (séchage, extraction d'huile) sont formés par session.

Le centre emploie environ 10 gardiens autochtones. Une école primaire de 3 classes avec un enseignant payé par l'Etat existe au PK 144.

Le PK 144 est constitué de 12 campements saisonniers sont 2 sont actuellement occupés, soit un total de 250 pirogues.
Les pêcheurs sont des sénégalais affrétés par des mauritaniens.

Les saisons de pêche sont :

- Janvier-Novembre et mai : langouste
- Sole, dorade et pélagiques en mars-mai ainsi que la courbine en (mars-juin) par la pêche aux filets dormants avec les travailleurs sénégalais
- Pêche au pot pour le poulpe de mars à juillet

Seule la pêche artisanale est pratiquée avec principalement la pêche journalière avec 4 personnes sur des pirogues de 10-12 mètres.

Les pêches sont débarquées au PK 144 et emmenées par les armateurs en véhicule sur Nouakchott.

Dans le cadre de la pêche au poulpe par 30-40 m de profondeur, ils observent une diminution tendancielle des ressources entre 2007 à 2009 (consignée dans les journaux de l'IMROP)
Il y a peu de problèmes de dézonage de la pêche industrielle.

Question : Est-ce que Tullow compte mener des actions de développement sur la localité, telles que le goudronnage de la route ou l'approvisionnement en eau ?

| | |
|---|---|
| *Date* | Lundi 16 Juillet 2012 |
| *Heure* | 10h |
| *Lieu* | Poste DSPCM PK144 |
| *Institution rencontrée* | DSPCM |
| *Présents* | 2 marins de la DSPCM de Ndiago<br><br>Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM) |
| *Sujet* | Consultation |
| *Notes* | Les marins de la DSPCM sont en charge du contrôle de l'espace maritime en relation avec les activités de pêche.<br><br>2 types de pêche sont pratiqués à PK144 :<br>- Les marées de 7 jours maximum avec des pirogues de 18m suivant l'économie de la glace<br>- La pêche journalière<br><br>Les limites d'intrusion pour les navires de pêche industrielle sont respectivement de 3 nautiques pour les crevettiers, 6 pour le poulpe et 12 pour les pélagiques.<br><br>Ils rapportent des problèmes d'intrusion sur l'espace maritimes de pêcheurs sénégalais sans licence.<br><br>Les accidents et collisions sont extrêmement rares et ils ne déplorent aucune conséquence (accident, pollution, etc.) du développement passé de champs pétroliers en off-shore. |

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|---|---|
| *Date* | Lundi 16 Juillet 2012 |
| *Heure* | 11h |
| *Lieu* | PK144 |
| *Institution rencontrée* | Mohameden ould Abdallahi. Villageois de PK144 |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| *Sujet* | Consultation |
| *Notes* | 20 familles sont installées de façon permanente autour du centre CASAMPAC de PK 144 ainsi que 20 familles saisonnières qui sont constituées en moyenne de 5 membres.<br><br>Les familles sont originaires de l'endroit (tribu Tendgha) et sont d'anciens nomades venus se sédentariser lors de la création du centre en espérant des débouchés économiques. Le chef de village est parti en nomadisme. Ils font face aujourd'hui à un manque d'eau douce et d'une école appropriée.<br><br>Elles vivent principalement de l'élevage (5 familles possèdent en moyenne 3 a 5 têtes d'ovins/caprins par familles) et de l'aide de parents émigrés en ville. Les revenus secondaires sont la fourniture de sel aux pêcheurs (troqué contre du poisson) et certains emplois de gardiens au centre CASAMPAC (payés à 45000 UM/mois).<br><br>Leur dépense quotidienne est évaluée à 2000 UM. |

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| *Date* | Lundi 16 Juillet 2012 |
| *Heure* | 16h |
| *Lieu* | PK 93 (Legweichich) |
| *Institution rencontrée* | Coopérative des pêcheurs, membre de la FLPA<br>El Hadj M'Bodj, Trésorier<br>Omar Sarr, membre notable<br>Sghair Diop, membre<br>Moussa gueye, membre et chef de village |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba ((Consultant indépendant)) |
| *Sujet* | Consultation |
| *Notes* | Il y a au moins 6 armateurs mauritaniens avec un total de plus de 100 pirogues sénégalaises au PK93. 40 capitaines de pêche dont seuls 3-4 ne sont pas membres de la FLPA.<br><br>Ils sont originaires de Ndiago, Rosso, Keidi, Bogue, Keur Massene.<br><br>75 familles de résidents permanents mauritaniens (souvent mariés à des sénégalaises) sont arrivées en 2005-2006 avec le Projet espagnol (Projet Legweichich)<br><br>Les saisons de pêche sont :<br>- Février-octobre : pêche à la ligne (daurade, Thiof, mérou)<br>- Novembre – janvier pêche au filet (daurade, sole, langouste, courbine, thon)<br><br>La pêche pratiquée est journalière avec des sorties de 10 à 26 km du littoral et 30 m de profondeur.<br><br>Les problèmes les plus fréquemment rencontrés sont :<br>- L'utilisation par des embarcations étrangères (sénégalaises) des filets monofilaments qui entraînent des dégats sur les ressources halieutiques. Ces pêcheurs sont aussi accusés de corrompre les institutions chargées de la surveillance maritime (DSPCM)<br>- Les conflits avec les agents de la DSPCM qui saisissent les embarcations et demandent des paiements<br>- Problèmes de dézonage de pêcheurs industriels<br>- Manque d'eau potable et d'électricité au PK 93, de matériel de pêche, de véhicules de transport des pêches, de boutiques, d'infrastructures de santé etc. |

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|---|---|
| *Date* | Mardi 17 Juillet 2012 |
| *Heure* | 17h |
| *Lieu* | PK 28 |
| *Institution rencontrée* | Directeur adjoint du CASAMPAC et 4 formateurs du centre |
| *Présents* | Amadou Ba (Consultant)<br>Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM) |
| *Sujet* | Consultation |
| *Notes* | 4 à 5 formateurs travaillent en permanence au centre<br>5 à 6 familles de pêcheurs sont résidents permanents et 20 à 30 pêcheurs ont immigrés depuis les années 70. Auparavant l'endroit était utilisé par les pêcheurs sénégalais seulement. La plupart sont membres de la FNP.<br><br>50 mareyeurs de la FMM de Nouakchott y travaillent en saison des poulpes.<br><br>5 armateurs sont non-résidents.<br><br>En tout il y a plus de 300 pirogues à raison de 4 à 5 pêcheurs par embarcation ainsi qu'une centaine de baraques. Il faut noter la présence d'un hôtel à PK 28.<br><br>Les saisons de pêche sont :<br>- poulpe : du 15 juillet au 15 septembre et du 1er novembre au 30 avril. (utilisation de pêcheurs sénégalais et maliens et pêche à 20/30 km et 50 brasses de profondeur) ; et<br>- pêche au filet de septembre à décembre : mulet, langouste, courbine, sole<br><br>La vente se fait à Nouakchott et aux 2 usines de moka situées à PK28.<br><br>Les problèmes sont :<br>- la diminution des ressources halieutiques, en particulier la courbine. Ils supposent que l'exploitation pétrolière en est la cause ; et<br>- les infractions commises par les pêcheurs industriels qui entre autres détruisent les filets de pêche |

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| *Date* | Mercredi 18 Juillet 2012 |
| *Heure* | 10h |
| *Lieu* | Village M'haijratt |
| *Institution rencontrée* | Abdallahi Ould Nacer Eddine , Chef de village ainsi qu'une dizaine de notables |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| *Sujet* | Consultation |
| *Notes* | |

Village de 270 ménages dont 30 sur site (rivage) et 240 ont migré vers la route nationale. Fondé il y a 200 ans d'une tribu venant de Nouakchott et du littoral (de Nouamghar à Belawakh).
Il y a une école de 4 classes et un poste de santé avec infirmière. L'eau est amenée de citerne de Nouakchott (coût 46 000 MRO)
La seule activité est la pêche. Le taux de pauvreté est de 60%.

La pêche au filet depuis le rivage a disparu depuis 15 ans.
Les pirogues à moteur ont été fournies par l'Etat à raison de une pour 12 habitants. Les pirogues sont partagées entre 2-3 familles et ont une capacité de 3-4 personnes.

Le chef de village est élu et n'a pas de prérogatives sur la pêche. Les conflits sont résolus par une assemblée communautaire.

Il y a sur site 5 à 6 campements saisonniers soit environ 700 pêcheurs mauritaniens et étrangers. Les villageois sont propriétaires de leurs pirogues mais les frais de fonctionnement (essence, filets, pots) sont fournis à crédit par des armateurs venant de Nouakchott contre 2/3 de la pêche de poulpes destinée à la vente à Nouakchott (sur un prix de vente fixé en avance par les armateurs). Ils sont pris dans une spirale de remboursement de dettes. Leurs propres prises sont vendues sur place à des mareyeurs.

Les saisons de pêche sont :
Sept-Nov : sole et mulet
Jan – Mars : courbine
Mars-Juin : requin
Juin-oct : poulpe (pêche au pot)

Zones de pêche : pêche journalière jusqu'à 1 km des côtes et marées de 10 à 13 miles nautiques. Utilisation des campements à Tiwilit.

Pour ces pêcheurs, l'exploitation du pétrole est la cause de la disparition de la courbine depuis 4 ans.

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|---|---|
| *Date* | Mercredi 18 Juillet 2012 |
| *Heure* | 12h |
| *Lieu* | Village de Tiwilit |
| *Institution rencontrée* | Beibah Ould Boilil, Chef de village ainsi que 3 notables |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba |
| *Sujet* | Consultation |
| *Notes* | |

Village de 200 ménages dont 400 pêcheurs/marins.
La pêche est la seule activité économique.
20 pirogues financées par l'état pour le village de Tiwilit
50 pirogues pour le campement permanent financées par des armateurs
Entre 30 et 40 pêcheurs dont des ouvriers saisonniers.
Chaque pirogue comprend un capitaine de Tiwilit et 4/5 ouvriers de Tiwilit ou externes

La méthode de pêche traditionnelle (à pied) a disparu depuis 20 ans avec la raréfaction des ressources. Aujourd'hui seule la pêche aux pirogues à moteur est pratiquée.

Les villageois travaillent avec des armateurs qui préfinancent les pots, le gasoil etc. Le prix du poulpe est déterminé par l'armateur au début de la campagne et le décompte est fait tous les 15 jours. Une fois le crédit remboursé un nouveau contrat est signé pour payer les employés. La vente du produit de la pêche se fait par la route à destination de Nouakchott.

Les saisons de pêche sont :

- Oct-Dec : mulet
- Jan-Mai : courbine (arrêt biologique de 2 mois)
- Juil- Sept. : pêche par les saisonniers extérieurs

Zones de pêche :

- Mulet : 500 m du rivage
- Courbine : 4 miles nautiques (filets dormants)
- Poulpe : 15 miles nautiques (sortie journalière)

Problèmes : conflits avec les pêcheurs sénégalais qui pratiquent la pêche à la palangre pour des armateurs mauritaniens. Une plainte a été déposée auprès du ministère via la FNP section artisanale.

Question :

- Quelles sont les possibilités de Tullow d'aider les pêcheurs ?

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|---|---|
| *Date* | Mercredi 18 Juillet 2012 |
| *Heure* | 14h |
| *Lieu* | Village de Lemcid |
| *Institution rencontrée* | Brahim Ould Zeindane, Chef de village adjoint |
| *Présents* | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mahfoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| *Sujet* | Consultation |
| *Notes* | Village de 100 ménages permanents avec 15 pirogues. Tous sont pêcheurs.<br>6 campements à côté du village dont 3 permanents (environ 400/500 personnes) et 3 nouveaux.<br><br>La pêche est l'activité économique principale. D'autres activités sont le petit commerce et le séchage de poisson par les femmes.<br><br>5 armateurs travaillent avec le village pour le poulpe et le poisson, le reste du campement est une entreprise privée. Tous les produits de pêche sont vendus aux armateurs qui se chargent du transport.<br><br>Les saisons de pêche :<br>- Oct-Dec : mulet<br>- Jan-Mai : courbine<br>- Juin-Sept : poulpe<br><br>Problèmes :<br>- Pêche industrielle qui a détruit les filets (chalut)<br>- Conflits avec les pêcheurs migrants illégaux (plainte portée auprès des services de l'Etat et de la FNP)<br>- Fuites de gasoil observées sur les bateaux de pêche industrielle ainsi que des fûts d'huiles usagées flottants dans la mer<br>- Accès à l'eau (prix de la citerne : 36 000UM / 12m³) et à l'électricité. Moyens de transport.<br><br>Question :<br>- Quel est l'impact du développement du secteur pétrolier ? |

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|---|---|
| ***Date*** | Mercredi 18 Juillet 2012 |
| ***Heure*** | 15h |
| ***Lieu*** | Village de Belawakh |
| ***Institution rencontrée*** | Saleck Ould Maatalla . Chef de village et 9 notables |
| ***Présents*** | Arnaud Uzabiaga (ERM)<br>Sebastien Cognet (ERM)<br>Mohamed Mafoud (SCET RIM)<br>Amadou Ba (Consultant indépendant) |
| ***Sujet*** | Consultation |
| ***Notes*** | Villages de 321 ménages sont une bonne partie vivent à Nouakchott durant la période scolaire. Le second adjoint du maire de Nouamghar réside à Belawakh.<br>Le village compte une école, un centre de santé avec sage-femme. Le CASAMPAC est aussi présent à Belawakh.<br>Les activités économiques sont la pêche, le petit commerce et l'élevage de petits ruminants.<br>L'eau est apportée par citerne (30 000UM/12 m³) et un projet de dessalinisation a été stoppé.<br><br>Il y a 20 campements dont certains non permanents soit environ 1500 ouvriers (mauritaniens, maliens, sénégalais) ou 300 pirogues.<br>Le village possède une quinzaine de pirogues.<br><br>Saisons de pêche :<br>- Oct-Fev. : mulet<br>- Jan-Fev. : sole, banda (Filet à dos, filet dormant)<br>- Mai-Aout : poulpe<br>- Sept.-Oct. arrêt biologique<br><br>La vente se fait à des mareyeurs et le transport est fait par les armateurs.<br><br>Problèmes :<br>- réduction du nombre de courbines depuis 2007 (la courbine est sensible au bruit)<br>- incompatibilité pêche et secteur pétrolier ; et<br>- les filets à 7 miles nautiques sont endommagés par les pêcheurs industriels.<br><br>Question :<br>- Quelles sont les possibilités d'appui au développement communautaire par Tullow ? |

## 2.2 *ONSHORE COMPONENT STAKEHOLDERS CONSULTATIONS*

### 2.2.1 *Introduction*

Between November 2012 and February 2013 a series of 8 consultation meetings was held with stakeholder groups or organisations from Nouakchott. Stakeholders consulted included government authorities, representatives of the main project currently developed in the vicinity of the Project area and residents.

The objectives these consultations were to share Project information, collect baseline data and understand key stakeholder concerns for the onshore component of the Project. The consultation guide presented in *Table 2.2* (in French) was used during these meetings.

*Table 2.2* ***Consultation guide (in French)***

| Partie prenante | Questions type |
|---|---|
| Direction des Infrastructures de Transports | • Explication du but de la visite et des consultations<br>• Croisement de la route de Nouadhibou<br>• Conseil sur d'autres personnes à rencontrer<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Nouvel aéroport international de Nouakchott | • Explication du but de la visite et des consultations<br>• Calendrier de construction de l'aéroport<br>• Emplacement et servitudes de l'aéroport<br>• Conseil sur d'autres personnes à rencontrer<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Programme Spécial de la Protection de la Ville de Nouakchott (PSPVN) – Ceinture verte | • Explication du but de la visite et des consultations<br>• Emplacement de la ceinture verte<br>• Impacts attendus, proposition de mesures, inquiétudes<br>• Conflits actuels avec les autres usagers de la zone |
| Projet de la Nouvelle Université de Nouakchott | • Explication du but de la visite et des consultations<br>• Calendrier de construction de l'université<br>• Emplacement de l'université<br>• Capacité de l'université<br>• Conseil sur d'autres personnes à rencontrer<br>• Impacts attendus, proposition de mesures, inquiétudes |
| Propriétaires de campings | • Explication du but de la visite et des consultations<br>• Capacité des campings<br>• Impacts attendus, proposition de mesures, inquiétudes<br>• Conflits actuels avec les autres usagers de la zone |
| Résidents | • Explication du but de la visite et des consultations<br>• Nombre d'habitants<br>• Taille moyenne des familles<br>• Occupation permanente / temporaire<br>• Nombre d'agropasteurs, description de leurs habitudes<br>• Occupation principale / secondaire des habitants<br>• Structures présentes<br>• Impacts attendus, proposition de mesures, inquiétudes<br>• Conflits actuels avec les autres usagers de la zone |

### 2.2.2 *Summary*

The key issues that were raised during the consultations are summarized in this section.

*Plant location*

- "The site selected is too close to the city and sensitive spots such as the new university and the new airport" (several authorities and residents)
- "Studies need to assess the risks caused by the plant for local communities" (University project coordinator)
- "If the impacts (noise, smell) are managed the plant location is ok" (Camping owners)

*Development opportunity for of communities*

- "The Project can create employment opportunities" (resident)

- "The Project can improve access to electricity" (resident, camping owner, authorities)

### 2.2.3 *Consultation records (in French)*

| | |
|---|---|
| *Date* | Mardi 06 novembre 2012 |
| *Heure* | 12h30 |
| *Lieu* | Ministère de l'Equipement et des Transports (Nouakchott) |
| *Institution rencontrée* | Direction des Infrastructures de Transports (DIT) |
| *Présents* | Mohamed Mahmoud Ould Yahya (Coordinateur de projets) 22 06 26 01<br>Moustapha Ould Taleb (Consultant indépendant)<br>Arnaud Uzabiaga (ERM)<br>Abba Ould Mamoune (Tullow) |
| *Sujet* | Consultation au sujet du Projet gazier de Banda |
| *Notes* | Mohamed Mahmoud Ould Yahya est un ingénieur chargé de la coordination des projets d'infrastructure routière de grande envergure : construction des routes nationales (exemple Atar – Tidjikaja) et du périphérique au niveau de Nouakchott. Ce dernier projet (dont l'étude d'Avant-Projet Détaillé vient d'être terminée) comporte un volet en intersection avec la route Nouakchott-Nouadhibou au niveau du point kilométrique 12 au voisinage de la zone prévue pour l'installation de traitement du gaz.<br><br>Recommandations :<br><br>Il recommande au Projet de préciser le mode opératoire qu'il utilisera dans le cadre de la traversée de la route par la conduite de gaz. Ce plan d'intention (schéma d'intervention et remise en état prévue) doit être joint dans la lettre adressée par l'entreprise au Ministère.<br><br>Il recommande à l'équipe de l'EIE de se rapprocher d'un responsable du projet de périphérique pour recueillir ces recommandations et préoccupations au sujet du Projet. (*Note : cette personne étant absente ce jour-là l'équipe de l'EIE retournera au Ministère de l'Equipement et des Transports pour la rencontrer).* |

| | |
|---|---|
| *Date* | Mardi 06 novembre 2012 |
| *Heure* | 13h |
| *Lieu* | Ministère de l'Equipement et des Transports (Nouakchott) |
| *Institution rencontrée* | Direction des Infrastructures de Transports (DIT) |
| *Présents* | Mohamed Ould Souleymane (Service des ports et voies navigables) 22 04 6696 / 46779944<br><br>Arnaud Uzabiaga (ERM)<br>Abba Ould Mamoun (Tullow)<br>Moustapha Ould Taleb (Consultant indépendant) |
| *Sujet* | Consultation au sujet du Projet gazier de Banda |
| *Notes* | Mohamed Ould Souleymane a été désigné par le ministère comme point focal pour les consultations liées à l'EIE du Projet gazier de Banda. Il invite l'équipe de l'EIE à lui adresser toute liste de questions. Il tâchera d'y répondre ou d'orienter vers les interlocuteurs appropriés. Mohamed Ould Souleymane est joignable au 22046696 / 46779944.<br><br>Au sujet du Projet, sa principale préoccupation en tant que représentant de la DIT concerne la traversée de la route Nouakchott/Nouadhibou par la conduite.<br><br><u>Recommandations :</u><br>Il faut prévoir d'enfouir la conduite à une profondeur suffisante de préférence sous le terrain naturel. La concertation avec la DIT peut être utile à ce sujet. La profondeur est aussi importante pour la viabilité du Projet car les vibrations des gros engins peuvent endommager la conduite. La profondeur dépend de l'endroit (déblai/remblai) et dans la zone du Projet il y a parfois peu de marge (la nappe est parfois à moins de 20 cm et il est important d'empêcher les remontées d'eau saline).<br><br>Il faut prévoir de construire un moyen de visiter la conduite sous la route (buse) pour faciliter d'éventuelles réparations sans perturber la route.<br><br>Tullow doit prendre en charge et anticiper le budget pour la déviation de la route pendant les travaux et sa remise en état.<br><br>Le ministère de tutelle (Pétrole) doit inviter un représentant de la DIT à la consultation publique du Projet.<br><br><u>Préoccupation personnelle</u> : L'emplacement prévu pour l'installation de traitement du gaz pose problème. Le site est très proche de la ville et notamment de points sensibles comme l'université et l'aéroport. Il devrait en être éloigné d'au moins 40 Km. |

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|---|---|
| ***Date*** | Jeudi 08 novembre 2012 |
| ***Heure*** | 12h 30 |
| ***Lieu*** | Nouakchott, Ministère de l'Equipement et des Transports |
| ***Institution rencontrée*** | Cellule d'exécution du nouvel aéroport de Nouakchott (NAIN) |
| ***Présents*** | Dr. Kebir Ould Sellamy (Coordinateur du projet)<br>Arnaud Uzabiaga (ERM)<br>Moustapha Ould Taleb (Consultant indépendant) |
| ***Sujet*** | Consultation au sujet du Projet gazier de Banda |
| ***Notes*** | La construction du nouvel aéroport de NKC devrait être terminée pour le premier trimestre 2014, avant le début des travaux du Projet gazier de Banda.<br><br>Une fois le design du Projet Gazier de Banda communiqué, plusieurs points détermineront l'avis du coordinateur sur l'impact environnemental du Projet et sur son voisinage avec l'aéroport (l'emplacement exact de la future installation de traitement du gaz et sa superficie; la distance entre le pipeline et la mer et la profondeur du pipeline).<br><br>Pour le moment, et en référence à la carte révisée de l'aéroport, les installations prévues par le Projet gazier seront situées dans la zone d'influence de l'aéroport et non dans sa zone de sécurité.<br><br>Le coordinateur recommande la lecture du décret n°038 en date du 23 mars 2006 au sujet du nouvel aéroport de NKC ainsi que l'Etude d'Impact Environnemental du projet de construction du nouvel aéroport de NKC qui est disponible à la moughataa de Tevragh Zeina *(Note : suite à cet entretien l'équipe d'EIE s'est rendue à la moughataa de Tevragh Zeina. Le rapport d'EIE du nouvel aéroport est en fait uniquement disponible auprès du hakem adjoint de Tevragh Zeina qui était absent ce jour-là. L'équipe de l'EIE y retournera pour consulter le rapport et en obtenir une copie si possible)* |

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|---|---|
| *Date* | Jeudi 17 janvier 2013 |
| *Heure* | 13h 30 |
| *Lieu* | Ministère chargé de l'Environnement et du Développement Durable, (Nouakchott) |
| *Institution rencontrée* | Programme Spécial de la Protection de la Ville de Nouakchott (PSPVN) – Ceinture verte |
| *Présents* | Cheikna Ould Mohamed Salem (Coordinateur)<br>22369504<br>Arnaud Uzabiaga (ERM)<br>Moustapha Ould Taleb (Consultant indépendant) |
| *Sujet* | Consultation au sujet du Projet gazier de Banda |
| *Notes* | Le Programme Spécial de la Protection de la Ville de Nouakchott - financé à 100% sur le budget de l'Etat- date de 2010 et consiste principalement en une ceinture verte autour de Nouakchott. Le coordinateur a reçu une lettre du ministère du pétrole et de l'énergie l'informant de la future installation d'une usine de gaz sur une partie de la zone de la ceinture au niveau du bloc 2 implanté en 2010 au nord de Nouakchott. C'est empiétement nécessiterait selon le coordinateur l'actualisation des limites de la ceinture verte en concertation avec le ministère de l'urbanisme.<br><br>Cette situation accentue le besoin de collaboration entre le porteur du projet d'usine et le PSPVN. La concertation devrait concerner toutes les parties prenantes dont la société d'électricité (SPEG). Sur un niveau spécifique, par exemple, les frais de déplacement de la clôture de la ceinture devraient être pris en charge par l'usine.<br><br>Les impacts de la construction d'une usine sont donc déjà perceptibles sur la ceinture verte au niveau de la modification de ces limites. En plus de ce point, le coordinateur s'interroge sur l'environnement végétal de l'usine elle-même et comment il sera préservé. Selon lui, l'usine pourrait bénéficier de l'effet de protection de la ceinture. .<br><br>Enfin, ce projet d'usine de traitement du gaz lui semble complémentaire avec la ceinture verte dans la mesure où en favorisant l'utilisation domestique du gaz il contribuera à diminuer la pression sur les ressources en bois ce qui pourrait contribuer à la protection des ressources naturelles du pays..<br>Le coordinateur a précisé que l'accès à la ceinture verte est interdit pendant les deux à trois premières années afin de permettre aux plans de devenir adultes. La ceinture devra ensuite être protégée des animaux. Afin de contenter les éleveurs, des couloirs de passage ont été prévus. Il est important de noter que la zone est une zone périurbaine et non une zone pastorale. |

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|---|---|
| ***Date*** | Jeudi 17 janvier 2013 |
| ***Heure*** | 9h 30 |
| ***Lieu*** | Ministère de l'Education Nationale, (Nouakchott) |
| ***Institution rencontrée*** | Direction des projets de l'Education (DPE) |
| ***Présents*** | Mohamed Vall Ould Dickeh (Chef de projet )<br>22369504<br>Arnaud Uzabiaga (ERM)<br>Moustapha Ould Taleb (Consultant indépendant) |
| ***Sujet*** | Consultation au sujet du Projet gazier de Banda |
| ***Notes*** | Le site du campus de la nouvelle université est situé à 8 km du centre ville. Sa superficie est de 900 ha et est prévue pour accueillir 20.000 personnes. Il comprendra quatre facultés : Médecine, Sciences et Techniques, Lettres et Sciences Humaines et Economie. Son ouverture est planifiée pour la prochaine rentrée en septembre 2013.<br><br>Notre interlocuteur n'était pas au courant du projet d'usine de traitement du gaz. Après une brève présentation du Projet sa réaction a été de savoir si des études de danger seraient réalisées pour ce projet. Nous lui avons confirmé que le porteur de projet réalisait bien une étude de danger. Nous l'avons aussi informé que dans le cadre de l'étude d'impact environnemental des modélisations de bruit et de qualité de l'air étaient réalisés. . |

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|---|---|
| ***Date*** | Lundi 11 Février 2013 |
| ***Heure*** | 17h 30 |
| ***Lieu*** | Nouakchott, Camping- Restaurant Océanides |
| ***Institution rencontrée*** | Camping- Restaurant Océanides |
| ***Présents*** | Lalla Mint Choumad (propriétaire de la structure)<br>Moustapha Ould Taleb (Consultant indépendant) |
| ***Sujet*** | Consultation au sujet du Projet gazier de Banda |
| ***Notes*** | Le camping Océanides (titulaire d'une autorisation du ministère du tourisme) existe depuis 2009 et a été financé par des fonds propres. Il est situé au bord de la mer (PK 13 du carrefour Sabah) et est constitué des installations suivantes :<br>- une salle de restauration ;<br>- huit tentes ;<br>- 3 bungalows.<br><br>La structure touristique dispose de l'électricité (éolienne et solaire) et accueille environ 100-300 personnes par semaine dont environ 80% durant le weekend. Elle emploie à temps partiel 6 employés. La majorité des clients est constituée de Nouakchotois, en particulier des expatriés.<br><br>Mme Lalla est favorable au projet d'usine de traitement du gaz du fait qu'il présente à ses yeux un intérêt général. Outre cet aspect, notre interlocutrice pense que son emplacement est pertinent par rapport à son camping et pourra susciter un peuplement des environs de la côte s'il créera des emplois. |

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| *Date* | Lundi 16 Février 2013 |
| *Heure* | 17h 30 |
| *Lieu* | Nouakchott, Camping- Restaurant les Sultanes |
| *Institution rencontrée* | Camping- Restaurant les Sultanes |
| *Présents* | Nicolas Bovet (propriétaire de la structure)<br>Moustapha Ould Taleb (Consultant indépendant) |
| *Sujet* | Consultation au sujet du Projet gazier de Banda |
| *Notes* | Le camping Les Sultanes (titulaire d'une autorisation du ministère du tourisme) existe depuis 2005 et a été financé par des fonds propres. Il est situé au bord de la mer (en face du PK 13) et est constitué des installations suivantes :<br>- une salle de restauration ;<br>- six tentes ; et<br>- 4 latrines.<br><br>La structure touristique dispose de l'électricité (solaire) et accueille environ 60 personnes durant le weekend. Elle emploie à temps partiel 4 employés.<br><br>M. Bovet n'était pas au courant du projet gazier. Il est favorable à celui ci si les conditions de sécurité seront remplies et s'il n y aura pas de nuisance sonore ou d'odeur très marquants. L'usine peut présenter à ses yeux un intérêt général si elle participe dans la fourniture du service énergétique au littoral qui en a grandement besoin selon lui. C'est aussi une bonne ressource pour le pays.<br><br>M. Bovet pense que le littoral est de plus en plus fréquenté y compris par des gens qui s'y installent (développement des cabanons).<br><br>A son niveau, en plus de certains ajustements pour répondre à la demande de plus en plus importante, il envisage d'ailleurs de se lancer dans l'organisation d'activités nautiques dés que les formalités d'assurances seraient terminées. |

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| ***Date*** | Jeudi 17 Février 2013 |
| ***Heure*** | 11h 30 |
| ***Lieu*** | Nouakchott, Ksar |
| ***Personne rencontrée*** | Cheikh Ould Lemrabott (résident dans la zone du projet) |
| ***Présents*** | Arnaud Uzabiaga (ERM)<br>Moustapha Ould Taleb (Consultant indépendant) |
| ***Sujet*** | Consultation au sujet du Projet gazier de Banda |
| ***Notes*** | Notre interlocuteur réside depuis plus de 10 ans au niveau du PK13 de la route NKC-NDB. Il y tient une place de vente de lait de chamelle (issue de son propre troupeau) ainsi qu'un poulailler.<br><br>M. Lemrabott pense que l'emplacement de l'usine prévue est inadéquat du fait de la présence humaine dans la zone. Selon lui, cela ne peut que perturber le cadre de vie des populations: dégradation de la végétation, les mauvaises odeurs, la perturbation du parcours pastoral etc.<br><br>Il pense que ce genre d'usine devrait être situé à 20-30 km des habitations. Etant un ancien émigré aux Emirats Arabes Unis, il donne comme bon exemple de position géographique une usine de traitement du gaz à Abu Dhabi, située à 11Km de la ville.<br><br>La sensibilité de cette zone tient aussi selon notre interlocuteur au fait que c'est passage international avec des infrastructures comme le nouvel aéroport de Nouakchott, la route NDB qui permet l'accès au Maroc et à l'Europe.<br><br>Hormis ces remarques relatives à l'emplacement, Cheikh salue ce projet comme une action de développement qui peut créer des emplois et faciliter la vie des ménages à travers la disponibilité d'électricité. |

## 2.3 *PUBLIC CONSULTATION*

Upon validation of the Terms of Reference by the DCE, a public consultation meeting was held on 20 March 2013 at Hotel Sabah in Nouakchott as required by Article 17 of the Mauritanian EIA Decree (*Decree n°2004-094 amended and supplemented by Decree n°2007 – 105*).

Nearly 60 sixty representatives of ministries, local governments, fishermen unions and local Non-Governmental Organisations attended this meeting.

### 2.3.1 *Public consultation report (in French)*

Dans le cadre de l'étude d'impact environnemental (EIE) du projet gazier de Banda, une journée de consultation publique a été organisée par la direction du contrôle environnemental (DCE), Tullow Oil Mauritanie et le bureau d'études ERM, à l'hôtel Sabah à Nouakchott, le 20 mars 2013.

Ont assisté à cette journée de consultation publique, plus de soixante personnes dont des représentants de la DCE, de la direction des aires protégées et du littoral (DAPL) et de la direction des hydrocarbures bruts (DHB), les autorités administratives et communales de Tevragh Zeina, un représentant du l'institut mauritanien de recherches océanographiques et des pêches (IMROP), un représentant du ministère de l'équipement et des transports, des représentants de Kinross-Tasiast et des organisations non gouvernementales (ONG) locales opérant dans le domaine de l'environnement (cf liste des participants).

Dans son discours d'ouverture, l'Adjointe du Hakem de Tevragh Zeina a souhaité la bienvenue aux participants et a insisté sur l'importance de l'équilibre entre le respect de l'environnement et les bénéfices économiques attendus des projets d'extraction des ressources naturelles. Elle a mis en exergue les espoirs portés sur le projet gazier de Banda par l'Etat. Elle a ensuite déclaré ouverts les travaux de la journée de consultation publique.

Les représentants de la DCE ont introduit les travaux par une caractérisation globale du Projet d'un point de vue environnemental. Selon eux la journée de consultation publique est importante dans la mesure où elle permet de recueillir l'avis de la population sur l'exploitation des ressources en gaz dans le pays. Le représentant de la DHB est ensuite intervenu pour expliquer que l'Etat s'intéresse aux ressources naturelles y compris maritimes. Il a rappelé que l'Etat assure un contrôle sur les projets en cours et un suivi des mesures prises pour la protection de l'environnement.

M.Ahmed Sidi Mohamed (Adda), cadre à Tullow Mauritanie et modérateur de la journée a remercié les autorités administratives, les représentants des ministères et l'ensemble des participants. Il a précisé que le projet de centrale électrique de la SOMELEC qui exploitera le gaz qui sera produit par le projet gazier de Banda ne fait pas partie de l'EIE en question. Il a ensuite passé la parole au bureau d'études ERM.

La présentation d'ERM a comporté les points suivants :

- une présentation des intervenants (dont David Wright, chef du projet Banda pour Tullow et Baptiste Galmiche conseiller environnement de Tullow);
- la localisation du Projet ;
- la description du Projet ;
- le contexte réglementaire ;
- les sources d'impacts considérées dans l'EIE;
- les milieux récepteurs considérés dans l'EIE ;
- la méthodologie d'évaluation des impacts ;
- les principales sources d'information utilisées dans l'EIE ;
- les études approfondies réalisées dans le cadre de l'EIE ;
- le planning prévisionnel du Projet ; et
- les modalités de participation du public à cette EIE.

Au cours de la présentation, une traduction en hassaniya a été assurée par Moustapha Ould Taleb (consultant indépendant) pour permettre une meilleure compréhension et participation de tous les présents.

A la fin de la présentation par ERM, le débat a été ouvert en demandant aux participants de faire part de toutes leurs questions, suggestions ou commentaires au sujet de l'EIE du Projet gazier de Banda

La liste des interventions ayant eu lieu au cours du débat est présentée dans le tableau ci-après. Les différents sujets abordés ont été les suivants :

- la localisation du Projet en particulier sa composante terrestre ;
- la durée de vie du Projet ;
- les zones de protection induites par le Projet et leurs emprises ;
- les attentes de la société civile ;

- le design de l'usine et les spécifications techniques des pipelines ;
- les effets du Projet sur la ressource halieutique et la biodiversité ;
- le plan de gestion environnementale prévu pour le Projet ;
- le monitoring du projet et le dispositif prévu à cet effet ;
- les retours d'expériences similaires à ce Projet dans le monde ; et
- la méthodologie de l'EIE.

Les représentants de la DCE, de la DHB, de Tullow Oil et d'ERM, ont apporté des éléments de réponse aux questions, suggestions et commentaires émis au cours du débat.

A la clôture de la journée de consultation publique, Tullow Oil et ERM ont répété être disponibles pour recevoir tout commentaire de la société civile pendant la durée de l'étude.

Conformément au Décret n°2007–105 du 13 avril 2007, un registre a été mis à la disposition des participants au cours de cette journée de consultation publique pour qu'ils y consignent leurs appréciations, observations et suggestions par rapport au Projet.

Après la clôture de l'atelier de consultation publique vers 15 h 30, les participants ont été conviés à un déjeuner offert par Tullow Oil

*Tableau 1 - Questions et commentaires formulés lors de l'atelier de consultation publique du 20 mars 2013 (Traduits en français par M.O.Taleb)*

| N° | Prénom et Nom | Statut/localité | Questions/ Commentaires | Réponse |
|---|---|---|---|---|
| 1 | Ahmed O Soueidi | Journaliste membre du cyber forum des ONG /NKC | Est-ce que la zone d'exclusion autour du pipeline serait temporaire et limitée à la phase de construction de celui-ci ? | Tullow : Le pipeline doit être protégé de manière durable. A cet effet les constructions permanentes seront interdites pendant la durée de vie du Projet (20 ans) sur 60 m de part et d'autre du pipeline. |
| 2 | Marieme Mint Sidi Mohamed | Présidente ONG ANPE | Je remercie Tullow et ERM pour cette importante initiative. Je fais partie d'un groupe d'activistes dans le domaine de l'environnement qui a bénéficié d'une courte formation sur la prévention de la pollution en Allemagne. A ce titre, nous souhaitons être intégrés dans les activités du projet.<br><br>Quels sont les impacts du projet en termes de pollution ? | ERM : Des modélisations d'émissions atmosphériques ont été réalisées dans le cadre de l'EIE. Elles permettent de comparer les niveaux de concentration attendus pour certains polluants aux standards internationaux.<br><br>Les résultats préliminaires de ces modélisations montrent des contributions du Projet bien inférieures aux standards de la Société Financière Internationale (SFI – Groupe Banque Mondiale). |
| 3 | Cheikh Bouchraya O Abdallah | Président ONG El Emel Jed | Je demande que la société civile soit impliquée dans ce Projet pour la collecte d'informations et le contact avec les populations. Au moins 5 à 6 ONGs doivent être associées à ce processus.<br>Mon constat est que la société civile est marginalisée dans ce processus car sa position réelle est devrait être d'être traitée au même titre que le hakem par exemple. En effet, c'est une institution comme les autres.<br><br>J'avais demandé aussi par le passé qu'on nous envoie par internet les documents relatifs à chaque réunion mais ce souhait n'a jamais été réalisé. | MDEDD : Le code de l'environnement organise le processus d'EIE et donne à chaque partie les prérogatives qui sont les siennes. Ainsi, la place que vous réclamez pour la société civile ne correspond pas à celle qui lui est prévue par les lois relatives à ce domaine.<br><br>ERM : Nous pouvons envoyer les supports de cette présentation à ceux/celles qui le souhaitent si on dispose de leurs contacts électroniques. vous pouvez ainsi l'indiquer sur la liste de présence. |
| 4 | Mouna Mint Siyam | Présidente ONG ANPFEE | Je voudrais avoir des informations sur le bureau d'études ERM. Est-ce qu'il a un site internet ?<br><br>Quelles sont les procédures de mise en place d'une zone d'exclusion ? | ERM : Oui, ERM a un site : www.erm.com<br>Cependant ne vous attendez pas à y trouver des informations sur le projet gazier de Banda. Ce n'est pas la vocation de ce site qui présente les services de notre société.<br>La société Tullow Oil a aussi un site internet. http://www.tullowoil.com/<br>Le Projet Gazier de Banda n'a pas de site internet propre.<br><br>Tullow : La zone d'exclusion vise à protéger le pipeline et les autres usagers de la zone. Le pipeline sera enterré à environ 1.5m. de profondeur. Il sera donc invisible mais un marquage permettra de repérer sa présence au niveau du sol.<br><br>Les constructions permanentes seront interdites pendant la durée de vie |

| N° | Prénom et Nom | Statut/localité | Questions/ Commentaires | Réponse |
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| | | | | du Projet (20 ans) sur 60 m de part et d'autre du pipeline. |
| 5 | Isselmou O Bechir | - | Sur quelle base considérez-vous que le Projet a une durée de vie de 20 ans? | Tullow : Le contrat avec la SOMELEC qui doit exploiter ce gaz est sur 20 ans cette durée correspond au potentiel estimé du réservoir de gaz de la zone considérée.<br><br>Si ces éléments changeaient, en particulier le potentiel du réservoir, le projet pourrait aller au-delà de cette durée initiale de 20 ans.<br><br>Le design de l'usine du traitement du gaz est prévu pour 25 ans. |
| | | | Avez-vous un plan pour gérer les problèmes environnementaux qui peuvent survenir lors de l'exploitation ou le traitement? | ERM : Un plan de gestion environnementale sera établi en concertation avec l'opérateur du Projet (Tullow). Il s'agit de l'ensemble des mesures d'atténuation qui engagent l'opérateur.<br><br>Le ministère de l'environnement ne donne son avis de faisabilité environnementale au Projet que sous condition du respect de son plan de gestion environnementale. |
| *6* | *Nom de l'intervenant* | | Le pipeline sous-marin a-t-il aussi une zone d'exclusion ? | Tullow : Non, il sera enfoui mais n'aura pas de zone d'exclusion. Cependant, les puits exploités seront protégés par une zone de sécurité d'un rayon de 500 m dans laquelle les activités pouvant entrer en interaction avec les têtes de puits (telles que le chalutage de fond) seront interdites. Cette zone d'exclusion de même que les pipelines apparaitront sur les cartes maritimes.<br><br>Ce pipelines est sous-marinset de ce fait n'affectera pas les usagers comme les pêcheurs artisanaux ou le transport maritime. |
| | | | Quelles sont les fonctions qui seront assurés par le département de l'environnement au niveau de ce Projet ? | MDEDD : Explication en hassaniya sur le processus d'EIE et comment il accompagne l'ensemble des étapes du Projet avec notamment une fonction de suivi-contrôle assurée par le ME dans la phase post-projet. |
| 7 | Oumou elkhairy Kane | ONG ADDFM | Nous n'avons pas reçu les comptes rendus de la journée de consultation publique précédente.<br><br>Quelles sont les mesures prévues pour atténuer les impacts prévisibles de ce projet sur les populations ? | ERM : Pour chaque impact considéré, des mesures d'atténuation sont développées avant de l'atténuer à un niveau acceptable.<br>Par exemple les impacts liés au trafic routier sont considérés. La formation des chauffeurs et la limitation de la vitesse des véhicules du Projet sont des mesures d'atténuation proposées. Les chauffeurs de la société Tullow suivent actuellement une formation sur la sécurité routière dispensée par un expert international. |
| *8* | *Nom de l'intervenant* | | Quelle est la distance de l'installation terrestre prévue vis-à-vis du nouvel aéroport de Nouakchott ? | ERM : L'installation de traitement de gaz proposée sera située à une vingtaine de kilomètres de l'aéroport. Elle est donc située en dehors de sa zone de sécurité (15km). |

| N° | Prénom et Nom | Statut/localité | Questions/ Commentaires | Réponse |
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| | | | Est-ce que c'est habituel d'avoir ce genre d'installation à proximité des concentrations humaines ? Quels peuvent être les impacts sur les populations ? | ERM : Ce projet d'installation de traitement de gaz à quelques kilomètres de zones résidentielles ne constitue pas un cas isolé.<br><br>La présence de zones résidentielles à environ 5 km au sud et de récepteurs potentiels tels que la nouvelle université à 3 km au sud-ouest ont été prises en compte dans l'EIE.<br><br>Les principaux impacts sur les populations qui ont été considérés sont liés au bruit et aux émissions atmosphériques. Afin de les évaluer des modélisations des émissions sonores et atmosphériques ont été réalisées dans le cadre de l'EIE pour évaluer l'impact au niveau des récepteurs les plus proches (comme par exemple la future université à 3km au sud ouest). Elles permettent de comparer les niveaux attendus aux standards internationaux.<br><br>A la fois pour le bruit et les émissions atmosphériques, les modélisations que nous avons développées ont donné des résultats inférieurs aux seuils recommandés par la SFI.<br><br>Une étude de risque a également été réalisée par Tullow pour quantifier les risques de feu et d'explosion liés à l'installation de traitement de gaz. Les zones potentiellement impactées incluses dans l'enceinte du Projet et son voisinage immédiat et ne devraient pas exposer les populations. |
| | | | Qu'est ce qui a dicté le choix de l'emplacement actuel de l'usine envisagée ? S'agit-il de contraintes budgétaires par exemple ? | Tullow : L'emplacement de l'usine n'a pas été choisi par Tullow mais par la SOMELEC et l'Etat. |
| 9 | Mohamed O Souleimane | Chef service MET | Est-ce que ERM a tenu compte des retours d'expériences similaires dans d'autres pays pour s'engager dans l'étude de ce genre d'installation ? | ERM : ERM et Tullow ont une riche expérience dans ce genre d'installations de par le monde. ERM réalise l'EIE d'un grand projet de pipeline dans la mer adriatique (Grèce, Albanie, Italie). Nous avons aussi l'expérience sur de projets gaziers onshore de grande envergure, comme par exemple le projet Touat-Gaz en Algérie.<br>Tullow : Tullow a développé et opère une installation terrestre de traitement du gaz similaire au Bangladesh. Nos sous–traitants ont également développé différents projets similaires. |
| | | | La profondeur du pipeline terrestre est 1.5 m alors que l'eau de la sebkha est à 40 cm sous le sol. Comment allez-vous s'y prendre dans ces conditions ? Quelles sont les mesures techniques que vous envisagez pour emmener le pipeline à | Tullow : Une étude géotechnique comprenant plusieurs carottages au niveau de l'installation et du tracé du pipeline a été réalisée. Les données sont en cours d'étude par l'équipe design. La présence d'eau n'est pas un problème pour l'installation du pipeline. |

| N° | Prénom et Nom | Statut/localité | Questions/ Commentaires | Réponse |
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| | | | la terre ferme ? | |
| 10 | Mohamed O Chah | Président ONG OMDD | Je voudrais savoir la nature du matériel prévue pour le pipeline, ceci me préoccupe du fait de la fragilité du cordon dunaire ? | Tullow: Le pipeline sera en acier et doté d'un système de protection anti corrosif en polyéthylène. Une fois installé, il sera enterré et ne devrait pas affecter le cordon dunaire. |
| | | | Comment seront gérés les problèmes qui peuvent survenir ?<br><br>La société a-t-elle la volonté de compenser les parties concernées en cas de dégâts évidents ? | Le plan de gestion environnementale du Projet décrit les procédures mises en place pour gérer les problèmes d'ordre environnemental qui peuvent se présenter. |
| 11 | Abderahmane O Sidi | ONG ASSPCI | Je constate que la zone du projet est une zone de pêche artisanale notamment pour des espèces démersales. Ceci peut constituer une menace pour nos ressources halieutiques. | ERM : Lors de l'étude de l'état initial, nous avons contacté les pêcheurs et documenté les zones de pêche. La pêche artisanale est active uniquement jusqu'à 12 km des côtes. Son interaction avec le projet sera donc très limitée et principalement localisée au niveau de la zone d'arrivée du pipeline sur le littoral.<br><br>Les opérations de forage sont temporaires et les déblais ont un impact mineur sur la ressource halieutique. |
| | | | Est-ce qu'on a découvert réellement du gaz en Mauritanie ? A-t-on confirmé la rentabilité de ce projet ? | Tullow : Oui, du gaz a été découvert dans le champ de Banda en quantité suffisante pour justifier son exploitation. |
| | | | Comme dans la zone considérée on trouve des tortues marines, je vous recommande de s'approcher de l'IMROP qui dispose de compétence dans ce domaine. | ERM : l'équipe locale d'ERM comprend un spécialiste de la biodiversité marine et côtière. C'est M. Amadou BA, présent aujourd'hui parmi nous dans cette journée de consultation publique. Il a apporté son expertise y compris sur les aspects liés aux tortues marines.<br>Intervention d'Amadou BA sur la distribution des tortues dans la zone et leur cycle de ponte. |
| | | | Comment allez-vous s'y prendre pour garantir la durabilité environnementale de ce projet ? | ERM : L'implémentation du plan de gestion environnementale du projet a pour objectif sa durabilité environnementale. Un suivi de ce plan de gestion sera assuré par les autorités mauritaniennes. |
| 12 | Ismael | - | Vous avez cité comme parties prenantes le projet d'université, et le projet de l'aéroport. Il y a d'autres parties prenantes que vous n'avez pas mentionnées. | M.Ould Taleb : En plus des projets cités, notre étude d'état initial a considéré les usagers et riverains de la zone suivants : éleveurs, résidents, projet de ceinture vert, exploitants de coquillages. |
| | | | Le vent souffle à NKC dans la direction Nord Est. Si donc un accident survient au niveau de l'usine c'est toute la population qui en pâtira. | ERM : La modélisation des émissions atmosphériques réalisée par ERM inclut un scénario accidentel. Il a été modélisé pour toutes les conditions de vent de l'année 2011 et le résultat le plus défavorable a été retenu. Les résultats préliminaires montrent que même en scénario accidentel les concentrations en polluants modélisées sont bien inférieures aux standards de la SFI. |

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| 13 | Sidi Mohamed O Dah | ONG | Est-ce que l'usine produira autre chose que le gaz ? | ERM : L'installation de traitement de gaz produira de petites quantités d'autres produits associés à la production de gaz comme le condensat (pétrole léger) les eaux produites. Tullow étudie actuellement des options de valorisation de ces produits. L'export du condensat par camion au port de Nouachott est considéré. Les eaux produites seront-elles traitées et éventuellement utilisées pour de l'irrigation au niveau du site. |
| | | | Les pipelines terrestre et marin seront-ils de la même nature ? | Tullow : Oui, les deux pipelines seront en acier et dotés d'un système de protection anti corrosif en polyéthylène. |
| | | | Le gaz produit aura-t-il une odeur ? Est-il prévu de lui donner une odeur pour détecter les fuites. | Tullow : D'après les études préliminaires le gaz du champ de Banda a une faible teneur en soufre et ne devrait donc pas l'odeur caractéristique des gaz soufrés. Il n'est pas prévu de lui donner une odeur car le destinataire étant adjacent à l'usine, le gaz ne sera pas transporté sur de grandes distances. |
| | | | Le prix du gaz domestique va-t-il baisser ? | - |
| | | | On sent déjà l'impact de ce projet à travers l'augmentation vertigineuse des prix du poisson. Nos poissons nous rassemblent, nous serons donc affectés comme eux par ces activités. | - |
| 14 | Mohamed Yahya | ONG Globe | Est-ce que le choix de l'emplacement du site de l'usine fait partie du mandat du bureau d'études ? | ERM : Non mais si celui-ci pose des problèmes environnementaux majeurs ils seront reflétés dans l'étude d'impact environnemental. |
| | | | Est-ce que le bureau est impliqué dans le design de l'usine du traitement du gaz ? | ERM : Non mais si des éléments de design posent des problèmes environnementaux majeurs ils sont rapportés au développeur du Projet au cours du processus d'étude d'impact afin d'adapter le design et/ou de développer des mesures d'atténuation appropriées. |
| | | | Qu'en est-il de la responsabilité juridique d'ERM en cas d'accident au niveau de l'usine ? | Tullow : ERM est un bureau d'études qui fournit une expertise sur des questions environnementale et sociale. Sa responsabilité n'est pas engagée dans la construction ni le fonctionnement de l'usine. |
| 15 | Mohamedou O Moulaye | S.G /commune de Tevragh Zeina | Je voudrais avoir des informations sur les aspects commerciaux de ce projet. Avez-vous des clients pour ce produit ? Sera-t-il exporté ? | Tullow : Nous sommes en discussion avec un consortium dit SPEG (Société de Production d'Electricité à partir du Gaz) constitué de plusieurs entités (SOMELEC, Kinross Tasiast, SNIM, et Etat) qui est intéressé par notre production. Les aspects commerciaux ne sont pas finalisés. |
| | | | Qu'en est-il du dispositif de transport lié à ce projet : y aura-t-il de nouvelles routes par exemple ? | Il y aura une voie d'accès spécifique au site à partir du périphérique qui est prévu dans le schéma routier de la ville de Nouakchott. |

| N° | Prénom et Nom | Statut/localité | Questions/ Commentaires | Réponse |
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| 16 | Djibril Alpha Ba | ONG BSF | Je remercie Tullow, les départements ministériels et ERM pour cette réunion importante. | |
| | | | Est-ce que l'Etat peut instruire une étude de contre-expertise et mandater un autre bureau d'étude pour cela ? | MDEDD : Oui, la loi prévoit ce genre de dispositions (contre-expertise) quand cela est jugé nécessaire. |
| | | | Je constate que la société civile n'a pas été suffisamment associée à ce projet. Je demande pour nous une réelle participation. | La participation de la société civile est souhaitable et importante. la réunion d'aujourd'hui illustre cette volonté et son implication dans ce processus. Les portes du MEEDD sont ouvertes pour la société civile. Les registres et les résumés non techniques sont des outils pour favoriser leur participation. |
| | | | Ce gaz est-il inflammable comme le gaz domestique ? | Tullow : Oui, le gaz qui sera produit est inflammable et est très similaire au gaz domestique. |
| | | | Dans d'autres pays d'Afrique les populations tentent de percer les pipelines pour récupérer le pétrole ou le gaz. Est-ce qu'il y aura un système d'alerte en cas d'attaque sur les pipelines ? | Le pipeline sera enterré. Une surveillance de la zone sera assurée afin de prévenir les attaques sur le pipeline. |
| 17 | Mohamed O Abdallahi | | Quels seront les impacts en termes de bruit (liés au forage) sur la pêche ? | ERM : Les impacts du bruit lié au forage seront très localisés et mineurs. Les poissons sont mobiles et peuvent s'éloigner des sources de bruit. Par ailleurs, la pêche artisanale est active uniquement jusqu'à 12 km des côtes. Son interaction avec le projet sera donc très limitée et principalement localisée au niveau de la zone d'arrivée du pipeline sur le littoral. |
| | | | Ne pensez-vous pas que la zone choisie pour l'usine est impropre à la construction ? Je le dis en se fondant sur l'expérience du projet Ribat Al Bahr car je vois qu'il n'a pas avancé depuis longtemps | MDEDD : Ribat Al Bahr est un projet immobilier gigantesque qui est prévu pour environ 30 000 habitants. Son arrêt temporaire n'est pas lié à la nature du sol ou autres facteurs environnementaux mais plutôt à des considérations internes à ses développeurs. Sa durée de construction est prévue sur dix ans |
| | | | Le projet a-t-il pris en considération le phénomène Nouakchotois de « Gazra » ou occupation spontanée des terrains ? | ERM : Les Gazras présentes au niveau de la zone du Projet ont été identifiées dans le cadre de l'état initial. |
| 18 | Hawa Sidibé | ONG ADPDH / Comatour | Notre groupe de femmes disposes de terrains à côté de la zone de Ribat Al Bahr au niveau du PK 13. Nous souhaitons être maintenus informés par la suite du projet. | - |

*Tableau 2 – Commentaires inscrits dans le registre de l'atelier de consultation publique du 20 mars 2013 (Traduits en français par M.O.Taleb)*

| N° | Prénom et Nom | Institution/Contact | Questions/ Commentaires |
|---|---|---|---|
| 1 | Abdelwahab Hamid | Le Groupe Mauritanien d'Investissement (ouldhamed@gmail.com) | Je vous recommande de vous concerter avec le projet Ribat Al Bahr qui est l'un des plus grands projets riverains de ce projet. abdelwehab@mmisa.sa.mr / www.mmisa.mr, Tel : + 222 45 24 00 24 |
| 2 | Mohamed O Souleymane | Chef service à la DIT/MET | Comme ce type de projet existe dans d'autres pays, est ce que vous avez pris les renseignements nécessaires sur ce type de projets et les problèmes rencontrés pour les éviter lors de la réalisation de ce projet. |
| 3 | Mohamed Chah | ONG OMDD omdd@omdd.mr | Nous recommandons de prendre les précautions utiles pour faire face aux événements qui peuvent survenir.<br>Prévoir des fonds conséquents pour les compensations des éventuels préjudices notamment pour les groupes qui peuvent être affectés par le projet |
| 4 | Isselmou O Brahim | - | Des solutions adéquates doivent être apportées aux problèmes environnementaux que va susciter l'exécution de ce projet. Ces problèmes résultent principalement des analyses chimiques à l'intérieur de l'usine. Cette dernière étant proche des populations et de l'aéroport, ceci peut entrainer une catastrophe. |
| 5 | Cheikh Bouchraya | emjed@gmail.com | Je ne puis m'empêcher d'insister sur la nécessité d'associer concrètement la société civile à ce projet. la société Tullow peut solliciter sur ce sujet les départements concernés. |
| 6 | ONG DEPAMAC | depamac@yahoo.fr 464659 43 | Je viens d'insister sur les aspects environnementaux à respecter à 90% ainsi que la vie humaine. |
| 7 | Mohamed Mahmoud O Dahi | Clean Beach Clean_beachmr@yahoo.fr 22 31 51 55 | Nous saluons cette initiative qui nous a permis de s'instruire sur l'ensemble des questions environnementales et de connaitre les études qui ont été menées .Nous sollicitons que l'ensemble des recommandations qui sont de nature à préserver l'environnement et à aider les populations sur le plan social soient prises en considération. |
| 8 | Hapsatou Bal et Djeinaba Ba, | Kinross Tasiast | Nous observons que cette CP se déroule de la même manière que celles organisées par organisées par notre société Tasiast dans une volonté de transparence et de partage d'informations avec les différentes parties prenantes. |
| 9. | Elhassen O Chenan | Pdt .ONG Tiris pour la protection de l'environnement et la santé (ATPES) / 46 77 81 20 | Nous demandons à la société de financer des projets d'intérêt général au profit des populations et de collaborer avec la société civile et notamment les ONGs actives dans l'environnement. Il faut les associer dans le contrôle des projets. |
| 10. | Bâ Djibril Alpha | ONG Bienfaisance sans frontières 22 17 84 82 | L'exposé très argumenté, documenté et convaincant du bureau d'études ERM pour le développement du champ gazier Banda et son impact environnemental a attiré notre attention et suscité notre adhésion à ce projet. Nous sommes persuadés de l'intérêt socioéconomique que ce projet représente. Nous sommes prêts à lui apporter la contribution constructive. |
| 11 | Mohamedou Moulaye | | Je pense que notre partenaire Tullow Oil est en mesure d'assumer toutes ses responsabilités vis-à-vis des populations mauritaniennes. |

| N° | Prénom et Nom | Institution/Contact | Questions/ Commentaires |
|---|---|---|---|
| | | | L'administration mauritanienne doit prendre toutes les mesures pour protéger les populations de toutes les catastrophes susceptibles. |
| 12 | Hamadi O vayek | SG.Commune Tevragh Zeina/22 20 96 79 | Je pense que le bon exemple donné par Tullow en matière d'environnement peut entrainer les autres investisseurs dans une politique de respect de l'environnement et de l'investissement. |
| 13 | Hawa Sidibé | Pdt.ONG Surveillance de l'environnement | J'appartiens au projet Comatour (100 femmes) qui dispose de parcelles au PK 13 sur la route NKC-NDB . Nous sommes préoccupés par les risques que peut présenter ce projet pour nous. Si danger il y a, je suggère de délocaliser l'usine peur préserver la santé des populations |
| 14 | Mouna Mint Siyam | Pdt.ONG ADPDH<br>Membre réseau Comatour<br>ongadpdh@gmail.com<br>Tel :46 41 37 66 | Il faut trouver des solutions adéquates aux problèmes environnementaux identifiés.<br>Il faut associer toutes les organisations de la société civile dans la sensibilisation et le contrôle.<br>Il faut mettre en place un comité pour le projet au sein de laquelle la société civile serait représentée. |
| 15 | Mariéme Mint Sidi Mohamed | Pdt ONG ANPFPEE<br>anpfpee@gmail.com<br>Tel.22022465 | Je vous remercie pour ce projet et vous souhaite une bonne réussite. |
| 16 | Oumou Elkairy Kane | Membre ANPFPEEE<br>Tel.33 96 38 80 | Il faudra tenir compte des femmes et des enfants qui sont les groupes les plus vulnérables. Dans ce sens, utilisez une approche genre pour tenir compte de leur situation. en effet en cas de dégradation de l'environnement l les femmes et les enfants seront les premières victimes. Dans ce cas c'est l'exode rural qui survient. |
| 17 | Mekfoula Mint Brahim | Oumouk_2@yahoo.fr<br>Tel.46 41 34 72 | Je souhaite savoir l'impact direct de ce projet sur les récifs coralliens côtiers. |
| 18 | Sektou Mint Mohamed vall | Tel.22 20 56 22<br>ONG AMANE<br>mvsektou@yahoo.fr | J'aurai voulu que la présentation et les documents afférents à ce sujet nous aient été donnés pour garder le contact avec le sujet et en guise aussi de complément d'informations.<br>Je suggère de faire une mailing list pour avertir 2 à 3 jours en avance les participants et pour qu'ils soient préparés au débat.<br>Je pense qu'un tel projet nécessite la participation active de la société civile. |

*Tableau 3 - Liste des participants à l'atelier de consultation publique du 20 mars 2013*

| N° | Prénom et Nom | Institution | Fonction |
|---|---|---|---|
| 1 | Mohamed Elmahjoub O cheikhna | MDEDD | Chef service DAPL |
| 2 | Mohamed Lemine O Mohamed Moustapha | MDEDD | |
| 3 | Rabiaa Bint Hassena | MDEDD | DCE |
| 4 | Djibril Alpha Ba | ONG BSF | Coordinateur |
| 5 | Mohamedou O Moulaye | Commune Tevragh Zeina | Secrétaire General |
| 6 | Mohamed Elhafedh O Cheikh | ONG Amal | President |
| 7 | Arnaud Uzabiaga | ERM | Consultant |
| 8 | Mohamed Abdallahi O Had maaloum | ONG Elyusr | |
| 9 | Mohamed Mahmoud O Hamady | DCE | Chef service SNCC |
| 10 | Sidi Mohamed O Dah | ONG | |
| 11 | Mokhtar O Daddah | ONG Amis des oiseaux | Président |
| 12 | Mohamed O Ahmed Taleb | IMROP/ antenne NKC | Ingénieur de recherches |
| 13 | Abdelwahad Hamed | MMSIA | Assistant DG |
| 14 | Abderahmane Cherif | ASSPCI | |
| 15 | Mohamed Chah | ONG OMDD | Président |
| 16 | Cheikh Sidi Mohamed Bechar | MPEM/DHB | Chef service Patrimoine |
| 17 | Abdallahi Sene | ONG Biomacéne | Président |
| 18 | Ahmed O Soueidi | Cyber forum de la société civile | Journaliste |
| 19 | Mohamed Salem O Mohamed Yehdhih | ONG AMCSCREER | Président |
| 20 | Mohamed Naji O Lemrabott | ONG AGFD | Président |
| 21 | Mohamed O Souleymane | Ministère de l'Equipement et des Transports/DIT | Chef de service |
| 22 | Khaifa O Chenounne | Reseau environnement | Président |
| 23 | Elhassen O Chenoune | ONG Tiris | Président |
| 24 | Aminettou Min Yarba | ONG FAP | |
| 25 | Lalla Marieme Mint Mini | ONG ELLEFA | Président |
| 26 | Bellahi O Cham | ONG protection Environnement Côier | |
| 27 | Abidine O Cheikh | ONG Elghad Essihi | Président |
| 28 | Ahmed Vall Boumouzouna | ONG AFE | Président |
| 29 | Mohamed Yahya O Eyil | ONG Globe | Président |
| 30 | Mekfoula Mint Brahim | ONG for mvd | Présidente |
| 31 | Sekou Mint Mohamed Vall | ONG AMANE | Présidente |
| 32 | Laila Mint Ahmed | ONG Femme et Art | Présidente |
| 33 | Hademine O Memoudi Jiddou | ONG OMASSAP | Président |
| 34 | Aicha Mint Mohamed Mahmoud | RFP M2000 | Membre |
| 35 | Lalla Mint Saad bou | NdB M 2000 | Membre |
| 36 | Twilla Mint Mane | M2000/NKC | Membre |
| 37 | Isselmou O Barchin | ONG CAM | Conseiller environnement |
| 38 | Defal O Mouhcen | ONG Ceinture Verte | |
| 39 | Cheikh Bouchraya O Abdallah | ONG El Emel Elj | |
| 40 | Mohamed Abderahmane OSidi Baba | ONG DEPAMAC | |
| 41 | Mohamed Mahmoud O Dadi | ONG Clean Beach | Président |
| 42 | Mouna Mint Siyame | ONG ANPFPEE | Présidente |
| 43 | Cheikh O Mohamed lemine | ONG Univers | Président |
| 44 | Marieme Mint Sidi Mohamed | ONG ANPE | Présidente |
| 45 | Baptiste Galmiche | Tullow | Conseiller HSE |
| 46 | David Wright | Tullow | Project Manager |

| | | | |
|---|---|---|---|
| 47 | Amadou Diam Ba | - | Consultant |
| 48 | Daouda Niang | ONG ADEM | Président |
| 49 | Hapsatou Bal | Kinross Tasiast | Resp.Relations communautaires |
| 50. | Djeinaba Ba | Kinross Tasiast | Traductrice |
| 51 | Oumou Elkhairy Kane | ADDFM | Membre |
| 52 | Hawa Sidibé | ADPDH | Présidente |
| 53 | Abacar O Amanatoullah | DCE | Directeur |
| 54 | Ahmed O Mohamed | DCE | Cadre |
| 55 | Mohamed mahmoud O Hamady | DCE | Chef SNCC |
| 56 | Ethmane O Mohamed | ONG ASDEP | Président |
| 57 | Hamadi O Vayed | ONG ASSLP | Président |
| 58 | Mohamed Nour O Ahmed | MDEDD | Chef service |
| 59 | Mohamed O Abdallahi | ONG AMCLPD | |
| 60 | Lemhaba O Ahmed | ONG OSE | Président |
| 61 | Moustapha O Taleb | - | Consultant |

Annex B

# Modelling Reports

*B-1 Drill Cuttings Modelling Report*

*B-2 Air Quality Modelling*

*B-3 Noise Baseline and Modelling*

*B-4 Oil Spill Modelling Report*

Annex B-1

# Drill Cuttings Modelling Report

*CONTENTS*

*LIST OF FIGURES*



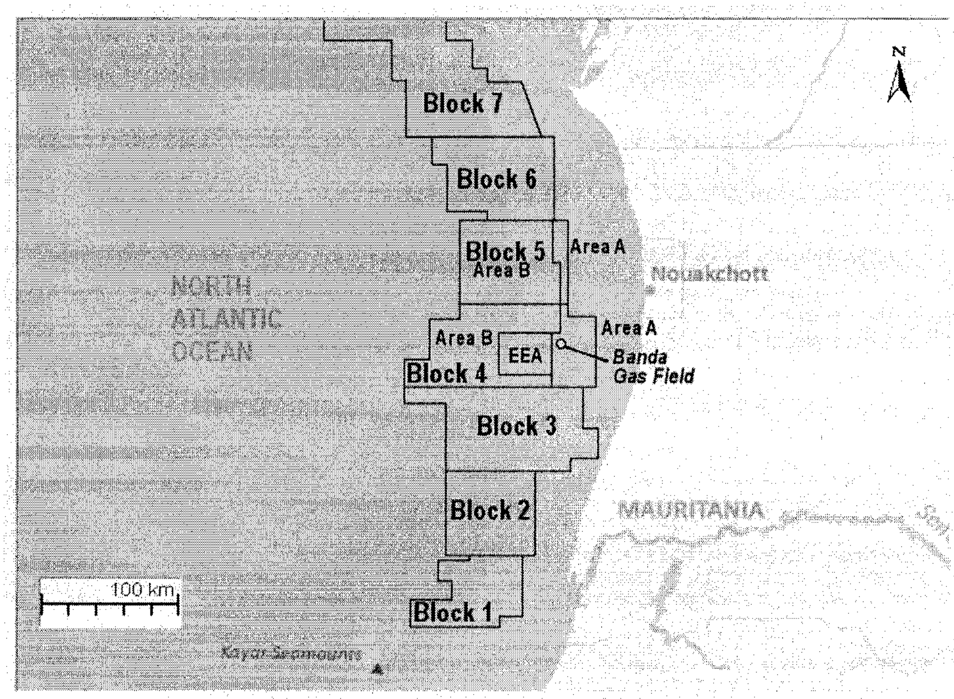
*LIST OF TABLES*

# 1 APPROACH

As part of the impact assessment process for the Banda Gas development proposed by Tullow Petroleum (Mauritania) Pty Ltd (hereafter referred to as Tullow) off the coast of Mauritania, ERM has conducted a modelling study for the release of drill cuttings and muds in the Banda field, approximately 50 km west of the Mauritanian coast (see *Figure 1.1*). This modelling was performed to assess potential environmental impacts that may occur as a result of the release of drill cuttings and muds.

Drill cuttings dispersion modelling was performed to determine excess suspended sediment concentrations discharged to the water column above background concentrations and also the seabed accumulation of the drill cuttings (the footprint) for assessment of impacts to benthic organisms.

*Figure 1.1* ***Location of Banda Field***



# 2 *DRILL CUTTINGS AND MUD DISCHARGE MODELLING*

## 2.1 *SIMULATION DESIGN*

The potential dispersion and deposition of released drill cuttings and muds has been quantified using hydrodynamic computer modelling techniques. Modelling allows the description of the ocean current velocity and direction in offshore Mauritanian waters, specifically around the Banda field, using the same hydrodynamic techniques employed in the oil spill modelling. Released material will pass vertically through the water column, because cuttings and muds are denser than the receiving water. Cuttings and muds dispersion is fundamentally a tri-dimensional phenomenon.

The drilling programme associated to the Banda field development plan proposed by Tullow considers drilling two new wells.

The month of July was examined for the cuttings corresponding to the time of the year when currents have no predominantly strong net direction. For the majority of the year, the offshore currents in this region travel to the southwest. The highest depositional thicknesses and sedimentation rates are likely to be observed at times when there is no strong net direction of transport spreading the discharge out across the seafloor.

Material from the 36" top-hole section will be removed by jetting in place. The 17-1/2" hole section will be drilled riser less, with cuttings pumped out of the well and released at the seabed. Cuttings will be carried out of the well using seawater as a drilling fluid in addition to a low-density water based gel mud pills. This gel mud will also be used to fill the hole section to ensure the hole does collapse while the casing is installed. However, very little of this gel mud material is expected to settle on the seabed close to the well, and it was therefore excluded from the modelling.

For drilling the two other well sections, WBM or an improved synthetic based mud (SBM) may be used if necessary. Once the riser is installed, cuttings and muds are brought to the surface, treated on-board the Mobile Offshore Drilling Unit (MODU) to separate the muds from the cuttings before been discharged overboard 5 m below sea level.

The model was run on a grid with 100 x 100 cells centred on the MODU location, covering an area of approximately 45 km by 40 km (each cell is 450 m by 400 m in length). The model was also run using a finer grid resolution (48 x 48 cells, each 16 m by 16 m) to capture the details of the top-hole deposition mound.

Modelling was performed using GEMSS® (Generalized Environmental Modelling System for Surfacewaters) and its drill cuttings and muds discharge module, GIFT (Generalized Integrated Fate and Transport). GIFT simulates the fate of dissolved and particulate material discharged from dredging barges, mine tailings, drill cuttings and muds, and produced water. This three-dimensional particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values (Shields number).

The modelling methodology is based on a deterministic mode of simulation. In deterministic single event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and muds were modelled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The combined action of erosion and deposition, based on particle size distribution and the intensity of release, resulted in the net accumulation of drill cuttings on the seabed.

Modelling data requirements included:

- drill section sizes and schedule;
- drilling mud types;
- cuttings and mud grain size distribution;
- mud and cuttings densities; and
- mud and cuttings release rates, durations, and discharge depths.

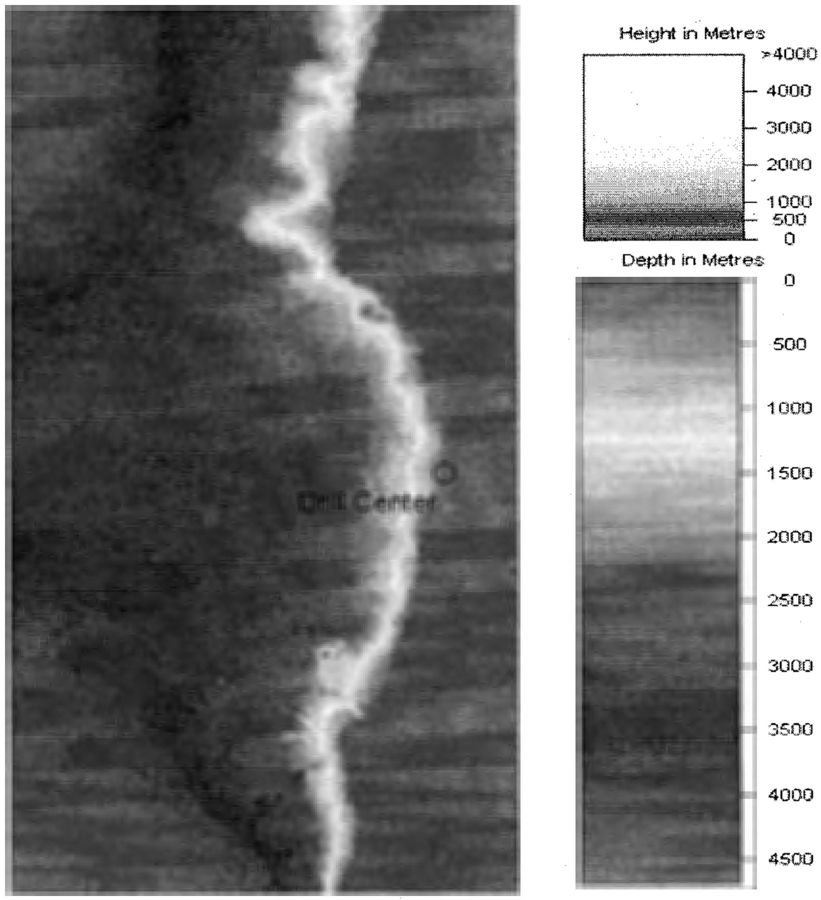
## 2.2 *ENVIRONMENTAL DATA*

The environmental data used by the model include bathymetric data, ocean current, temperature and salinity data, and are the same as those used for the oil spill modelling. Both, spatially varying data and time varying data, described below, are the same as those considered for oil spill model.

### 2.2.1 *Spatially Varying Data*

The primary spatial dataset is the bathymetric data, used to describe the depth and shape of the seafloor. The Banda field offshore Mauritania extends from the continental shelf to the foot of continental slope (*Fugro GEOS, 2012*). Bathymetric data are used to develop grids for the oil spill models. The General Bathymetric Chart of the Oceans (GEBCO), a publicly-available source, was used to extract seafloor bathymetry at the study site (*IOC et al., 2003*). The database used for this study is the GEBCO_08 Grid which has a 30 arc-second resolution. GEBCO bathymetry offshore Mauritania is shown in *Figure 2.1*.

**Figure 2.1** *GEBCO Bathymetry Map*




*Source: GEBCO (IOC et al., 2003)*

Information such as the location of the Banda field and the water depth at which activities and releases occur, are mapped onto the model grid. Accurate and consistent mapping are possible because all spatial data used by the model and produced in the course of modelling are geo-referenced. In addition, polyline shapefiles of the western African coastline act as a boundary in the model domain between land and water.

### 2.2.2 *Time Varying Data: Wind Data*

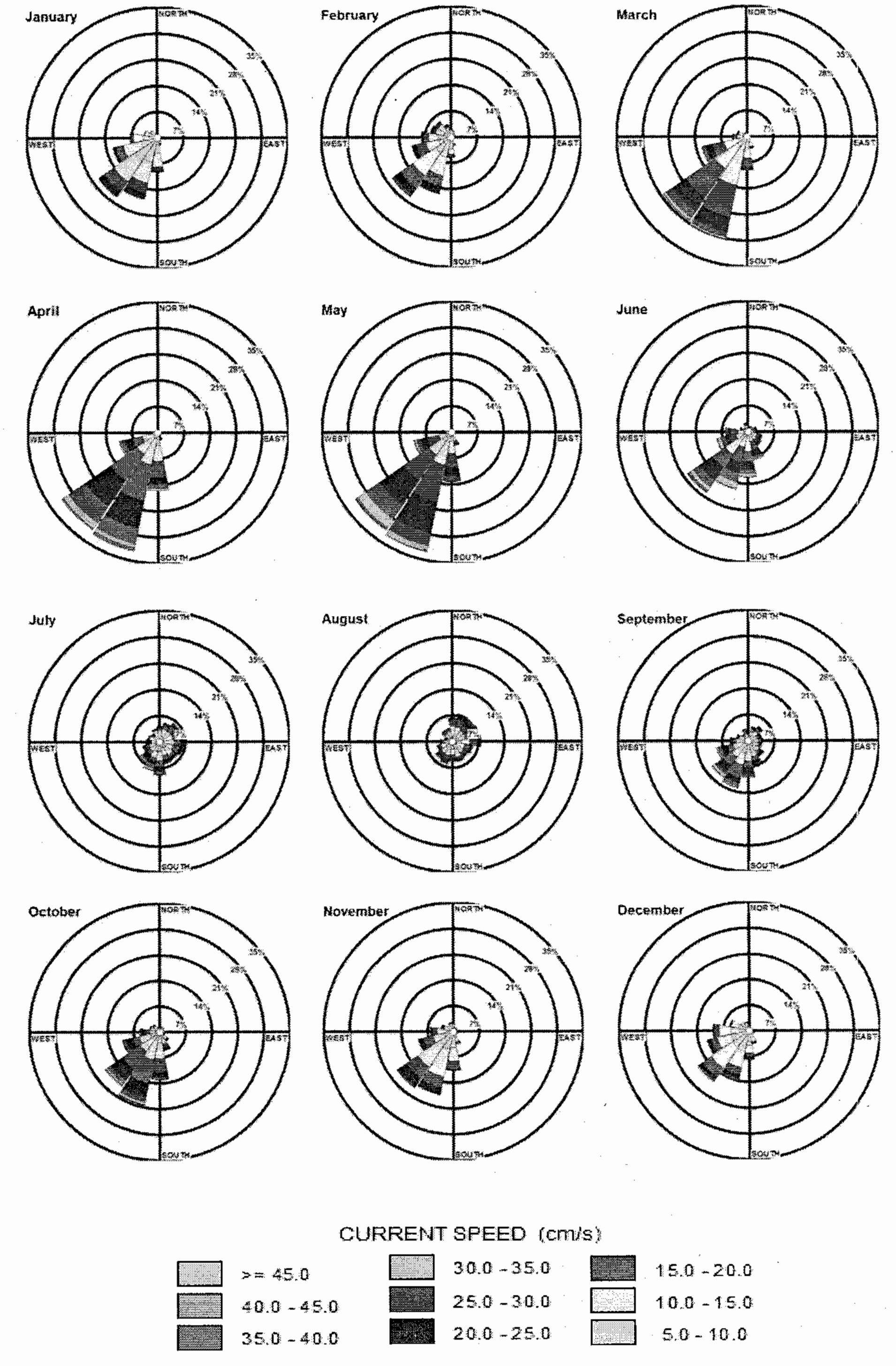
The effects of time varying winds are included in the hydrodynamic model. The influence of the winds on ocean currents decreases exponentially with depth, and is likely to have little influence on the settling of mud and drill cuttings.

### 2.2.3 *Time Varying Data: Ocean Current, Temperature and Salinity Data*

Depth-varying, six-hour average currents (speed and direction), salinity and water temperature data were obtained from the National Centers for

Environmental Prediction (NCEP, 2011), an arm of the U.S. National Oceanographic and Atmospheric Administration (NOAA), using oceanographic output from their Climate Forecast System Reanalysis (CFSR) program (*Kistler et al., 2001*). Data are available for the earth's oceans at every 0.5° horizontally (latitude and longitude). Vertically, values of currents, salinity and temperature are available at 10 m intervals starting from the depth of 5 m to 225 m from the water surface and continue till the ocean floor at variable depth intervals. NCEP data was analyzed from the period of December 1995 through March 2001 and was graphed as monthly current rose diagrams (*Figure 2.2*). July and August were determined to be the two months of the year without a strong dominant current direction; currents travel almost uniformly in all direction, minimizing the spreading away from the discharge location. The model was run using currents from June through the end of August along with the corresponded values for temperature and salinity from the NCEP model. The year 1996 was chosen as an arbitrary year representative of future conditions.

*Figure 2.2* *Monthly Current Roses (direction Current Traveling to) in the Banda Fields offshore Mauritania (1995-2001)*



## 2.3 *WELL PROFILES*

The well profiles that were used to simulate the drilling of the two new wells to be drilled are shown in *Table 2.1* and *Table 2.2*.

*Table 2.1* ***Well Profile #1***

| Hole Size (inches) | Casing | Drilling Interval (m) | Volume of Cuttings ($m^3$) | Volume of Mud to be Disposed ($m^3$) | Estimated Drilling Duration (days) |
|---|---|---|---|---|---|
| 36 | | 0 - 78 | 51.25 | 0 | 0.2 |
| 17 1/2 | | 78 - 796 | 197.52 | 0 | 1.9 |
| 12 1/4 | | 796 - 3170 | 320.08 | 15.45 | 6.4 |
| 8 1/2 | | 3170 - 3273 | 6.69 | 0.34 | 0.3 |
| Total | | 3273 | 575.54 | 15.79 | 8.8 |

*Table 2.2* ***Well Profile #2***

| Hole Size (inches) | Casing | Drilling Interval (m) | Volume of Cuttings ($m^3$) | Volume of Mud to be Disposed ($m^3$) | Estimated Drilling Duration (days) |
|---|---|---|---|---|---|
| 36 | | 0 - 78 | 51.25 | 0 | 0.2 |
| 17 1/2 | | 78 - 796 | 197.52 | 0 | 1.9 |
| 12 1/4 | | 796 - 2799 | 270 | 13.66 | 5.4 |
| 8 1/2 | | 2799 - 2821 | 1.43 | 0.07 | 0.1 |
| Total | | 2821 | 520.2 | 13.73 | 7.6 |

## 2.4 *CUTTINGS AND MUD VOLUMES AND PROPERTIES*

Cuttings and mud discharges for the two planned wells are included in *Table 2.3* and *Table 2.4*. A total of 1,485 tonnes of cuttings and 40 tonnes of muds are estimated to be discharged from both wells combined.

*Table 2.3* ***Cuttings and Muds Discharges in Well #1***

| Hole Size (inches) | Discharge Location | Cuttings Discharged (ton.) | Muds Discharged (ton.) | Muds Discharged ($m^3$) |
|---|---|---|---|---|
| 36 | Seafloor | 81.8* | 0 | 0 |
| 17 1/2 | Seafloor | 262.7 | 0 | 0 |
| 12 1/4 | Surface | 425.7 | 21.3 | 15.45 |
| 8 1/2 | Surface | 8.9 | 0.4 | 0.34 |
| **Total** | | 779.1 | 21.7 | 15.79 |

*Jetted

*Table 2.4* ***Cuttings and Muds Discharges in Well #2***

| Hole Size (inches) | Discharge Location | Cuttings Discharged (ton.) | Muds Discharged (ton.) | Muds Discharged ($m^3$) |
|---|---|---|---|---|
| 36 | Seafloor | 81.8* | 0 | 0 |
| 17 1/2 | Seafloor | 262.7 | 0 | 0 |
| 12 1/4 | Surface | 359.1 | 18 | 13.66 |
| 8 1/2 | Surface | 1.9 | 0.1 | 0.07 |
| **Total** | | 705.5 | 18.1 | 13.73 |

*Jetted

The specific gravity of the bulk cuttings and muds were 1,330 kg/$m^3$ and 1,318 kg/$m^3$, respectively. The volumes of the cuttings were estimated using a cuttings volume factor of 1.77. A washout factor of 1 was assumed for all sections.

The grain size properties of the drill cuttings and mud used in this study (*Brandsma and Smith, 1999*) are listed in *Table 2.5* and *Table 2.6*, and shown in *Figure 2.3* and *Figure 2.4*.

*Table 2.5* ***Drill Cuttings Grain Size Distribution***

| Class | Particle Size (μm) | Percent Volume |
|---|---|---|
| 1 | 12.56 | 2 |
| 2 | 41.17 | 9 |
| 3 | 107.96 | 15 |
| 4 | 217.95 | 18 |
| 5 | 620.53 | 16 |
| 6 | 1056.73 | 15 |
| 7 | 3612.28 | 25 |

*Figure 2.3* *Drill Cuttings Grain Size Distribution*

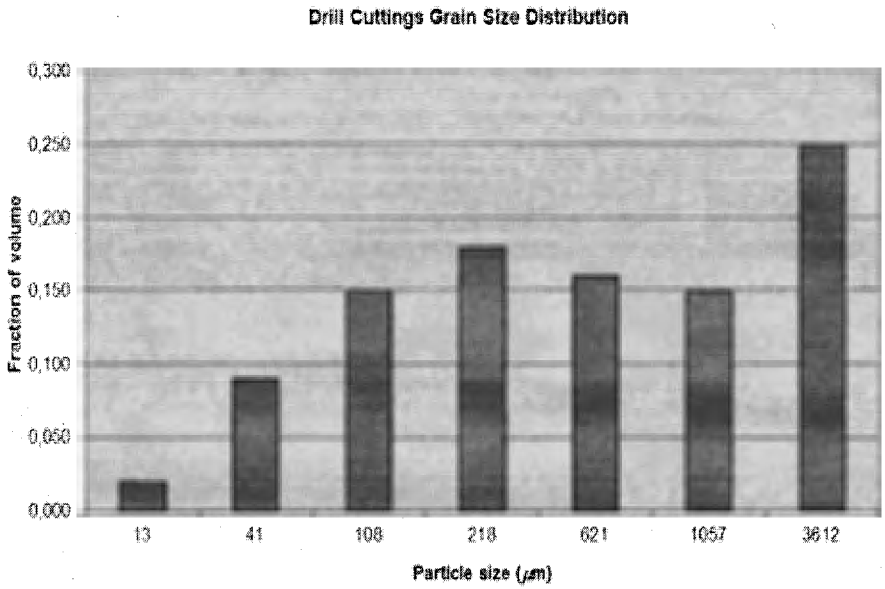
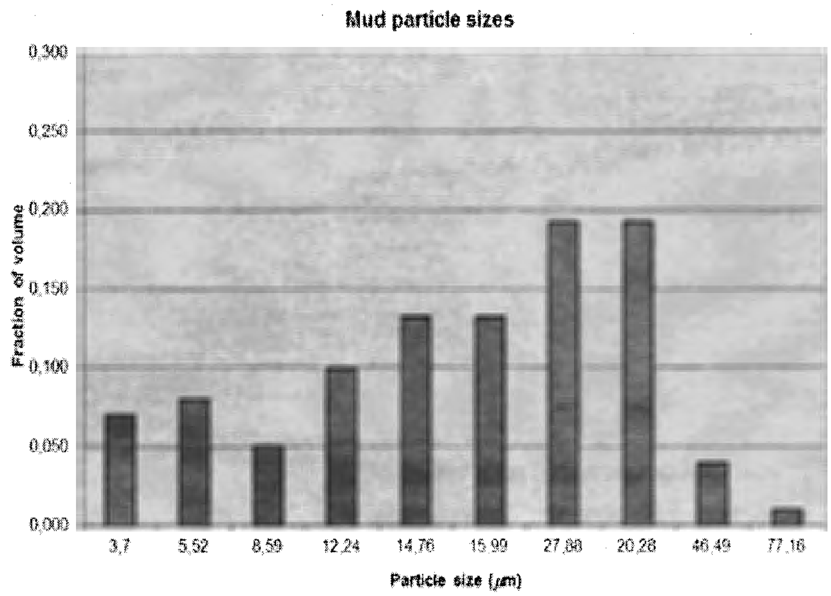



*Table 2.6* *Mud Grain Size Distribution*

| Class | Particle Size (µm) | Percent Volume |
|---|---|---|
| 1 | 3.70 | 7.01 |
| 2 | 5.52 | 7.99 |
| 3 | 8.59 | 5.00 |
| 4 | 12.24 | 10.00 |
| 5 | 14.76 | 13.26 |
| 6 | 15.99 | 13.26 |
| 7 | 27.88 | 19.24 |
| 8 | 20.28 | 19.24 |
| 9 | 46.49 | 4.00 |
| 10 | 77.16 | 1.00 |

*Figure 2.4* *Muds Particle Size Distribution*




It is assumed that the top-hole and surface sections (36" hole) will be drilled before the installation of the riser, with muds and cuttings discharged directly to the seabed. Once the riser is installed, muds and cuttings will be brought to the MODU and discharged through a vertical pipe after treatment, at a depth of 5 m below sea surface. This surface discharge is assumed to be continuous.

The two planned wells will be drilled from a single drill centre. The surface mud discharges will be released from the MODU, located at:

**Northing: 1965000 m, Easting: 334700 m, UTM WGS 1984, Zone 28 N**

The top-hole discharges are located above the two well heads located at:

- **Well Head #1.** Northing: 1965000 m, Easting: 334675 m, UTM WGS 1984, Zone 28 N.
- **Well Head #2.** Northing: 1965000 m, Easting: 334725 m, UTM WGS 1984, Zone 28 N.

It was assumed that the bottom discharges are released 3 meters above each well head to enable the model to calculate the formation of a depositional mound. For the model, the duration of each well was conservatively estimated to be 10 days, minimising the times spent without drilling activity.

## 3 *ASSESSMENT*

### 3.1 *DEPOSITIONAL THICKNESS*

Drill cuttings and mud discharges will create a footprint on the seabed. The deposition of muds and cuttings may result in physical damage and habitat loss / disruption over a defined area of the seabed. The discharge of water based muds and cuttings may affect seabed habitats only through physical smothering, since this type of mud is considered non-toxic. The constituents of the WBM discharges primarily consist of inert solids, water-soluble salts and organic constituents.

Burial by drilling muds and cuttings may cause physical impacts upon benthic communities. The specific thickness of burial which may cause an impact can vary depending on the benthic species and the amount of oxygen depletion which may occur, causing anoxic conditions beneath the depositional layer.

The severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen depleting material, and the duration of the burial.

### 3.2 *TOTAL SUSPENDED SOLIDS*

Increases in concentration of total suspended solids (TSS) will occur due to discharges of drill cuttings and mud. The highest concentration increases will naturally exist at the point of discharge or at the sea floor during top-hole drilling, and decrease over time and distance as the suspended solids plume dissipates. Larger particles will settle out more quickly than fine particles, such that the TSS plume of tiny particles may linger and travel further than plumes of larger grain-sizes. TSS impacts may occur if light penetration is impeded significantly for long periods of time reducing the ability of plants and phytoplankton to photosynthesize. Coral, which contain photosynthetic algae, has not been reported in the drilling area, and the top-hole drilling occurs at a depth where photosynthesis is already light-limited. However, the surface discharges may temporarily impede photosynthesis within the drill cuttings and mud plume.

### 3.3 *SEDIMENTATION RATE*

In addition to impacts related to the thickness of deposited materials, the rate at which the drill cuttings and mud are deposited is also considered as criteria for potential injury. Sedimentation rate is calculated as the total accumulated mass at a given area of the seabed, divided by the time since the discharges begin. Sedimentation rate is a measurement typically used to assess the net change in accumulation on a seabed after a long period of deposition, erosion, and resuspension. During a rapidly changing event, such as a mud and drill cutting discharge, values may appear very large due to the small time period examined. An excessively high rate of change in deposition may cause stress or injury to benthic life. Some benthic organisms are unable to move rapidly, and are slow to respond to excessive coverage. Studies of sedimentation rate threshold values are most commonly focused on various types of coral. Other organisms, such as filter feeders (octocorals and sponges), also have to potential to be impacted by a high sedimentation rate, but few studies have been performed.

# 4 RESULTS

The results of the modelling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point, taken as the drill centre. The results are presented for the following parameters:

- bottom thickness at the end of the simulation;
- maximum TSS measured in ppm at two locations: 1) at the seabed as a result of top-hole drilling and 2) at the rig discharge pipe located 5 m below the sea surface; and
- maximum sedimentation rate in $mg/cm^2$-day.

## 4.1 BOTTOM DEPOSITION

When the upper section is drilled without a riser installed, mud and cuttings are discharged directly to the seabed resulting in mound of material deposited around the well.

The material discharged at the seabed is deposited in the area directly adjacent to the well head and results in the thickest layers of deposited material. The material discharged at the sea surface disperses over a larger area, and can be deposited further away from the well head, with some tiny particles travelling at distances exceeding 5 km but making an insignificant contribution to the seabed thickness.

*Figure 4.1* shows the expected thickness of the mud and cuttings layer on the seabed as a result of the drilling activities at the end of the model simulation. The maximum thickness predicted by the model was 209 mm, located in the vicinity surrounding the first well. *Figure 4.2* shows this peak from a vertically exaggerated 3-D perspective. Seabed areas with deposited material over 1 mm thick are predicted to occur within a region approximately 66,200 $m^2$ around the central drilling location, while depositional areas over 10 mm are estimated to be 5,300 $m^2$.

*Figure 4.1 Bottom Deposition Thickness*

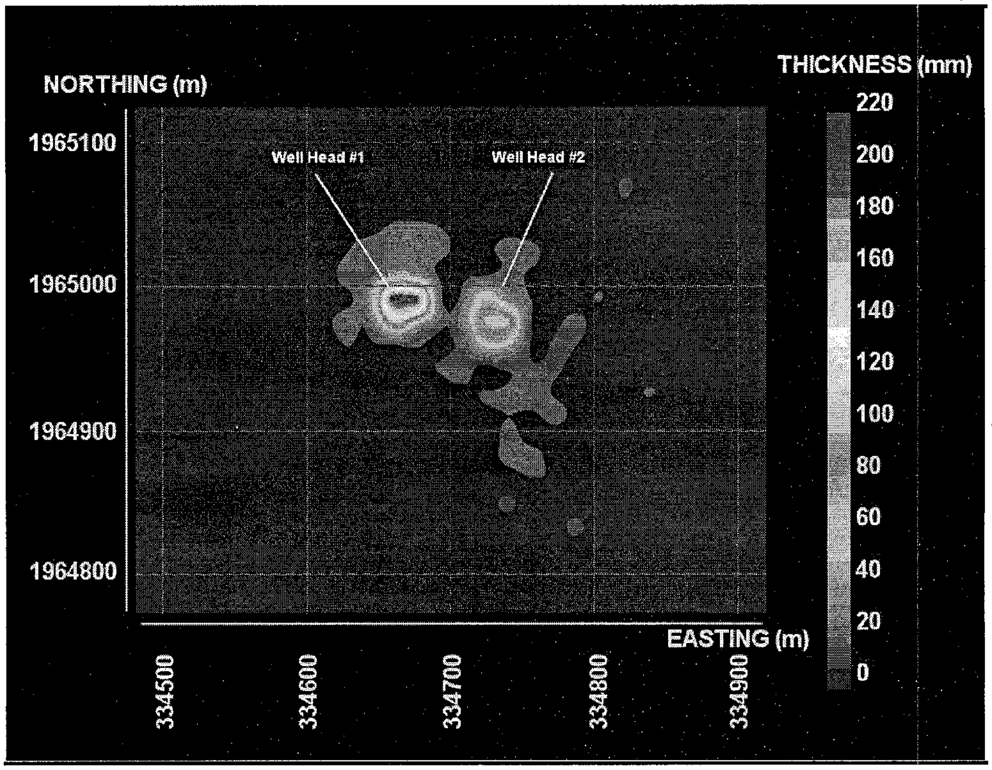
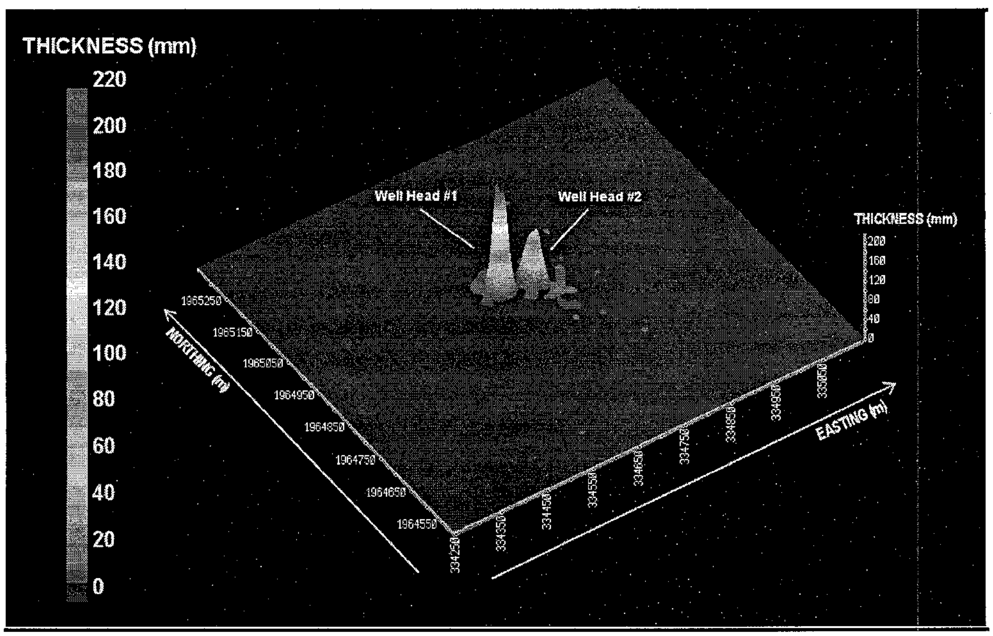



*Figure 4.2 Bottom Deposition Thickness – 3-D Perspective (vertically exaggerated)*



## 4.2 *TOTAL SUSPENDED SOLIDS*

The maximum excess TSS concentration was estimated to be 447 mg/L near the surface. More typically, during the surface release, the model estimated maximum concentrations added to ambient conditions near the surface range between 10 mg/L to 60 mg/L with fluctuations occurring as currents mix the depositional plume, and smaller particles, which settle more slowly, mix with faster-settling larger particles. Near the seafloor, deposition from the top-hole drilling is estimated to increase ambient TSS by 270 mg/L while receiving deposition from the surface releases mixed with the top-hole mass. Typical values at the bottom near the well heads ranged between 20 mg/L to 90 mg/L. Though the mass loading is higher at the bottom than on the surface, the maximum concentration is estimated to be less than at the surface since particles quickly settle onto the seafloor after the bottom release, with less opportunity for smaller slowly settling particles to recirculate and aggregate as on the surface.

*Figure 4.3* shows the maximum TSS concentration added to the background; note the small location with the spike reaching 434 mg/L was obscured by the graphical smoothening algorithm which reduced the spike to 272 mg/L. *Figure 4.4* shows the TSS concentrations during the first top-hole release, with a maximum of 42 mg/L above Well Head #1.

***Figure 4.3*** ***Maximum TSS Concentration Increase over Ambient Conditions near Surface***

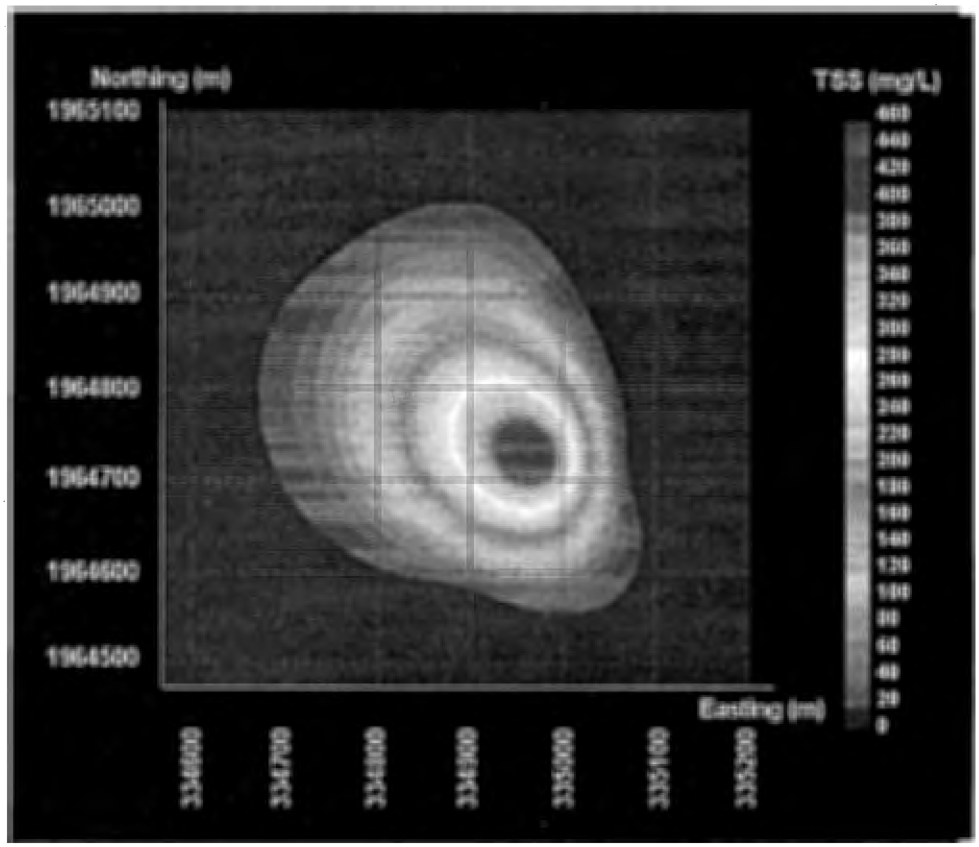
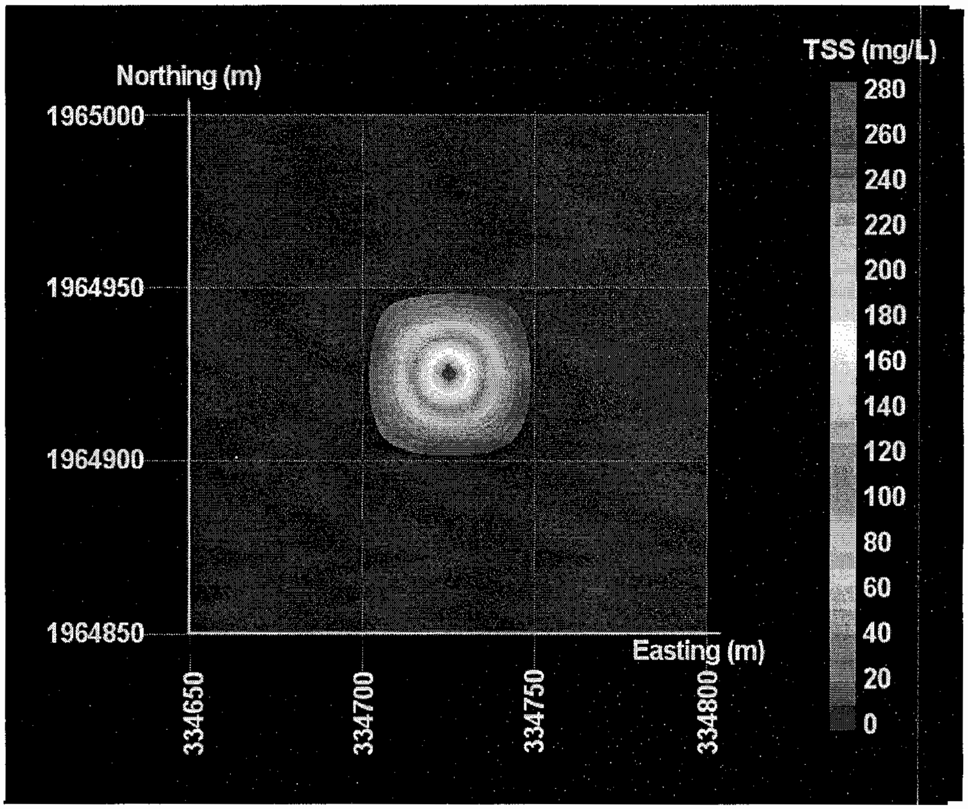


*Figure 4.4* *Maximum TSS Concentration Increase over Ambient Conditions near Seabed*




## 4.3 *SEDIMENTATION RATE*

The maximum sedimentation rate begins as a spike over 170,000 mg/cm$^2$-day on the seabed at the drilling centre, where top-hole discharges directly settle upon a small area. This initial value decreases by an order of magnitude within a day and spatially decreases by an order of magnitude radially from the first well head outside of a 30 m radius. These rates drop another order of magnitude after 60 m from the well head. Beyond this region, scatter locations have deposition rates above 10 mg/cm$^2$/day. The maximum sedimentation rates estimated at any time in the model is shown in *Figure 4.5,* occurring after six hours of the first deposition. These initial high sedimentation rates diminish to approximately 1,800 mg/cm$^2$-day after 20 days from the initial release. *Figure 4.6* shows the maximum sedimentation rate, anywhere within the depositional region, over time. As spatial maximum values, these rates are reflective of conditions at the first drill centre location. These sedimentation rates attenuate over time, since time is the denominator in the sedimentation rate equation. Therefore the rate is initially highest when the duration of time since the initial release is shortest. As a result, the effect of the second top-hole discharge on the sedimentation rate is obscured, as the time is measured relative to the first top-hole release.

*Figure 4.5* *Maximum Sedimentation Rate*

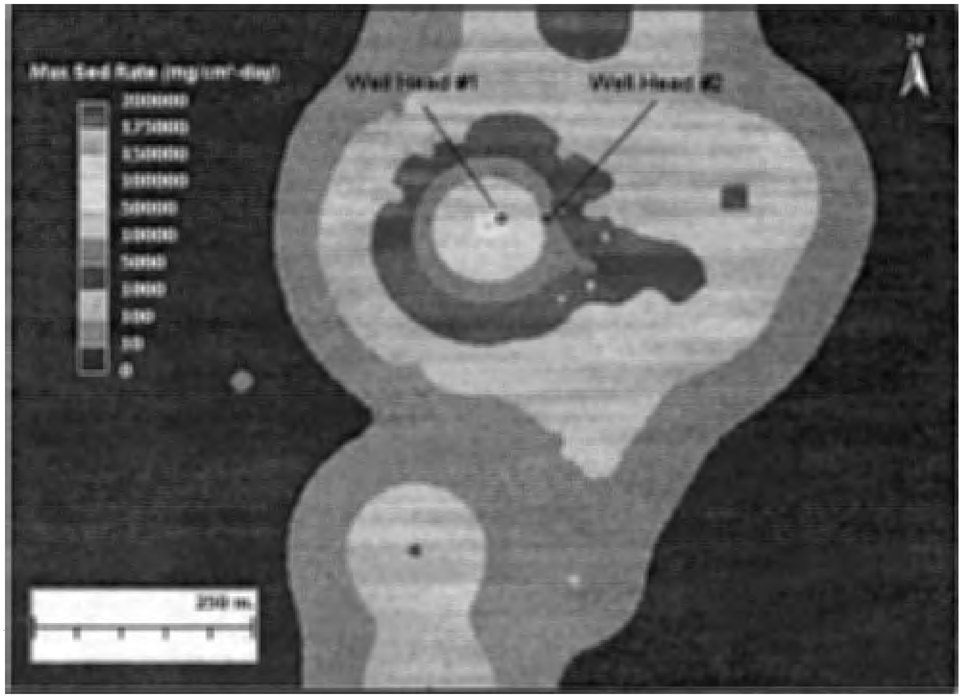
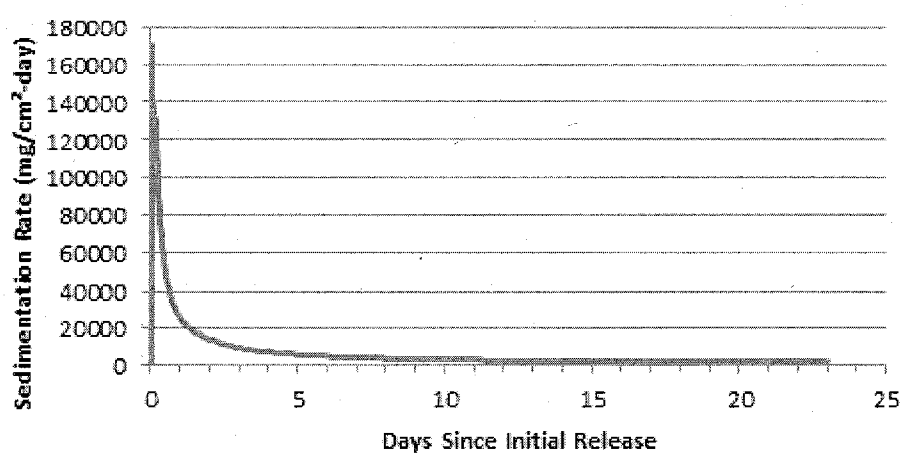


*Figure 4.6* *Maximum Sedimentation Rates over Time*



## 5 *SUMMARY AND CONCLUSIONS*

Modelling was performed using GEMSS® and its drill cuttings / drilling muds discharge module, GIFT. The simulation included material near the seafloor from the 36″ top-hole and the 17 ½″ section, followed by surface discharges of cuttings and muds for the subsequent sections. Discharge of a total of 1,485 tonnes of cuttings and 40 tonnes of muds from two wells was estimated. The duration of drilling each well was assumed to take 10 days; a total discharge duration of 20 days was therefore assumed.

Output from the drill cutting modelling included estimations of the thickness of deposition, increased total suspended solids concentrations above ambient conditions, and the sedimentation rate associated with the top-hole drilling discharges and releases from the surface.

Deposition of drill cuttings and muds on the seafloor may cause impacts due to smothering. The maximum thickness of deposited materials estimated was 209 mm, located near Well #1. Areas above 1 mm thickness of deposited material are predicted to occur within a region approximately 66,200 $m^2$ around the vicinity of the two wells, while depositional areas over 10 mm are estimated to be 5,300 $m^2$.

The maximum TSS concentration was estimated between 447 mg/L at the surface and 272 mg/L near the seabed. The maximum TSS concentration during drilling more typically ranges between 10 mg/L to 90 mg/L.

The maximum sedimentation rate was initially a spike over 170,000 mg/$cm^2$-day resulting from the top-hole drilling. This high rate is reflective of conditions at the drill center location receiving a large mass over a relatively short period of time and small area. The maximum rate decreases exponentially over time to approximately 1,800 mg/$cm^2$-day after 20 days. Sedimentation rates decrease by an order of magnitude within 30 m from the well head, and two orders of magnitude within 60 m. Sedimentation rate criteria are most commonly used for predicting impacts to sensitive coral species. However, this region of the world is not a major coral ecosystem; thus, this estimated sedimentation rate may not be relevant for impact predictions.

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Annex B-2

# Air Quality Modelling

*TABLE OF CONTENTS*

*LIST OF FIGURES*



*LIST OF TABLES*

## 1 INTRODUCTION

This annex presents the Atmospheric Dispersion Study carried out by ERM for the Banda gas processing plant. The project is being developed by *Tullow Mauritania* in Mauritania, approximately 10 km north of the capital, Nouakchott.

The air quality simulation has been performed with the CALMET-CALPUFF modelling system (version 5.8), adopted and recommended by the United States Environmental Protection Agency (US EPA) (*http://www.epa.gov/ttn/scram/dispersion_prefrec.htm#calpuff*). For a detailed description of the CALMET -CALPUFF model system and model run modules and settings please refer to *Section 3.1*.

The air dispersion modelling study aims to quantify the atmospheric ground-level concentrations of macro-pollutants produced by the atmospheric emissions associated to the operation of the High Pressure (HP) and Low Pressure (LP) flares of the Banda gas processing plant. The main atmospheric emissions arising from the combustion of sulphur-free flue gases at the HP and LP flares are $NO_x$, CO and PM.

According to the Project characteristics, two simulation scenarios were identified, for operational and emergency conditions respectively and the ground concentrations of $NO_x$ (conservatively considered as $NO_2$), CO and PM (conservatively considered as $PM_{10}$) have been modelled over a 30 x 30 km domain, roughly centred on the flares' location.

The quantitative data used in this study to define the emission scenarios have been taken from the following Technical Document provided by Tullow Petroleum: *Banda Gas Cap development, Process Datasheet, Flare Package (A-4301)). Tullow Petroleum (Mauritania) Pty Ltd. Assignment Number: L-200006-S01. Document Number L-200006-S01-DATA-270.*

In order to properly assess impacts on local air quality induced by the Banda Gas processing plant, model results have been compared against in force Air Quality Standards (AQSs).

The Mauritania Environmental Code (Framework Law n°2000-045 of 26th July 2000) sets general guideline on Air Pollution prevention and control but does not provide quantitative limits for air emissions or air quality standards. Therefore, relevant standards defined by the International Finance Corporation (IFC), the private sector financing organisation of the World Bank Group, have been used in the present study. These standards are presented hereinafter.

*Table 1.1* presents in force air quality standards, set by the IFC Environmental, Health, and Safety Guidelines for Air Emissions and Ambient Air Quality published on 2007, which refers to the WHO Air Quality Guidelines; the latter are available at *http://www.who.int/en*.

***Table 1.1*** ***Air Quality Standards set by the IFC Guidelines for Air Emissions and Ambient Air Quality***

| Pollutant | Parameter | WHO AQ Guidelines [μg/m³] |
|---|---|---|
| $NO_2$ | Annual average | 40 |
| | Maximum hourly concentration | 200 |
| CO | 8h moving average | 10000(*)(**) |
| $PM_{10}$ | Annual average | 20 |
| | Daily average | 50 |

*(*) WHO Air Quality Guidelines for Europe*
*(**)The maximum daily eight-hour mean concentration is selected by examining eight-hour running averages, calculated from hourly data and updated each hour. Each eight-hour average calculated is assigned to the day on which it ends, i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day is the period from 16:00 to 24:00 on that day.*

# 3 METHODOLOGY

## 3.1 CALPUFF MODELLING SYSTEM

The air quality simulation study was carried out with the CALPUFF modelling system (version 5.8, adopted and recommended by US-EPA since 06/29/2007. (http://www.epa.gov/scram001/dispersion_prefrec.htm#calpuff).

The chosen modelling system represents the state-of-the-art in Lagrangian puff modelling for assessing impacts of the long-range transport of certain air pollutants *(Allwine, Dabberdt, Simmons, 1998a).*

The CALPUFF modelling system consists of three main components, including a pre-processor and post-processor.

- The meteorological pre-processor CALMET produces the three-dimensional fields for the main meteorological variables, temperature, wind speed and direction, over the simulation domain.

- The processor CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing modules for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation.*(Allwine, Dabberdt, Simmons, 1998b)*.

- The post-processor CALPOST statistically analyses CALPUFF output data and produces datasets suitable for further analysis. Post-processed CALPUFF outputs consist of matrices of concentration values. Receptors in the simulation domain can be discrete or gridded. The values calculated at each receptor could be referred to one or more sources.

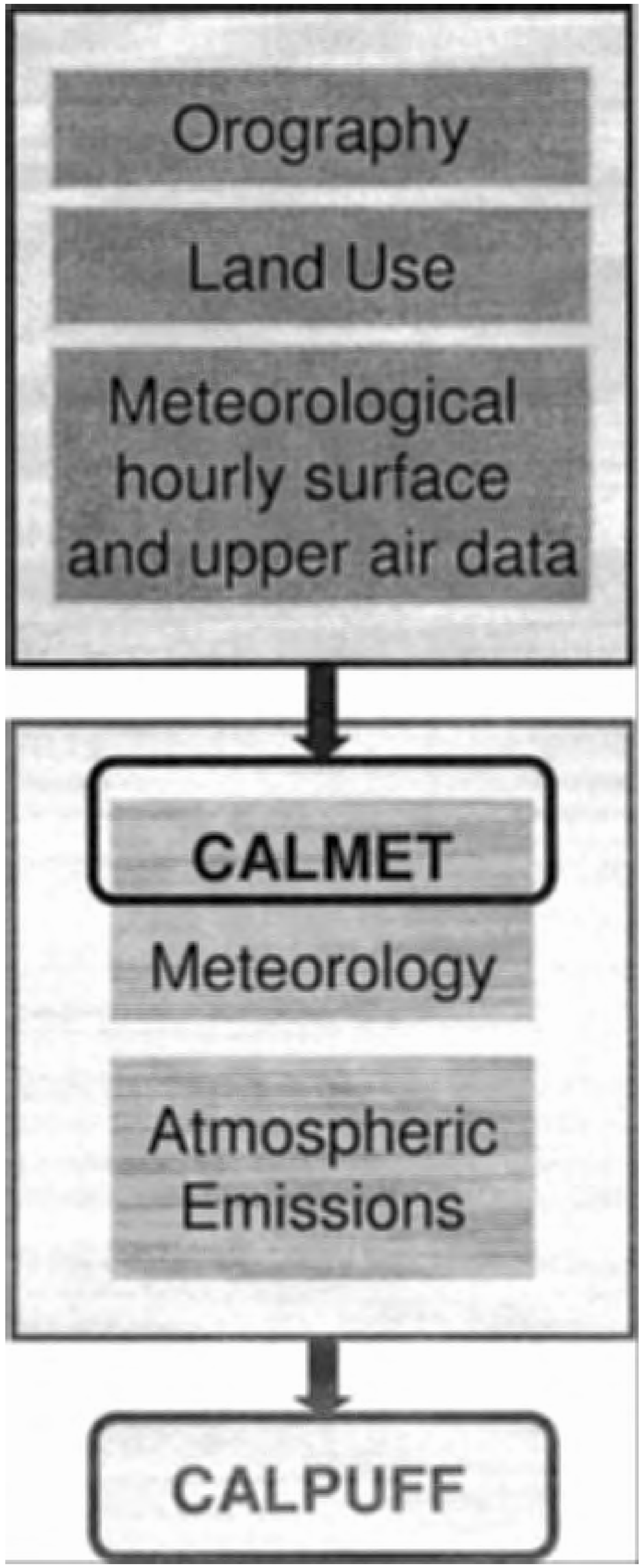
The results can be processed by any GIS software, creating iso-concentration maps as presented in section 4 of this annex.

The CALPUFF modelling system requires the following input data:

- meteorological variables' surface data and height profile, to build the three-dimensional wind field, with the meteorological pre-processor CALMET; and
- source characteristics and emission data, to simulate the pollutants atmospheric dispersion, with CALPUFF.

*Figure 3.1* presents a flow chart of the CALPUFF modelling system inputs, while *Box 3.1* gives a summary of the CALMET CALPUFF and CALPOST characteristics.

*Figure 3.1* *CALPUFF Modelling System Inputs*



*Box 3.1* *Features of the Pre-Processor CALMET, CALPUFF and Post-Processor CALPOST*

CALMET is a diagnostic meteorological pre-processor able to reproduce three-dimensional fields of temperature, wind speed and direction along with two-dimensional fields of other parameters representative of atmospheric turbulence. CALMET is able to simulate wind fields in complex orography domains characterized by different types of land use. The final wind field is obtained through consecutive steps, starting from an initial wind field often derived from geostrophic wind. The wind field is linked to the orography, since the model interpolates the monitoring station values and applies specific algorithms to simulate the interaction between ground and flow lines. The module contains a micro-meteorological module determining thermal and mechanical structures (turbulence) of lower atmospheric layers.

CALPUFF is a hybrid dispersion model (commonly defined 'puff model'). It is a multi-layer and non-steady-state model. It simulates transport, dispersion, transformation and deposition of pollutants, in meteorological conditions varying in space and time. CALPUFF uses the meteorological fields produced by CALMET, but for simple simulations an external steady wind field, with constant values of wind speed and direction over the simulation domain, can be used as input. The module contains different algorithms to simulate different processes, such as:

- buildings downwash and stack-tip downwash;
- wind vertical shear;
- dry and wet deposition;
- atmospheric chemical transformations;
- complex orography and seaboard.(1)

Besides, CALPUFF allows the selection of the source geometry (point, linear or areal), improving in this way the accuracy of the emission input. Point sources simulate emissions coming from a small area while areal sources describe a diffuse emission coming from a wider area; emissions from linear sources are distributed along a main direction (i.e. roads).

CALPOST processes CALPUFF outputs producing an outputs' format suitable for further analysis. CALPOST output files can be fed into graphic software to create concentration or deposition maps.

## 3.2 *MODELS DOMAIN*

The CALMET meteorological domain represents the area in which the CALMET pre-processor computes all the meteorology variables (i.e. temp. wind directions wind speed, atmospheric stability) needed to perform the pollutants air dispersion.

The CALMET meteorological simulation domain used in this modelling study is a 40 km x 40 km area, characterised by a resolution of 500 m. The domain size (1600 $km^2$) has been set according to the emissive source features and dispersion capability.

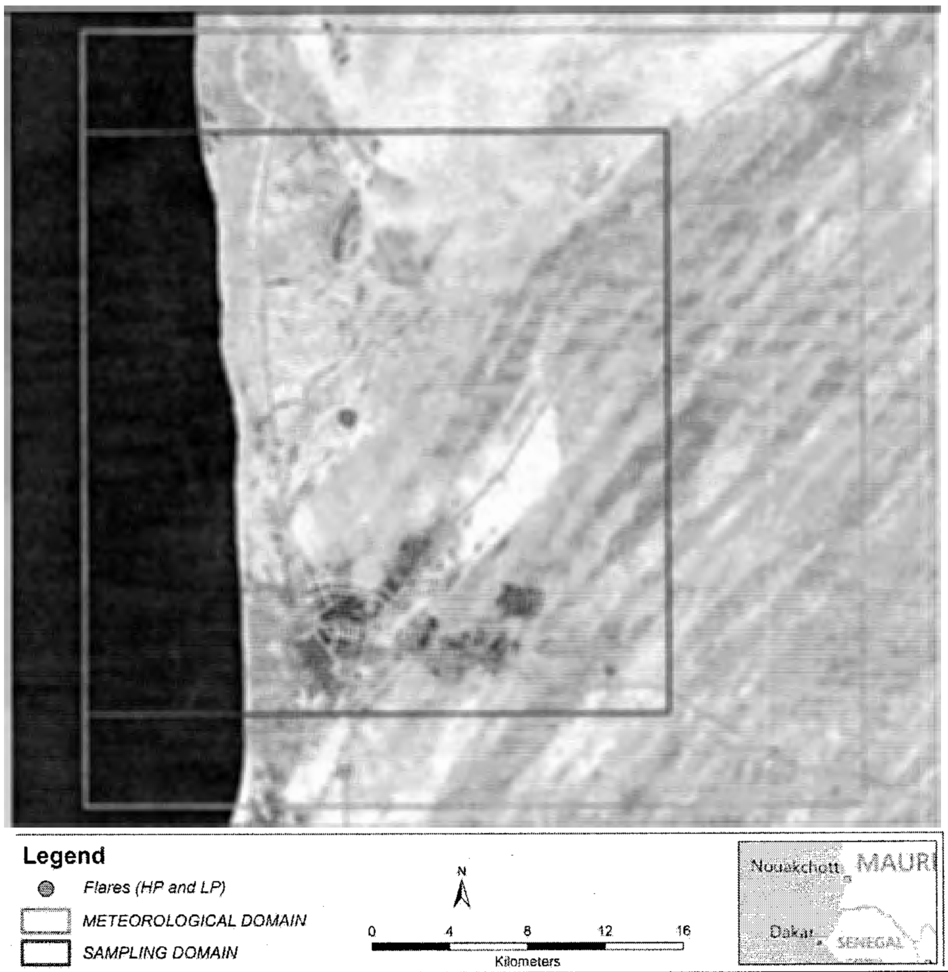
(1) In marine coastal areas, CALPUFF considers breeze phenomena in order to model efficiently the Thermal Internal Boundary Layer (TIBL) as in case of coastal sources, the TIBL causes a quick fall of pollutants to the ground.

The sampling simulation domain represents the matrix of gridded receptors at whose locations the model CALPUFF calculates the pollutant concentrations. The sampling domain used in this modelling study is a 30 km X 30 km subset of the meteorological domain, with a 250 m resolution.

The central point of each cell in the sampling domain represents a gridded receptor, whose elevation depends on the local orography and is given by the Digital Elevation Model of the area.

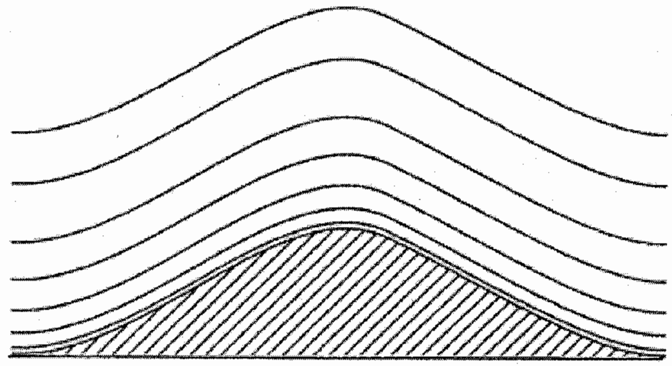
The following *Figure 3.2* presents both meteorological and sampling domains used for the present modelling study, highlighting the Flaring system location.

*Figure 3.2* *Meteorological and Sampling Domains, Flares location*




The CALMET-CALPUFF models operate in a terrain-following vertical coordinate system; terrain-following vertical coordinates are given by the Cartesian vertical coordinate minus the terrain height (the latter is available from the DEM). The concept of a coordinate system following the terrain is shown in the figure below.

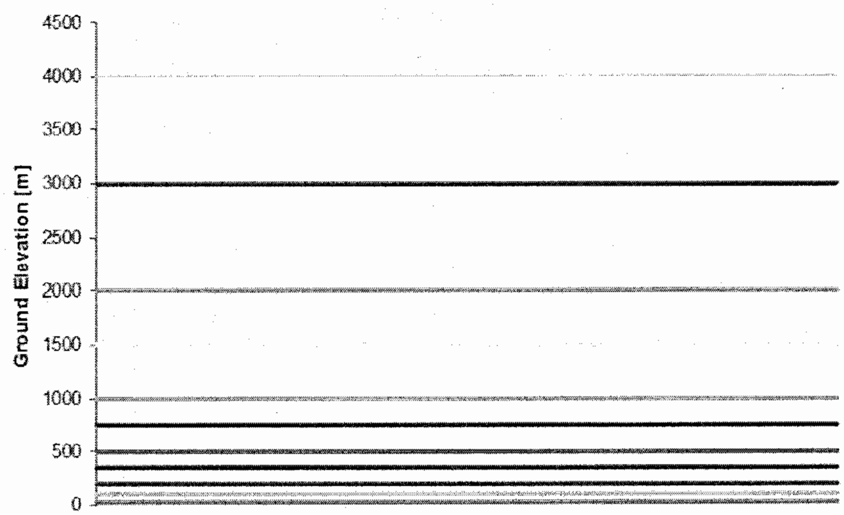
*Figure 3.3* ***Concept of Terrain Following Vertical Coordinate System***



The vertical resolution adopted in the present modelling study consists of 12 terrain following vertical layers, from the ground level up to 4000 m elevation (located at 20 m, 50 m, 100 m, 200 m, 350 m, 500 m, 750 m, 1000 m, 1500 m, 2000 m, 3000 m, 4000 m from the ground level).

The vertical layers resolution (see *Figure 3.4*) is higher near the surface, (Planetary Boundary Layer), where the transport and the dispersion of air pollutants take place, in order to investigate more accurately these dynamics and their interactions with the local orography.

*Figure 3.4* ***Models Vertical Resolution***




The dispersion modelling temporal domain or simulation period is the time period simulated by the model; in the present study the year 2011 was chosen as temporal domain.

## 3.3 *MODEL INPUT*

### 3.3.1 *Orography and land use*

Land Cover data were taken from the Land Cover database provided by the Food and Agriculture Organisation (FAO) within the geo Network Project , whereas site specific information about regional orography was reproduced using the ASTER Global Digital Elevation Model (ASTER GDEM); the latter is acquired by a satellite-borne sensor "ASTER" to cover all the land on earth and is developed jointly by The Ministry of Economy, Trade and Industry of Japan (METI) and the National Aeronautics and Space Administration (NASA).

### 3.3.2 *Meteorological Data*

The CALPUFF meteorological input was obtained with the meteorological pre-processor CALMET. The latter requires in input hourly surface data of: wind speed and direction, temperature, atmospheric pressure, relative humidity, cloud cover and ceiling height; and upper air data with a temporal resolution of at least 12 hours for: atmospheric pressure, temperature, wind speed and direction. Upper air data are necessary to characterize the wind regime and the atmosphere diffusive parameters (stability class, mixing height, thermal inversion, etc.), and to produce a three-dimensional simulation.

CALMET input meteorological surface data are typically taken from surface weather stations, if these stations are sufficiently close to the study area to be considered representative of its meteorological conditions. Upper air data are usually taken from radiosondes surveys, representative for the study area.

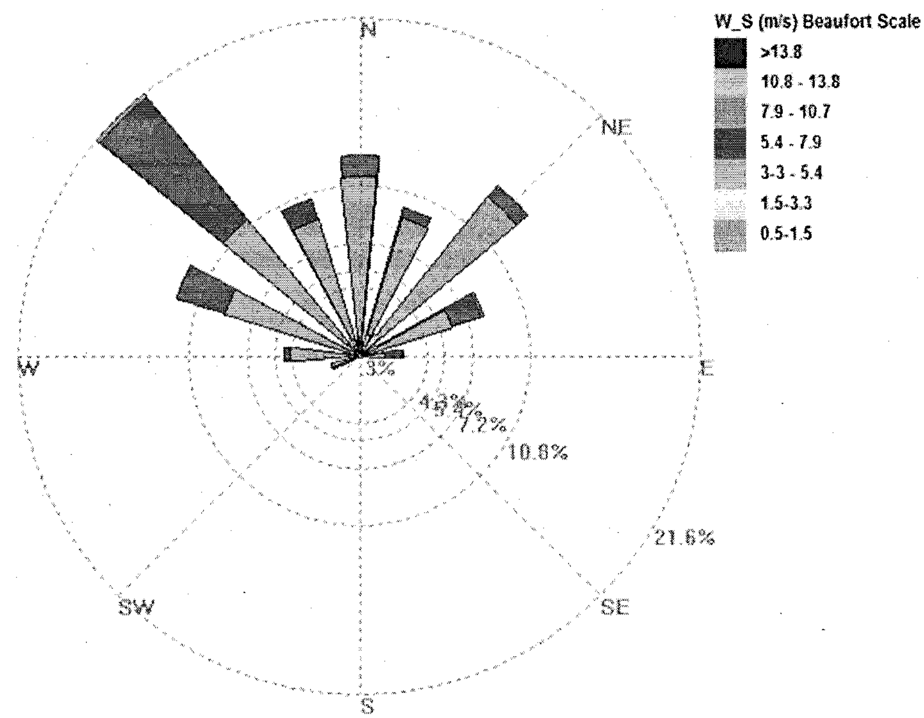
Due to the lack of radiosondes data and of representative weather stations monitoring meteorological variable over the above presented meteorological domain, CALMET surface and upper air input data for this study have been taken from MM5 meteorological model.

MM5 is a widely-used three-dimensional numerical meteorological model which contains non-hydrostatic dynamics, a variety of physics options for parameterising cumulus clouds, microphysics, the planetary boundary layer and atmospheric radiation.

MM5 is developed by Pennsylvania State University and the U.S. National Centre for Atmospheric Research (NCAR) and raw MM5 output can be converted into a format recognized by CALMET. All the MM5 meteorological data acquired as input for this study have been provided by Lakes Environmental™ , a worldwide provider of environmental data (terrain and meteo), recognized internationally for its technologically advanced air dispersion modelling software.

*Figure 3.5* shows the wind rose monitored extracted from the CALMET run performed for 2011, at the flares location.

*Figure 3.5* *Wind Rose Extracted from the CALMET run (2011) at the Flares Location*




Note: According to WMO (World Meteorological Organization) standards, the wind direction plotted in the wind rose is the wind provenance direction.

The wind rose *Figure 3.5* shows that winds in the Project area presents a predominant wind direction from NW. In terms of wind speeds, moderate winds are prevailing in the area (between 3.3 and 5.3 m/s). Winds are calm (< 0.5 m/s) only 0.25 of the time.

### 3.3.3 *Emissions*

*Methodological Approach for Flare Emissions Modelling*

Flares are commonly used as a control device for a variety of sources. A high-temperature oxidation process takes place in the flares and allows to burn combustible components, mostly hydrocarbons, contained in waste gases, or in excess gases, likely to be generated in emergency, plants' black out or start up condition.

The main problems in simulating gaseous emissions from a flare are related to the emissions' calculation and to their dispersion modelling. In the dispersion modelling, the buoyancy force associated with radiative heat losses and the flame length in estimating plume height, have to be taken into account.

This section describes the methodology used for modelling the two modelled emission scenarios. Formulae, assumptions and coefficients used were taken from the following technical document published by *EPA, (1992)*: "Workbook of screening techniques for assessing impacts of toxic air pollutants (revised)".

Mass Emission Rate

The formula used to calculate the generic emission rate of flare combustion products is the following:

$$Q_m(g/s) = \frac{(Vol(\%)/100) \cdot V(m^3/s) \cdot M_W(g/g-mol) \cdot (1-TOE)}{0.0224 \cdot (m^3/g-mol)}$$

Where:

*Vol ( )*: volume fraction of pollutant;
*V ($m^3/s$)*: volumetric flow rate to the flare;
*$M_W$ (g/g-mole)*: molecular weight of material released; and
*TOE*: Thermal Oxidation Efficiency (usually higher than 99 , up to 99,9 )

Heat Release Rate

The following equation *(Lahey and Davis, 1984)* is used to calculate the total heat release rate from the flare gas combustion:

$$H_r = 44.64 \cdot V \sum_{i=1}^{n} f_i H_i$$

Where:

*Hr (J/s)*: total heat release rate;
*fi*: volume fraction of each component of the flare input gas;
*Hi (J/g-mole):* net heating value of each component; and
*n*: components of the flare input gas stream.

Where the value 44.6 is derived for air as:

$$\frac{\rho_{air}(g/m^3)}{M_W(g/g-mole)} = \frac{1292}{28.97} = 44.6(g-mole/m^3)$$

Effective Release Height

Lastly, the effective release height is calculated by adding the flare height to the stack height, as follows *(Beychok, 1979):*

$$H_{sl} = H_s + 4.56 \times 10^{-3} \left( \frac{H_r}{4.1868} \right)^{0.478}$$

Where:

*$H_{sl}$ (m)*: effective release height before plume rise;
*$H_s$ (m)*: physical stack height above ground; and
*4.1868* is a conversion factor: Joules to calories.

The dispersion model used for the simulation estimates the "Plume raise" on the basis of the effective release height calculated as presented above.

*Industrial Flare Emission Factors*

The emission factors used to calculate the $NO_x$ , CO and PM flow rate are presented below. These factors are proposed by the *U.S. EPA, (1997)* in the chapter 13.5 (Industrial Flares) of the technical document "Emissions Factors & AP-42, Compilation of Air Pollutant Emission Factors, Volume 1, Fifth edition" and by *Kostiuk, L.W. and Johnson, M.R, (2000)* from the Alberta University in their publication "University of Alberta Flare Research Project Interim Report November 1996 - June 2000".

- $NO_x = 2.92 \times 10^{-5}$ [g/KJ]*( U.S. EPA, 1992);*
- $CO = 1.59 \times 10^{-4}$ [g/KJ] *(U.S. EPA, 1992);*
- PM = 1 [mg/g_pm] *(Kostiuk, L.W. and Johnson, M.R, 2000);*

*Emission Scenario*

The atmospheric dispersion model has considered two operating scenarios for the Tullow Banda gas Project. These scenarios describe the normal operation and an emergency situation, respectively. A conservative approach has been adopted in the present study. The operational and emergency scenarios are presented in the following part of this Section.

Operational Scenario

The atmospheric emissions occurring during the normal operation of the Project are produced by the combustion of purge gas at the HP and LP flares, which produces emissions to the atmosphere of macro-pollutants NOx, CO and PM.

Flare gas composition and parameters (gas flow rate, molecular weight and lower heating value) have been taken from the Flare Package, process datasheet.

The effective emission release height and flare diameter for rise calculation, have been determined using the EPA formulae presented above *(EPA, 1992)*; moreover the emission rate for $NO_x$, CO and PM has been calculated using specific referenced emission factors (i.e. U.S. EPA).

The following Table 3.1 shows the purge gas composition and parameters, whereas Table 3.2 and Table 3.3 summarise the emissions sources general characteristics and emissions rate and composition used as input in the operational scenario modelling study.

It has to be noted that the activity of the two flares has conservatively been considered continuous during the whole simulation period (entire 2011 year); this assumption enable to simulate the ground level concentration of airborne pollutants emitted during the project operation in the worst meteo-diffusive conditions occurring during the simulated year.

*Table 3.1* *Purge Flue Gas Composition and Parameters*

| Composition | Units | Value |
|---|---|---|
| Hydrogen sulphide | [ ] | 0.0 |
| Carbon dioxide | [ ] | 0.5 |
| Nitrogen | [ ] | 0.4 |
| Methane | [ ] | 97.4 |
| Ethane | [ ] | 0.7 |
| Propane | [ ] | 0.4 |
| Butane | [ ] | 0.2 |
| n Butane | [ ] | 0.2 |
| >C4 | [ ] | 0.2 |
| *Parameters* | | |
| Molecular weight | | 16.8 |
| LHV | [kJ/kg] | 48783 |

*Table 3.2* *Emissions Sources: Operational Scenario*

| Source | Type | UTM28N (WGS84) X [m] | UTM28N (WGS84) Y [m] | Height [m] | Exit Velocity* [m/s] | Temperature* [K] |
|---|---|---|---|---|---|---|
| HP Flare | Stack | 396762 | 2010632 | 30 | 20 | 1,273 |
| LP Flare | Stack | 396758 | 2010632 | 30 | 20 | 1,273 |

* *According to EPA-454/R-92-024 workbook of screening techniques for assessing impacts of toxic air pollutants (revised).*

*Table 3.3* *Gas and Pollutants Flow Rate: Operational Scenario*

| Source | Emission rate [kg/h] | NOx [g/s] | CO [g/s] | PM [g/s] |
|---|---|---|---|---|
| HP Flare | 250 | 0.10 | 0.54 | 0.28 |
| LP Flare | 250 | 0.10 | 0.54 | 0.28 |

Emergency Scenario

The emergency scenario was calculated on the base of Project design data contained in the Flare Package, process datasheet. A worst-case emergency scenario, in terms of gas flowrate, has been chosen for both flares in discussion with Tullow; moreover it was assumed that the HP and LP flares will operate in their worst emergency conditions at same time and continuously during the simulated year. The emergency scenario has therefore identified as a conservative worst-case assumption rather than a realistic emergency scenario.

Flare gas composition and parameters (gas flow rate, molecular weight and lower heating value) have been taken from the Flare Package, process datasheet. The blowdown event was chosen as the worst case for the HP Flare, whereas the fire relief event represents the worst emergency case for the LP Flare.

The effective emission release height and flare diameter for rise calculation, have been determined using the EPA formulae presented above *(EPA, 1992)*; moreover the emission rate for $NO_x$, CO and PM have been calculated using EPA emission factors.

The *Table 3.4* shows the gas composition and parameters for both HP and LP flares, whereas Table 3.5 and Table 3.6 summarise the emissions sources general characteristics and emissions rate and composition used as input in the emergency scenario modelling study.

Although emergency cases are likely to last for a limited time (few hours), the study conservatively assumed the activity of the two flares continuous and at the maximum gas flow rate during the whole simulation period (entire 2011 year); this assumption enable to simulate the ground level concentration of airborne pollutants induced by the identified emergency scenario in the worst meteo-diffusive conditions occurring during the simulated year.

***Table 3.4*** ***Purge Flue Gas Composition and Parameters***

| Composition | Units | HP Flare Blowdown | LP Flare Fire relief |
|---|---|---|---|
| Hydrogen sulphide | [ ] | 0.00 | 0.0 |
| Carbon dioxide | [ ] | 0.48 | 0.1 |
| Nitrogen | [ ] | 0.35 | 0.0 |
| Methane | [ ] | 94.06 | 1.7 |
| Ethane | [ ] | 2.26 | 0.3 |
| Propane | [ ] | 1.30 | 1.4 |
| Butane | [ ] | 0.39 | 1.7 |
| n Butane | [ ] | 0.48 | 2.6 |
| >C4 | [ ] | 0.68 | 92.2 |
| *Parameters* | | | |
| Molecular weight | | 17.6 | 131.8 |
| LHV | [kJ/kg] | 48626 | 36,464 |

***Table 3.5*** ***Emissions Sources: Emergency Scenario***

| Source | Type | UTM28N (WGS84) X [m] | UTM28N (WGS84) Y [m] | Height [m] | Exit Velocity* [m/s] | Temperature* [K] |
|---|---|---|---|---|---|---|
| HP Flare | Stack | 396762 | 2010632 | 30 | 20 | 1,273 |
| LP Flare | Stack | 396758 | 2010632 | 30 | 20 | 1,273 |

** According to EPA-454/R-92-024 workbook of screening techniques for assessing impacts of toxic air pollutants (revised).*

***Table 3.6*** ***Gas and Pollutants Flow Rate: Emergency Scenario***

| Source | Emission rate [kg/h] | NOx [g/s] | CO [g/s] | PM [g/s] |
|---|---|---|---|---|
| HP Flare | 59546 | 23.51 | 127.94 | 66.16 |
| LP Flare | 14377 | 4.26 | 23.16 | 15.97 |

## 3.4 *SUMMARY OF ASSUMPTIONS*

### 3.4.1 *Percentage Oxidation of Nitric Oxide to Nitrogen Dioxide*

During the combustion process, two nitrogen based pollutants are generated:

- nitrogen dioxide (NO2); and
- nitric oxide (NO).

Together these comprise emissions of oxides of nitrogen. $NO_2$ is the pollutant of interest from a health perspective as this is considered the more toxic of the two, with NO being largely inert. The emissions from the combined stack will comprise, initially, primarily NO, but through various chemical reactions that will take place in the atmosphere, the NO will be converted to $NO_2$. Only a proportion of the NO emitted will be converted to $NO_2$. This is due to the chemical reactions taking time to occur and also 'mopping up' other atmospheric chemicals such as ozone, a process which will limit the reaction rate and therefore limit the generation of $NO_2$. The conversion of NO to $NO_2$ is in part a function of the amount of ozone in the ambient air, and the travel time of the plume in the atmosphere (with time, more ozone is entrained into the plume and more conversion can therefore take place). Therefore only a part of $NO_x$ converts to $NO_2$ depending on the abovementioned different factors.

However, in the present study the worst case assumption was made that the entire NO emitted is converted to $NO_2$ by the time the emissions reach ground level and therefore human receptors. Thus simulated $NO_x$ have been considered as $NO_2$, and simulated $NO_2$ concentrations have been overestimated.

### 3.4.2 *Dust Emissions*

Assuming that the HP and LP flares are not smokeless, during the combustion process particulate matters of different sizes are generated. However, IFC guidelines sets air quality standards for $PM_{10}$; the latter are defined as all particles equal to and less than 10 microns in aerodynamic diameter; particles larger than this are not generally deposited in the lung.

All the particulate matter emitted by the Project emission sources has been conservatively assumed as $PM_{10}$; thus modelled concentrations of $PM_{10}$ have been overestimated and conservatively compared against in force air quality standards.

### 3.4.3 *Dry and Wet Depositions*

The model does not account for dry and wet deposition or photochemical reactions of the pollutants which in reality takes place and would reduce macro pollutants concentrations in the atmosphere. Thus results are overestimating the likely actual contribution of the sources. The approach again is on the safe side of assumptions and gives a conservative picture maximising pollutants modelled concentration values over the sampling domain.

### 3.4.4 *Emission Scenario*

As discussed on Page 13, the flares emergency activity period has been overestimated and considered continuous during the whole simulation year 2011 in order to find the worst dispersion conditions, and thus to maximizing the ground level pollutant concentrations.

Pollutant emission rates have been calculated on the base of Project design data. However for the emergency scenario the worst emergency case, in terms of gas flowrate, has been chosen for both flares; moreover it was assumed that the HP and LP flares will operate in their worst emergency conditions at same time.

## 3.5 *SIGNIFICANCE CRITERIA*

The significance of the predicted impacts is considered in terms of:

- the Process Contribution (PC) which is the impact on air quality arising from the process emissions only; and
- the Predicted Environmental Concentration (PEC) which is the PC added to the existing baseline.

No existing baseline data are available for the Project area thus PEC has not been calculated in the present study. Considering the rural nature of the Project area and the absence of existing atmospheric pollution sources in its proximity, it can reasonably be concluded that background concentrations of airborne pollutants are negligible over the Project area.

On this basis a significance criteria based on the PC has been defined and used in the present study.

The IFC General EHS guidelines (*IFC, 2007*) recommends that projects with significant sources of air emissions, such as the Project flares, should not contribute to the attainment of relevant ambient air quality guidelines or standards for more than 25 of the applicable air quality standards to allow additional, future sustainable development in the same airshed.

An adjacent proposed electrical power station is to be developed, owned and operated by a separate entity, the *Soci t de Production d'Electricit partir du Gaz* (SPEG). The SPEG power plant is being developed as a separate project from the Banda gas development, and is not covered by the scope of this EIA. However, this associated facility (1) will produce atmospheric emissions and potential impacts on local air quality. The significance criteria for air quality

(1)The IFC PS1 defines associated facilities as facilities that are not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable.

impacts have therefore been defined and used in the present study based on the IFC recommendation to allow additional development in the same airshed.

- If the PC <5 of the air quality standard, then impacts are **negligible**.
- If the PC between 5 and 25 of the air quality standard, then impacts are of **minor** significance.
- If the PC between 25 and 50 of the air quality standard, then impacts are of **moderate** significance.
- If the PC >50 of the air quality standard, then impacts are of **major** significance.

## 3.6 *AIR QUALITY RECEPTORS*

The nearest buildings identified in the vicinity of the proposed gas plant site are:

- the new University of Nouakchott located 2.7 km south/southwest of the proposed gas processing facility, still under construction (see *Figure 3.7*); and
- some scattered permanent residential buildings located 3.8 km west /northwest of the proposed gas processing facility, including also few temporary tents (see *Figure 3.8*).

These receptors have been identified by a desktop analysis of the local cartography or satellite images and confirmed by means of site visit to verify the state of the buildings and the presence of inhabitants.

*Figure 3.6* *Air Quality (AQ) receptors*

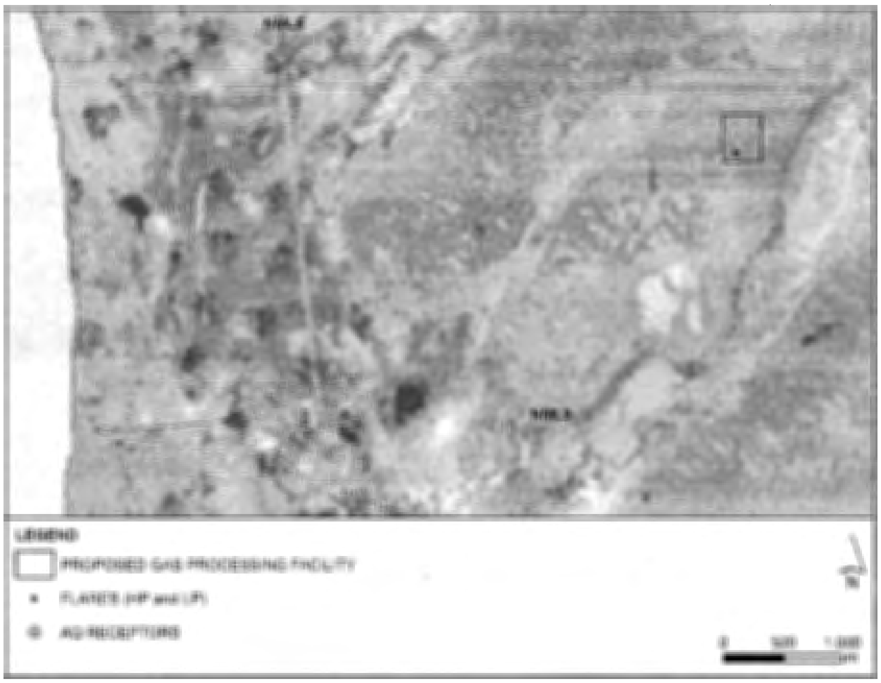



*Figure 3.7* *Pictures of the current University of Nouakchott Construction Site (November 2012)*

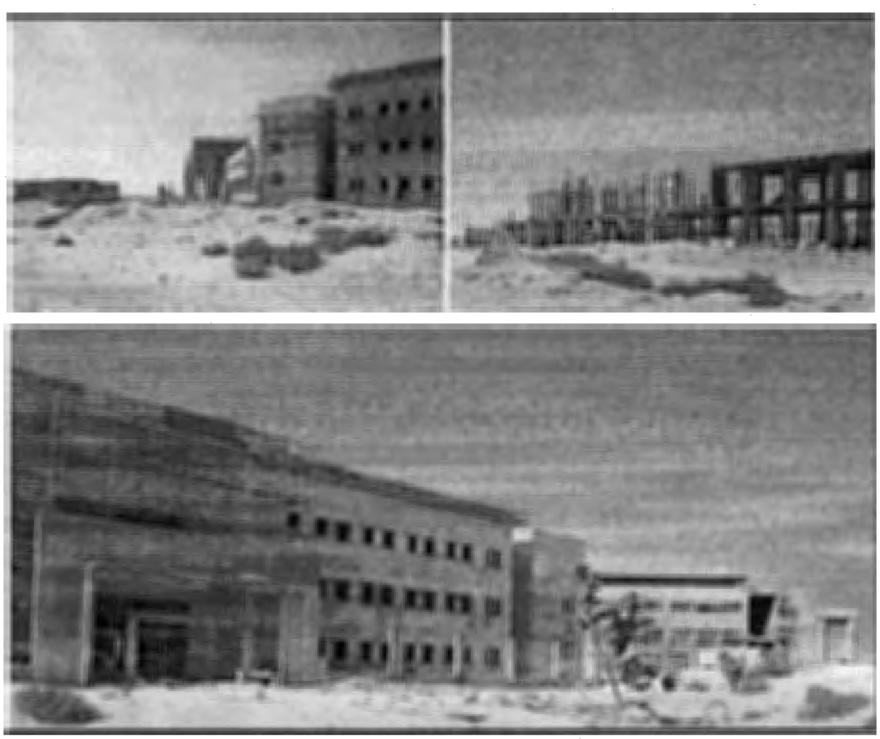
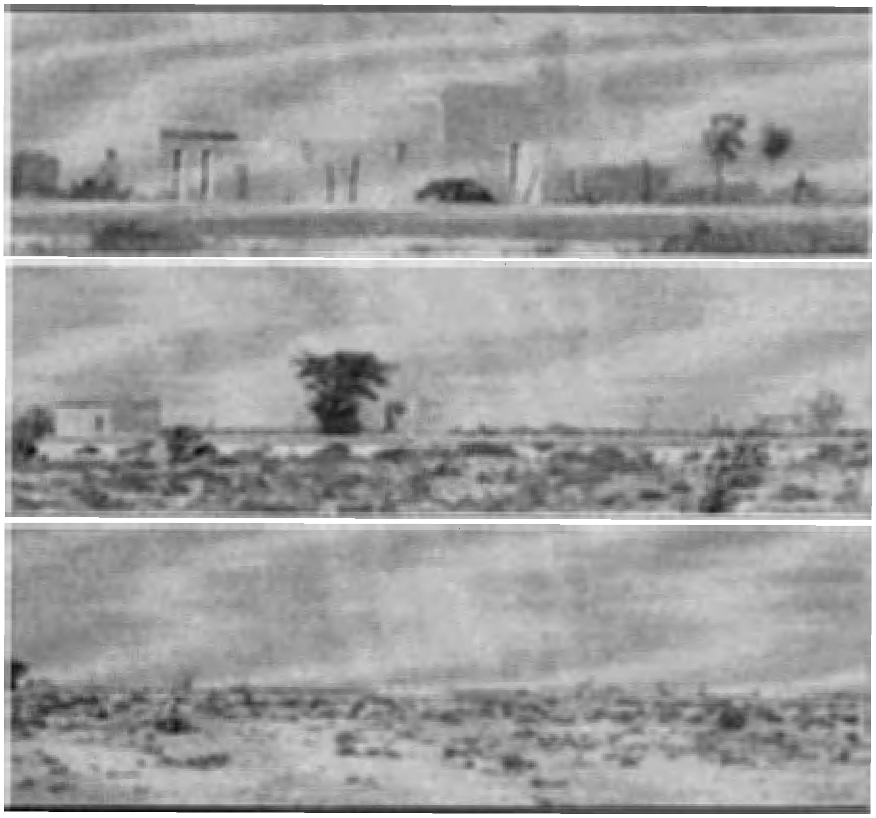


*Figure 3.8 Permanent Residential Buildings Located 3.8 km West of the Site (November 2012)*



# 4 RESULTS AND CONCLUSION

## 4.1 OPERATIONAL SCENARIO: IMPACT DESCRIPTION AND SIGNIFICANCE

The Project process contribution (hereinafter "PC") to local air quality in the operational scenario, has been modelled using the CALMET-CALPUFF modelling system; CALPUFF calculated $NO_2$ , CO and $PM_{10}$ ground level concentrations induced by the HP and LP flares operational activity, over an area of 30 km X 30 km, with a 500 m resolution.

Moreover, in order to assess potential impacts, the PC has been analysed with respect of the significance criteria set out in *Section 3.5* thus modelled PC have been compared against IFC air quality standards for short and long term concentrations.

*Table 4.1* provides a summary of the results of the performed modelling study along with the significance of impacts on local air quality assessed with respect to IFC Air Quality Standards.

**Table 4.1** ***Operational Scenario: Modelled Concentrations of Atmospheric Pollutants and Significance of Impacts on Local Air Quality***

| Pollutant | Parameter | Modelled concentrations [μg/m³ ] | IFC AQS [μg/m3 ] | Impact Significance |
|---|---|---|---|---|
| $NO_2$ | Annual average | 0.15 | 40 | Negligible |
| | Maximum hourly concentration | 1.87 | 200 | Negligible |
| CO | 8h moving average(*)(**) | 7.62 | 10000(*)(**) | Negligible |
| $PM_{10}$ | Annual average | 0.42 | 20 | Negligible |
| | Maximum Daily average | 1.41 | 50 | Negligible |

*(*) WHO Air Quality Guidelines for Europe*

*(**)The maximum daily eight-hour mean concentration will be selected by examining eight-hour running averages, calculated from hourly data and updated each hour. Each eight-hour average calculated will be assigned to the day on which it ends, i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day will be the period from 16:00 to 24:00 on that day.*

The *Table* shows that all pollutants concentrations modelled for the operational scenario comply with IFC air quality standards. In particular modelled concentrations of CO are four orders of magnitude smaller than their respective AQS.

According to the impact significance levels described in *Section 3.5*, impacts on local air quality due to $NO_2$, CO and $PM_{10}$ ground level concentrations induced by the combustion of purge gas at the HP and LP flares have been assessed as **Negligible.**

Modelled pollutants concentration were spatially localised by mean of iso-concentration maps, for $NO_2$ and $PM_{10}$. These contour maps are shown in the following figures:

- *Figure 4.1* *Operational Scenario: Predicted Annual Average Concentration.*
- *Figure 4.2* *Operational Scenario: Maximum Predicted Hourly Concentration.*
- *Figure 4.3* *Operational Scenario: Predicted Annual Average Concentration.*
- *Figure 4.4* *Operational Scenario: Maximum Predicted Daily Concentration.*

The iso-concentration maps shows that concentration maxima are localised downwind, thus south-east of flares; moreover the areas affected by the concentration maxima are confined in the near proximity of the Project atmospheric emission sources.

*Figure 4.1 Operational Scenario: Predicted Annual Average Concentration for $NO_2$*

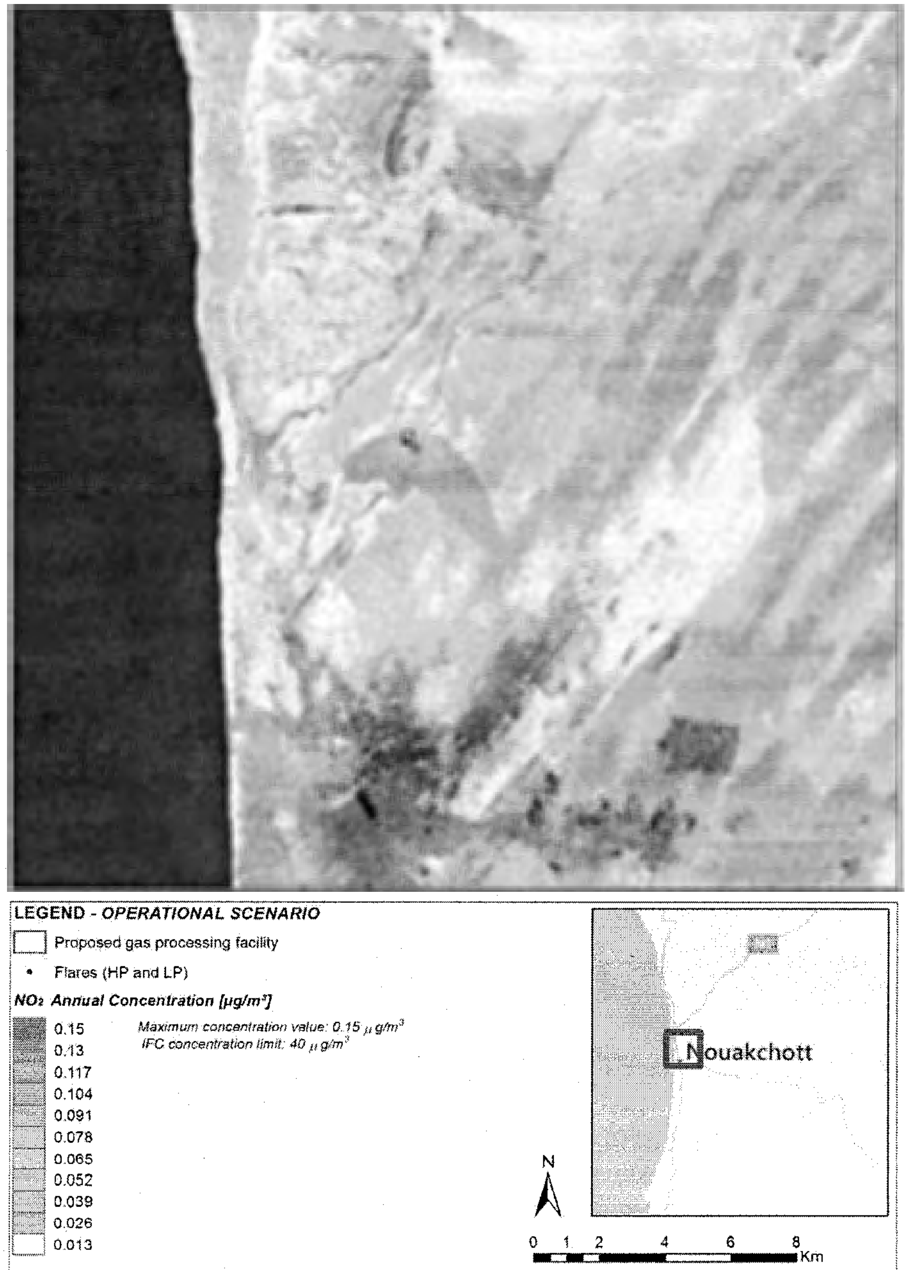


*Figure 4.2* *Operational Scenario: Maximum Predicted Hourly Concentration for $NO_2$*

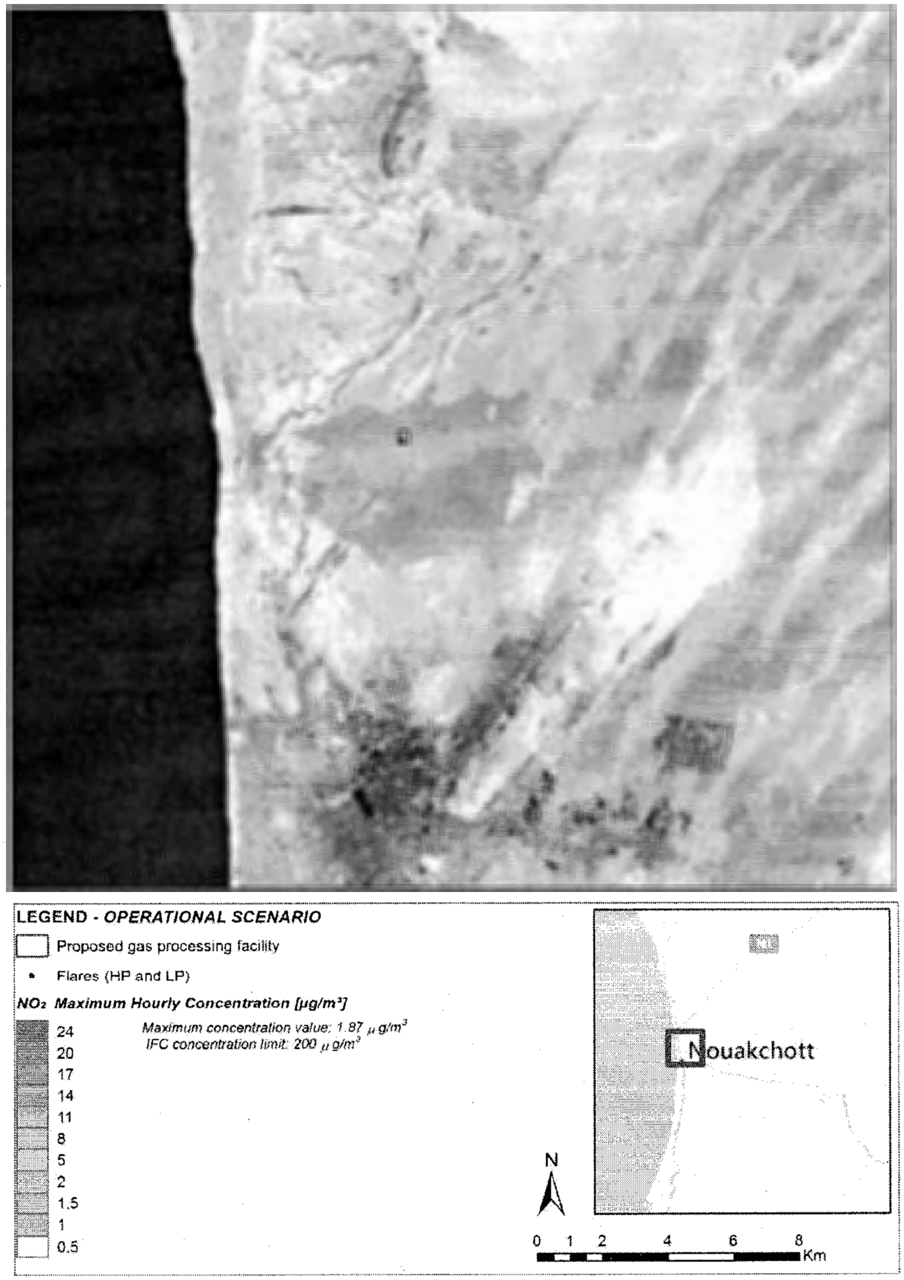


*Figure 4.3* *Operational Scenario: Predicted Annual Average Concentration for $PM_{10}$*

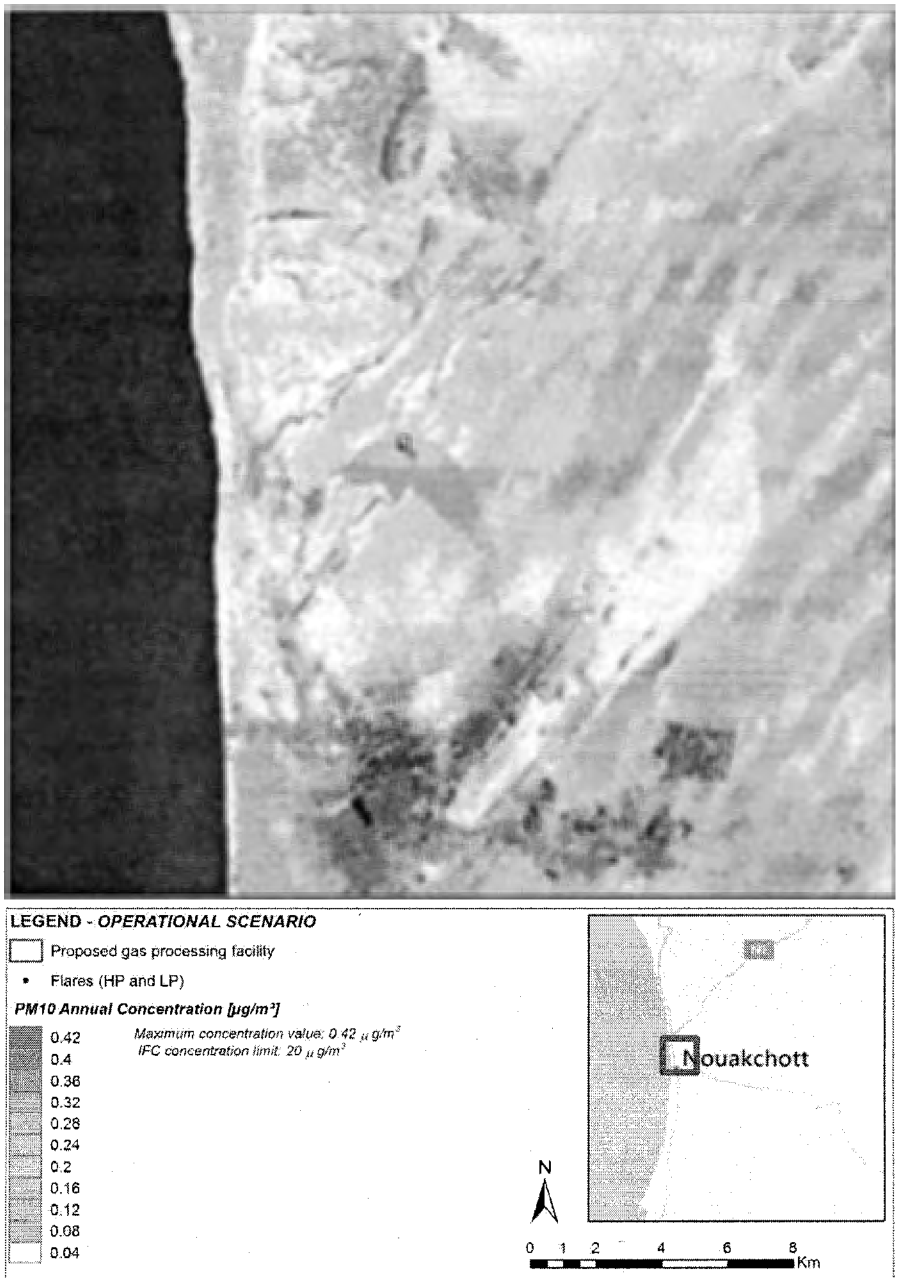
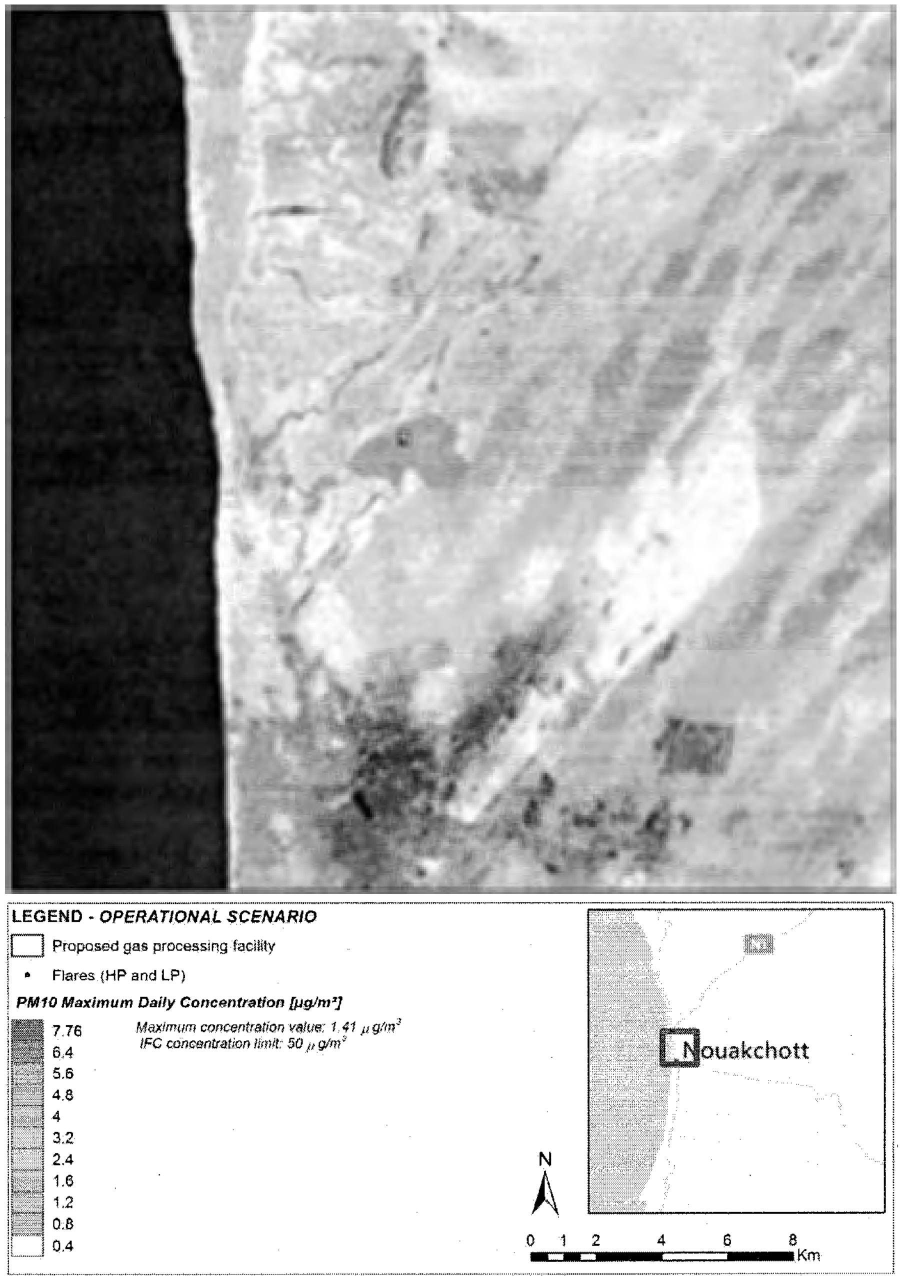


*Figure 4.4 Operational Scenario: Maximum Predicted Daily Concentration for $PM_{10}$*



## 4.2 *EMERGENCY SCENARIO: IMPACT DESCRIPTION AND SIGNIFICANCE*

Similarly to the modelling study carried out for the operational scenario, the Project contribution (process contribution: PC) to local air quality in the worst emergency case, has been modelled using the CALMET-CALPUFF modelling system; CALPUFF calculated $NO_2$ , CO and $PM_{10}$ ground level concentrations induced by the Power Plant activity, over an area of 30 km X 30 km, with a 500 m resolution.

Moreover, in order to assess potential impacts, the PC has been analysed with respect of the significance criteria set out in *Section 3.5* thus modelled PC have been compared against IFC air quality standards. It has to be noted that modelled pollutants ground level concentration obtained for the emergency scenario have only been compared against short term air quality standards, due to the short term nature of emergency events.

*Table 4.2* provides a summary of the results of the performed modelling study along with the significance of short term impacts on local air quality assessed with respect to IFC Air Quality Standards.

***Table 4.2*** ***Emergency Scenario: Modelled Concentrations of Atmospheric Pollutants and Significance of Impacts on Local Air Quality***

| Pollutant | Parameter | Modelled concentrations [μg/m³ ] | IFC AQS [μg/m3 ] | Impact Significance |
|---|---|---|---|---|
| $NO_2$ | Maximum hourly concentration | 24.05 | 200 | Minor |
| CO | 8h moving average(*)(**) | 43.00 | 10000(*)(**) | Negligible |
| $PM_{10}$ | Maximum Daily average | 7.76 | 50 | Minor |

*(*) WHO Air Quality Guidelines for Europe*
*(**)The maximum daily eight-hour mean concentration will be selected by examining eight-hour running averages, calculated from hourly data and updated each hour. Each eight-hour average calculated will be assigned to the day on which it ends, i.e. the first calculation period for any one day will be the period from 17:00 on the previous day to 01:00 on that day; the last calculation period for any one day will be the period from 16:00 to 24:00 on that day.*

As clearly apparent from the previous table all pollutants concentrations modelled for the emergency scenario comply with IFC air quality standards. In particular modelled concentrations of CO are three orders of magnitude smaller than their respective AQS.

According to the impact significance levels described in *Section 3.5*, impacts on local air quality due to CO ground level concentrations induced by the combustion of gas at the HP and LP flares in emergency conditions have been classified as **Negligible;** whereas impacts due to $NO_2$,and $PM_{10}$ ground level concentrations have been classified as **Minor**.

In comparison with the model results obtained for the operational scenario, short term modelled concentrations obtained for the emergency scenario appear to be higher. This trend was expected considering the higher atmospheric emissions produced in the identified emergency case. However, only **minor** impacts on local air quality are expected for the emergency scenarios.

Similarly to what is shown in the previous section for the operational scenario, pollutants concentration modelled for the emergency scenario were spatially localised by mean of iso-concentration maps, for $NO_2$ and $PM_{10}$ short term concentrations. These contour maps are shown in the following figures:

- *Figure 4.5* *Emergency Scenario: Maximum Predicted Hourly Concentration.*
- *Figure 4.6* *Emergency Scenario: Maximum Predicted Daily Concentration.*

In order to enable a comparison between model results obtained for the operational and the emergency scenarios, the same classes of concentration values have been adopted in the iso- concentration maps related to the future and present scenarios.

*Figure 4.5* *Emergency Scenario: Maximum Predicted Hourly Concentration for $NO_2$*

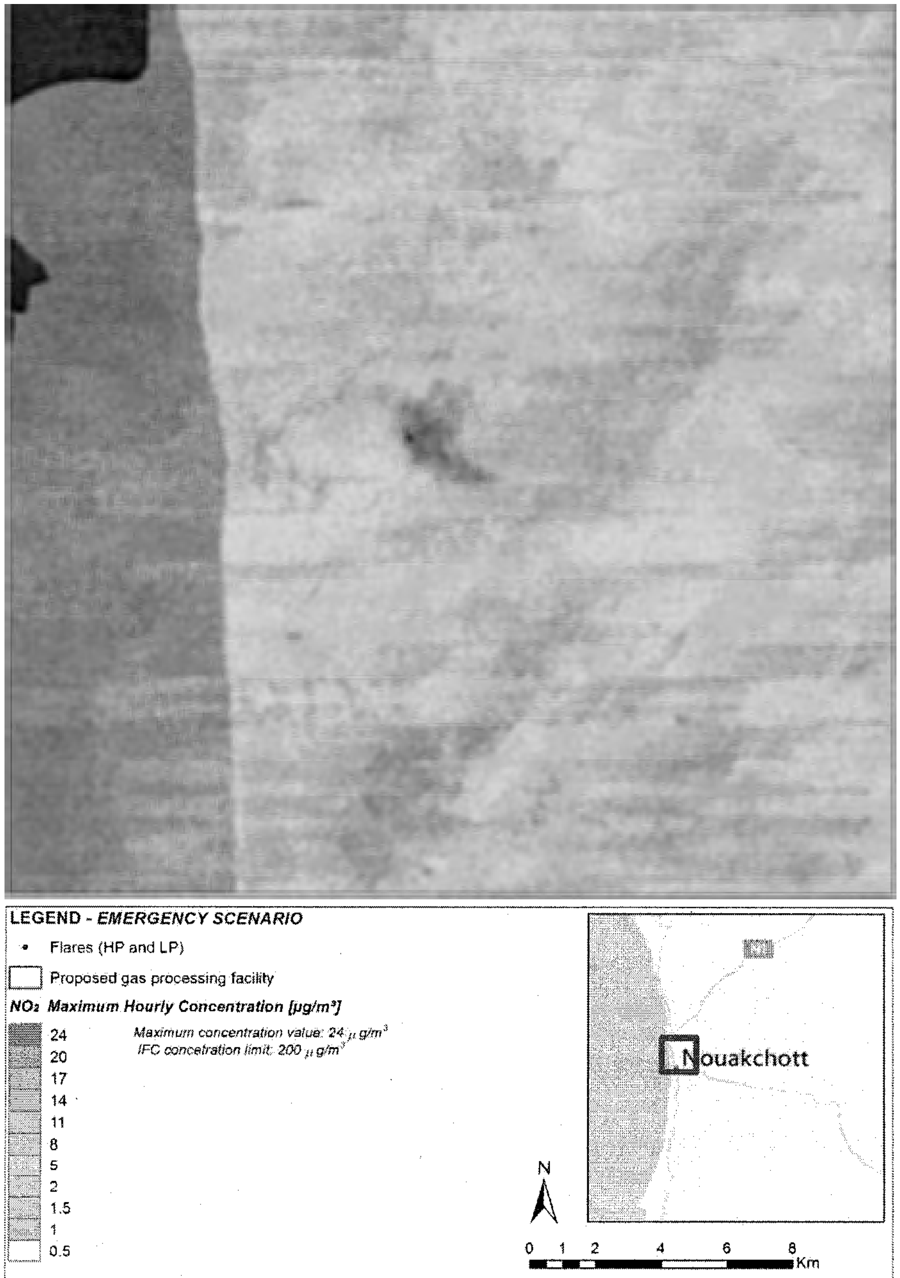
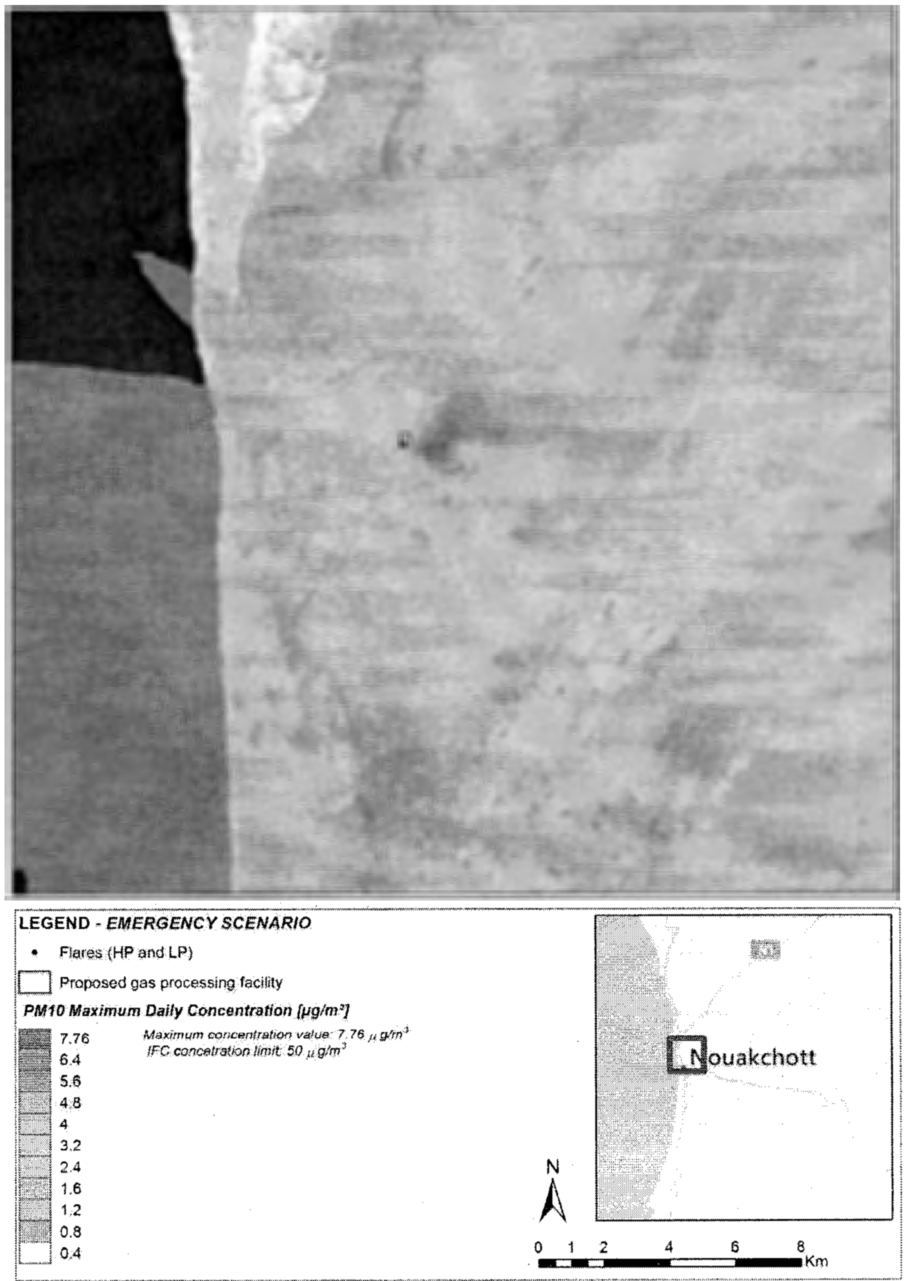


*Figure 4.6* *Emergency Scenario: Maximum Predicted Daily Concentration for $PM_{10}$*




The iso concentration maps shows that the concentration maxima are localised downwind, thus east south-east of the flares and the areas affected by the concentration maxima are confined in the proximity of the project atmospheric emission sources.

The maximum value for $NO_2$ hourly concentrations and $PM_{10}$ daily concentrations occurs at a distance of approximately 33 m and 79 m from the flare, respectively.

Time series extracted at the NML8 and NML9 locations for modelled short term concentrations of $NO_2$ and $PM_{10}$ are presented in the following Figures:

- *Figure 4.7 Time series of NO2 hourly concentrations at the receptor NML8 (Settlement near Nouakchott- Nouadhibou road).*
- *Figure 4.8 Time series of NO2 hourly concentrations at the receptor NML9 (University).*
-

*Figure 4.9 Time series of PM10 daily concentrations at the receptor NML8 (Settlement near Nouakchott- Nouadhibou road).*

- *Figure 4.10 Time series of PM10 daily concentrations at the receptor NML9 (University).*

***Figure 4.7 Time series of $NO_2$ hourly concentrations at the receptor NML8 (Settlement near Nouakchott- Nouadhibou road)***

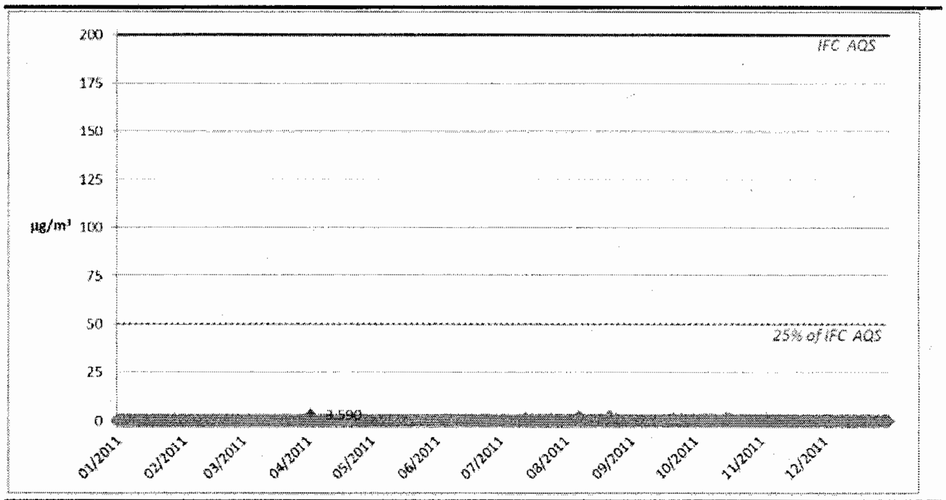



***Figure 4.8 Time series of $NO_2$ hourly concentrations at the receptor NML9 (University)***

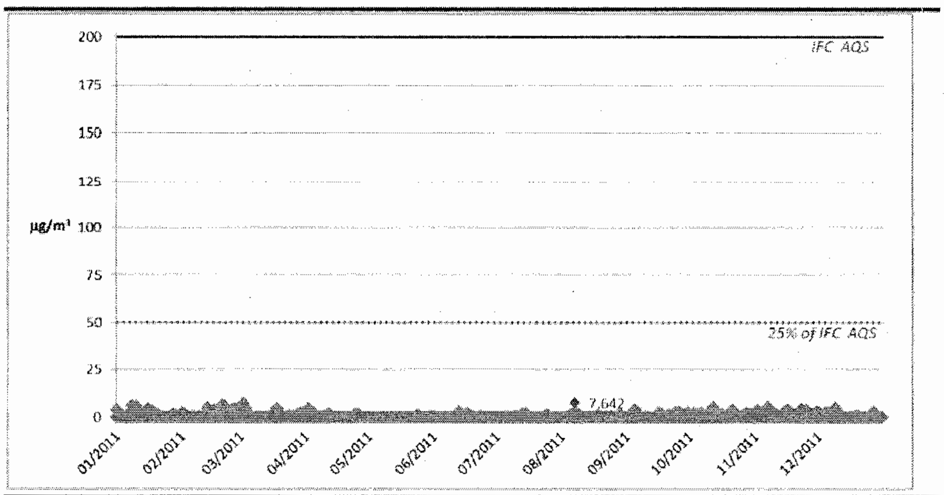


*Figure 4.9* *Time series of $PM_{10}$ daily concentrations at the receptor NML8 (Settlement near Nouakchott- Nouadhibou road)*

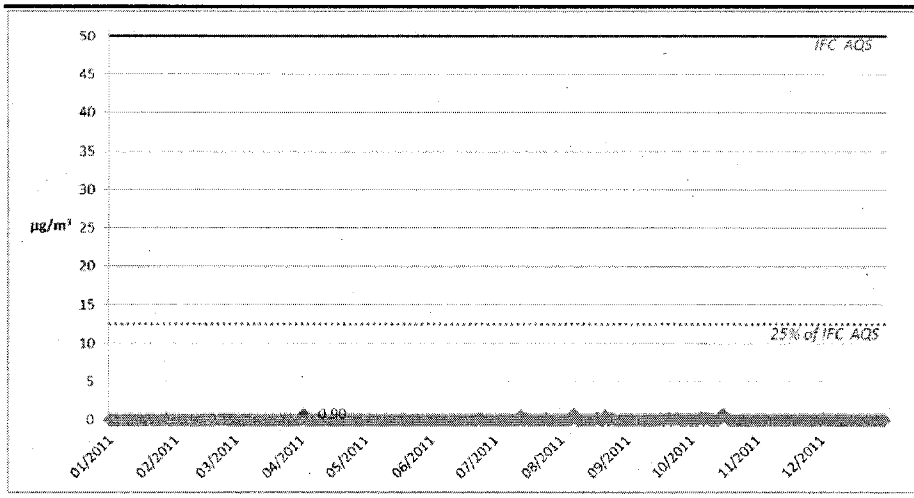
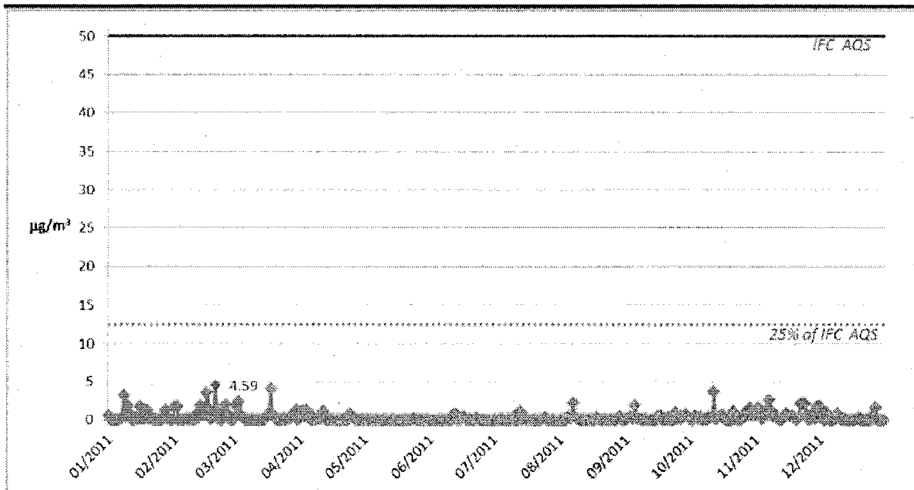



*Figure 4.10* *Time series of $PM_{10}$ daily concentrations at the receptor NML9 (University)*




As clearly apparent from the previous Figures, short term concentrations of $NO_2$ and $PM_{10}$ modelled for the emergency scenario are significantly below in force AQS Standards set by the IFC guidelines. In particular, maximum modelled concentrations at receptors accounts for less of the 5% of the regulatory limits, thus even in emergency cases, impacts on local air quality at the closest receptors are classified as **Negligible**.

## 5 *CONCLUSIONS*

The performed atmospheric dispersion study quantified the atmospheric ground-level concentrations of $NO_2$, CO and $PM_{10}$ produced by the atmospheric emissions associated to the Banda Gas Project under operational and emergency conditions.

Modelled ground level concentrations enabled the comparison with in force air quality standards, set by the IFC guideline, and subsequently the assessment of the significance of impacts on local air quality. It has to be noted that modelled pollutants ground level concentration obtained for the emergency scenario have only been compared against short term air quality standards, due to the short term nature of emergency events.

The project contribution in terms of induced ground level concentrations of CO, is **Negligible** both for the operational and the emergency scenarios.

The project contribution in terms of induced ground level concentrations of PM and $NO_2$, is **Negligible** for the operational scenario and **Minor** for the emergency scenario.

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Annex B-3

# Noise Baseline and Modelling

*TABLE OF CONTENTS*

*LIST OF FIGURES*



*LIST OF TABLES*

## 1 *GLOSSARY OF TERMS AND DEFINITIONS*

### 1.1 *ABBREVIATIONS*

| | |
|---|---|
| **dB** | Decibel |
| **dBA** | A-weighted decibel |
| **IEC** | International Electrotechnical Commission |
| **Hz** | Hertz |
| **IFC** | International Finance Corporation |
| **ISO** | International Standards Organization |
| **Laeq** | Equivalent Continuous A-weighted Sound Level |
| **Leq** | Equivalent Continuous Sound Level |
| **Lmax** | Maximum Sound Level |
| **Ln** | Percentile Level |
| **Lp (or SPL)** | Sound Pressure Level |
| **Lw (or SWL)** | Sound Power Level |
| **NML** | Noise Measurement Location |
| **NSR** | Noise Sensitive Receptors |
| **WB** | World Bank |
| **WHO** | World Health Organization |

### 1.2 *GLOSSARY*

| | |
|---|---|
| **Acoustic calibrator** | An instrument providing a reference noise source used to calibrate and check the performance of sound level meters. |
| **Ambient Noise** | The totally encompassing sound in a given situation at a given time usually being composed of sound from many sources near and far. |
| **A Weighting** | A standard weighting of the audible frequencies designed to reflect the response of the human ear to noise. |
| **Background noise** | The noise at a given location and time, measured in the absence of any alleged noise nuisance sources, also known as residual noise. |
| **Class 1** | Precision grade meters for laboratory and field use - also known as Type 1. |
| **Class 2** | General grade meters for field use - also known as Type 2. |

| | |
|---|---|
| **Decibel** | A unit of sound measurement which quantifies pressure fluctuations associated with noise and overpressure. The dB is a logarithmic unit used to describe a ratio between the measured level and a reference or threshold level. |
| **Equivalent Continuous A-weighted Sound Level** | The constant sound level that, in a given time period, would convey the same sound energy as the actual time-varying A-weighted sound level. |
| **Equivalent Continuous Sound Level** | The energy average of the varying noise over the sample period. It is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. |
| **Free field** | A free field or space occurs if there are no adjacent reflecting surfaces. |
| **Frequency** | The number of times that a periodic function or vibration occurs or repeats itself in a specified time, often 1 second. It is usually measured in hertz (Hz). |
| **Frequency Band** | A continuous range of frequencies between two limiting frequencies (i.e. 1/1 octave and 1/3 octave). |
| **Hertz** | The measure of frequency of sound wave oscillations per second - 1 oscillation per second equals 1 hertz. |
| **$L_{A10}$** | It is the noise level just exceeded for 10 of the measurement period, A-weighted and calculated by statistical analysis. The LA10 is a common noise descriptor for environmental noise and road traffic noise. |
| **$L_{A90}$** | It is the noise level exceeded for 90 of the measurement period, A-weighted and calculated by statistical analysis. It's usually used to describe background noise level. |
| **$L_{An}$** | Percentile level. Noise level exceeded for n of the measurement period with A-weighted, calculated by statistical analysis - where n is between 0.01 and 99.99 . |
| **$L_{Amax}$** | The maximum of the sound pressure levels recorded over an interval of 1 second. |
| **Measurement time** | The duration of a noise measurement. |

| | |
|---|---|
| **Noise emission level** | The dBA level measured at a specified distance and direction from a noise source, in an open environment, above a specified type of surface. Generally follows the recommendation of a national or industry standard. |
| **Octave** | A range of frequencies whose upper frequency limit is twice that of its lower frequency limit. In acoustical measurements, sound pressure level is often measured in octave bands, and the centre frequencies of these bands are defined by ISO. 1/1, 1/3 are used in acoustic. |
| **Omni-directional Source** | A source that emits equal amounts of energy in all directions and generates spherical waves. |
| **Sound Pressure Level** | The basic measure of noise loudness expressed in decibels. The level of the root-mean-square sound pressure in decibels given by: $SPL = 10*\log_{10}(p/p_0)$ where p is the rms sound pressure in Pascal and $p_0$ is the sound reference pressure at 20 μPa. |
| **Sound Power Level** | A measure of the energy emitted from a source as sound and is given by : $SWL = 10*\log_{10}(W/W_0)$ where W is the sound power in watt and $W_0$ is the sound reference power at $10^{-12}$ watt. |
| **Sound Level Meter** | An instrument, usually hand-held, designed to measure a frequency-weighted value of the sound pressure level in accordance with an accepted national or international standard. |
| **Spectrum** | the description of a sound wave's resolution into its components of frequency and amplitude. |

# 2 NOISE BASELINE ASSESSMENT

## 2.1 INTRODUCTION

An important part of the noise assessment is the quantification and understanding of the existing acoustic environment, including the identification of baseline noise levels at the location of nearby receptors that have the potential to be sensitive to a change in ambient noise levels. The baseline environment can be defined as the conditions that would prevail in the absence of the Project; it is intended to describe the spatial planning and the status of the noise climate in the area surrounding the Project site, setting the scene for the assessment of the potential noise impacts created by the Project.

This Section includes the environmental noise standards and guidelines applicable to the Project (*Section 2.2*), the approach taken for the baseline noise survey (*Section 2.4*) as well as the preliminary findings (*Section 2.5*).

Detailed supporting information is provided in the following Sections:

- *Section 1* - Acoustics: Glossary of Terms and Definitions.
- *Appendix 1* – Baseline Noise Monitoring Results.

## 2.2 ENVIRONMENTAL NOISE STANDARDS AND GUIDELINES

A brief description of the legislation, legal and institutional framework of noise requirements that would apply to the Project site and the surrounding areas is reported in the following paragraphs.

Mauritania currently does not have any specific national standards and procedures for the regulation of noise but only establishes general recommendations (Law n°2000-045 of 26th July 2000)).

Therefore, the IFC (International Finance Corporation) criteria have been applied for this Project . In addition the South African National Standards (SANS) codes of practice that have been developed based on the requirements of the IFC as well as the International Standard Organisation (ISO), have been considered for additional reference.

### 2.2.1 *IFC Guidelines for Ambient Noise Levels*

*Table 2.1* detail the IFC guidelines to community ambient noise levels, that prescribe an absolute level of 55 dB(A) during the daytime and 45 dB(A) during night time value in residential areas. These values make reference to noise from facilities and stationary noise sources, and are commonly applied as design standards for industrial facilities, and whilst this may imply they relate to some threshold of noise effects in a general sense, the IFC has indicated that they are not directly applicable to transport or mobile noise sources. Measurements are to be taken at noise receptors located outside the Project property boundary.

In environments where the ambient noise levels already exceed a level of 55 dB(A) daytime and/or 45 dB(A) night time the International Finance Corporation (IFC) include a guideline stating that noise emissions should not cause the ambient noise level in a residential area to rise by 3 dBA or more, determined during the noisiest hour of a 24 hour period.

*Table 2.1* *IFC Guidelines for Ambient Noise Levels*

| Receptor | Maximum Ambient Noise Level 1-hour Leq (dBA) | |
|---|---|---|
| | Daytime 06:00-22:00 | Night time 22:00-06:00 |
| Residential, Institutional, Educational | 55 | 45 |
| Industrial, Commercial | 70 | 70 |
| Notes: No noise levels for rural/desert areas are stipulated | | |

Referring to noise measurements, IFC gives several specifications on noise monitoring programs design, as follow:

- typical monitoring periods should be sufficient for statistical analysis and cover an appropriate time period according to noise variation (24h, hourly or more frequently); and
- monitors should be located approximately 1.5 m above ground and no closed to reflecting surface.

### 2.2.2 *World Health Organisation, Organisation for Economic Co-ordination and Development*

The standards applied by the international community are similar. The World Health Organisation (WHO) [1] together with the Organisation for Economic Co-ordination and Development (OECD) are two of the main bodies that have collected data and developed their own assessments on the effects of the exposure to environmental noise. On the basis of these assessments, guideline values for different time periods and situations have been developed.

The World Health Organization (WHO 1999) Guidelines for Community Noise (Eds B. Berglund, T. Lindvall, D.H. Schwela. Geneva: WHO) has given the following generic guidance concerning the onset of health effects from noise:

- To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB $L_{Aeq}$ for a steady, continuous noise. To protect the majority of people from being moderately annoyed during

(1) The World Health Organisation (WHO) offers similar advice on noise levels to the IFC.

the daytime, the outdoor sound pressure level should not exceed 50 dB LAeq.

- At night, sound pressure levels at the outside façades of the living spaces should not exceed 45 dB LAeq and 60 dB LAMax, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 dB.

### 2.2.3 *South African National Standards (SANS)*

*SANS 10328; (2003) Methods for Environmental Noise Impact Assessment*

SANS 10328 details the procedures and requirements to be followed in carrying out an environmental noise impact assessment. Under the requirements of this Standard an environmental noise impact assessment is necessary because of the change in land-use from bush and desert to industry.

*SANS 10103; (2004) The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication.*

The measurement procedure prescribed by SANS 10103 is derived from ISO 1996-1-3 'Description and Measurement of Environmental Noise'. SANS 10103 defines the basic quantities to be used for the description of noise in community environments and describes the basic procedures for the termination of these quantities. It also describes the methods for acquisition of data that enable specific noise situations to be checked for compliance with given noise limits.

SANS 10103 provides a guideline for estimating community response to an increase in the general ambient noise level caused by an intruding noise. *Table 2.2* details the community response to changes in noise levels.

**Table 2.2** ***Categories of Community Response to Changes in Noise Levels***

| Excess Change Lreg,T dBA | Estimated Community Response | |
|---|---|---|
| | Category | Description |
| 0 | None | No observed reaction |
| 0-10 | Little | Sporadic complaints |
| 5-15 | Medium | Widespread complaints |
| 10-20 | Strong | Threats of action |
| >15 | Very strong | Vigorous action |

Notes: There are overlapping areas in the categories of responses to increases. This is specifically done to underline the fact that there is no clear-cut transition from one community response to another. Instead, the transition is more gradual and may differ substantially from one scenario to another, depending on a large number of variables.

## 2.3 *ACOUSTIC CHARACTERISTICS OF THE PROJECT SITE*

Based on a desktop analysis, it was anticipated that, since the proposed area is not populated and does not host any specific industrial activities, the acoustic environment has low ambient noise levels which will not vary considerably across the Project area. The Project study area consists mainly of a sparsely populated desert environment and the whistling wind is the main source of noise. This was confirmed on the field, were no specific source of significative noise emission was detected during the site visit.

The Project site is located about 9 km north of the city of Nouakchott. It is characterized by fixed and semi-fixed dunes , alternating with some depression areas of salty clay called "*sebkha*". The site and its wider environment are are used by shepherds for the grazing of herds of camels and goats and crossings to remote places.

The nearest buildings identified along the proposed pipeline route and in the vicinity of the proposed gas plant site are:

- the new University of Nouakchott located 2.7 km south/southwest of the proposed gas processing facility, still under construction (see *Figure 2.1*); and

- some scattered permanent residential buildings located 3.8 km west /northwest of the proposed gas processing facility, including also few temporary tents (see *Figure 2.2*).

These receptors have been identified previously by a desktop analysis of the local cartography or satellite images and confirmed by means of site visit to verify the state of the buildings and the presence of inhabitants.

In addition to the future noise sources related to the Project, in the study area the only noise emissions derives from Nouakchott-Nouadhibou road traffic, even if no relevant noteworthy infrastructure affects the area.

*Figure 2.1* *Pictures of the current University of Nouakchott Construction Site (November 2012)*

*Figure 2.2* *Permanent Residential Buildings Located 3.8 km West of the Site (November 2012)*

## 2.4 *ASSESSMENT METHODOLOGY*

### 2.4.1 *Noise Baseline Measurements*

*Equipment*

Ambient noise levels for the Project Area were measured by undertaking a series of attended short-term measurements during the day over the period 6-7 November 2012.

A LarsonDavis Type 1 Sound Level Meter (SLM) was used to conduct the attended noise measurements, in compliance with IEC 61672-1/2/3:2002 regulations. The sound level meter was calibrated prior to use with a portable certified acoustical calibrator and the calibration was checked and verified after each period of use. No significant calibration drift was detected.

In detail, for the noise survey of November 2012 and for the data elaboration, the following instrumentation has been used:

- sound meter level: Larson Davis 831;
- microphone/preamplifier: Larson Davis PRMLXT1;
- calibrator: Larson Davis CAL 200; and
- software: Spectra Noise Work Win.

Meteorological conditions during the measurement period were observed as predominantly sunny; windy events did occur over the period of measurement, even if the average wind speed was always under 5 m/s. The average temperature was 31.2 degrees Celsius (°C).

*Monitoring Location and Intervals*

These locations were deemed representative of the acoustic environment for the typical desert areas, located at the Project site.

The SLM was set on a tripod to a height of 1.5 m. No reflective surface (except ground) was present in the area, so that it was a free-field measurement. The SLM automatically logged environmental noise measurement parameters including $L_{Aeq}$, $L_{A90}$, $L_{A10}$, $L_{AMax}$ and $L_{AMin}$ parameters.

Short term measurements were collected at a total of seven locations at 10 minute intervals (*Figure* 2.3, NML1 to NML7) in correspondence of the Project site boundary to identify the nature, character and dominant noise sources within the Project area.

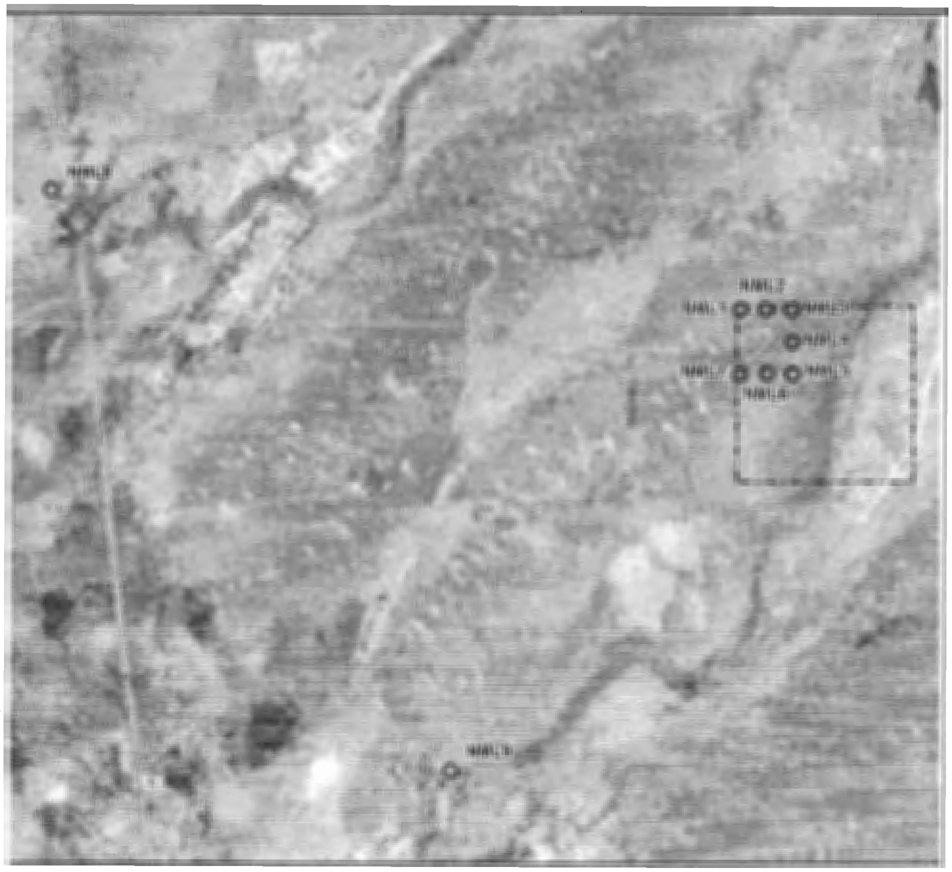
Due to the absence of any significant specific noise sources at or near the Project site, leading to very steady, low ambient noise conditions, a monitoring period of 10 minutes has been considered sufficient for statistical analysis and for covering any noise variations, according to IFC specifications on noise monitoring programs design.

*Project Surrounding Areas*

Two attended short-term (day time) measurements were undertaken to identify the nature, character and dominant noise sources surrounding the Project site (*Figure 2.3*, NML8 and NML9). A monitoring period of 1 hour per measurement site has been considered sufficient to provide a complete description of the noise levels and noise fluctuation during daytime.

The short-term SLM was set on a tripod to a height of 1.5m. No reflective surface (except ground) was present in the area, so that it was a free-field measurement. The SLM automatically logged environmental noise measurement parameters including $L_{Aeq}$, $L_{A90}$, $L_{A10}$, $L_{AMax}$ and $L_{AMin}$ parameters.

***Figure 2.3*** ***Noise Measurement Locations***



**Legend**

*Project Facilities*
- Onshore gas site
- Onshore gas terminal
- Onshore pipeline
- Proposed gas pipeline

*Noise Measurement Locations*
- Site boundary
- Near receptor

N

0 0.4 0.8 1.2 km

## 2.5 PRELIMINARY RESULTS

### 2.5.1 Noise Measurement Results. Site Boundary

The following series of graphs shows the results of measurements recorded at each of the seven attended short-term noise monitoring locations undertaken at the site boundary. *Appendix 1* reports the noise datasheet for each measurement.

*Figure 2.4* **Receptor NML1**

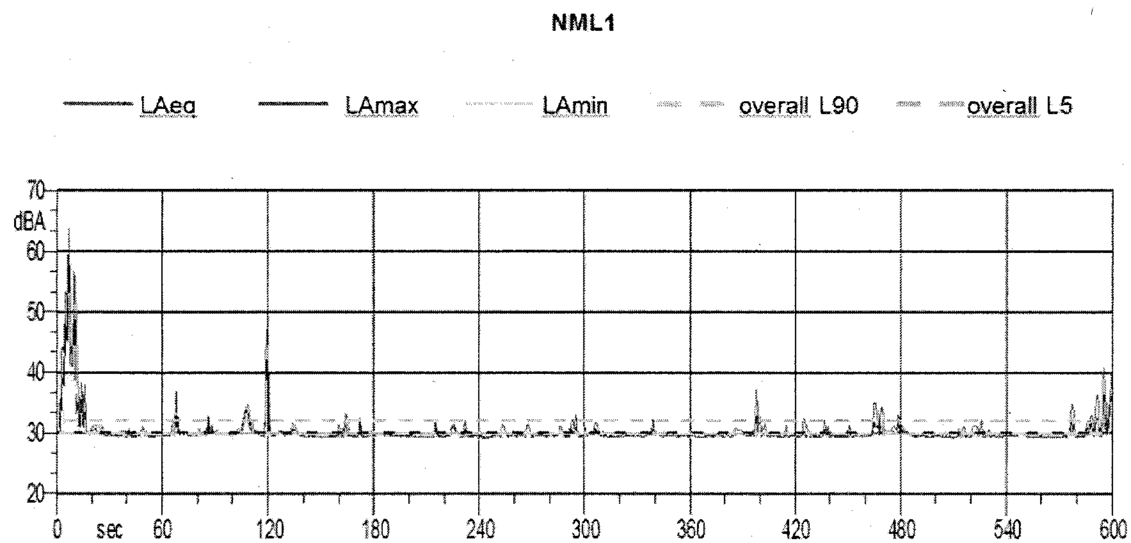



*Figure 2.5* **Receptor NML2**

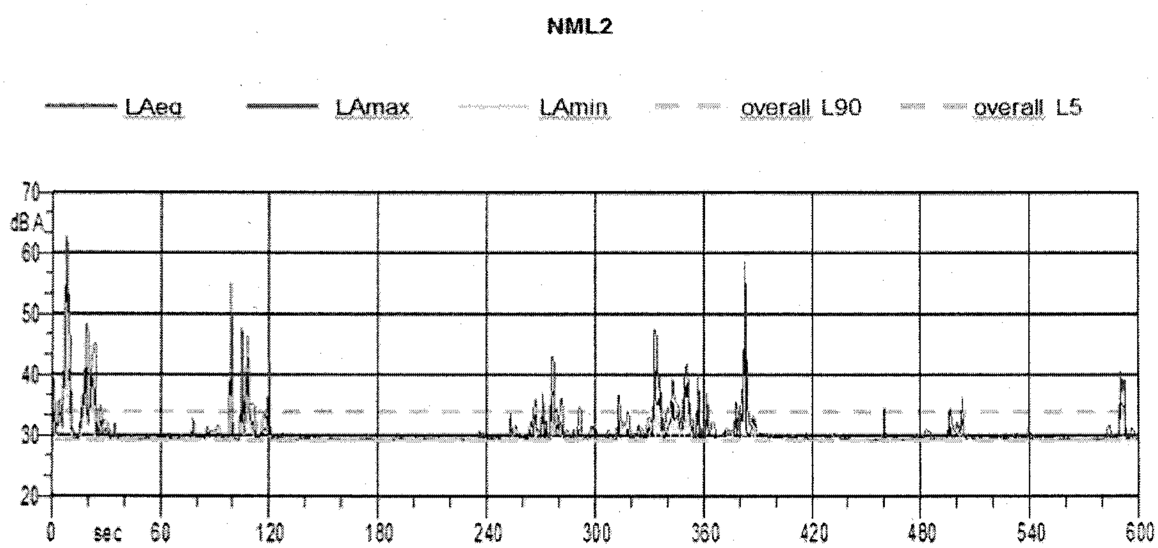


*Figure 2.6* *Receptor NML3*

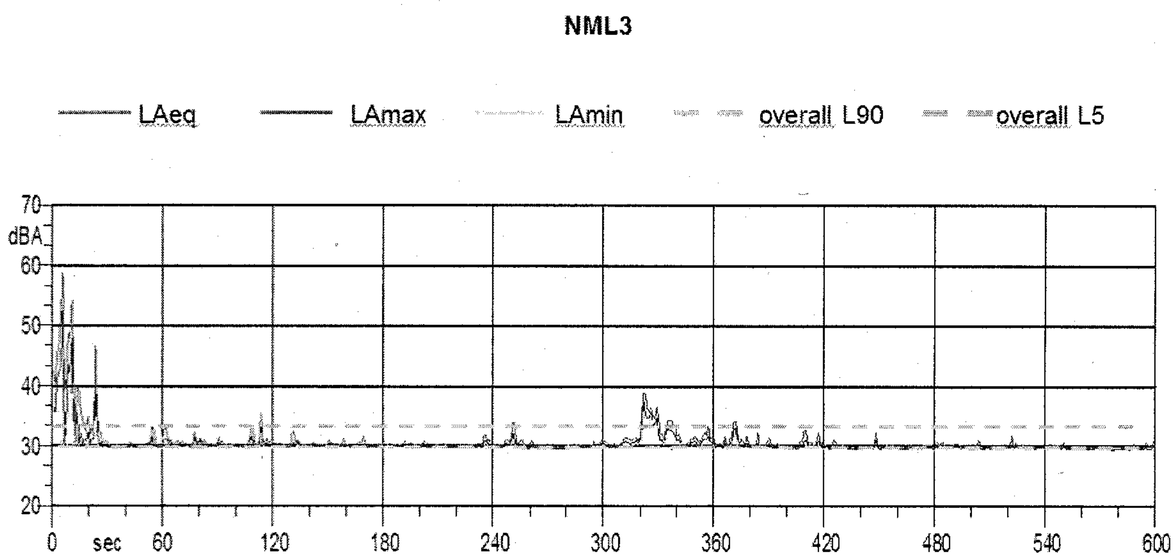



*Figure 2.7* *Receptor NML4*

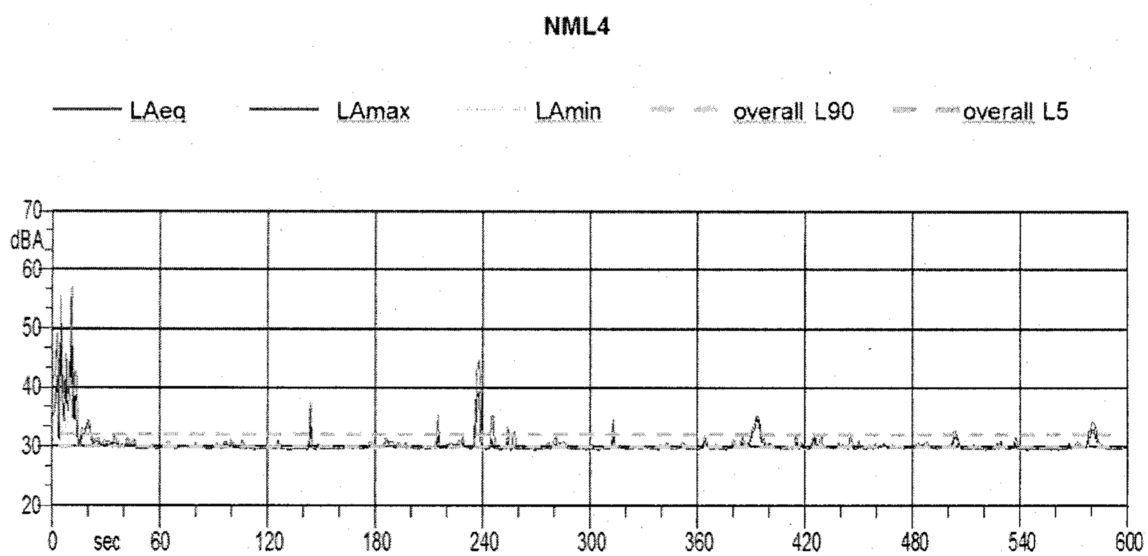


*Figure 2.8* *Receptor NML5*

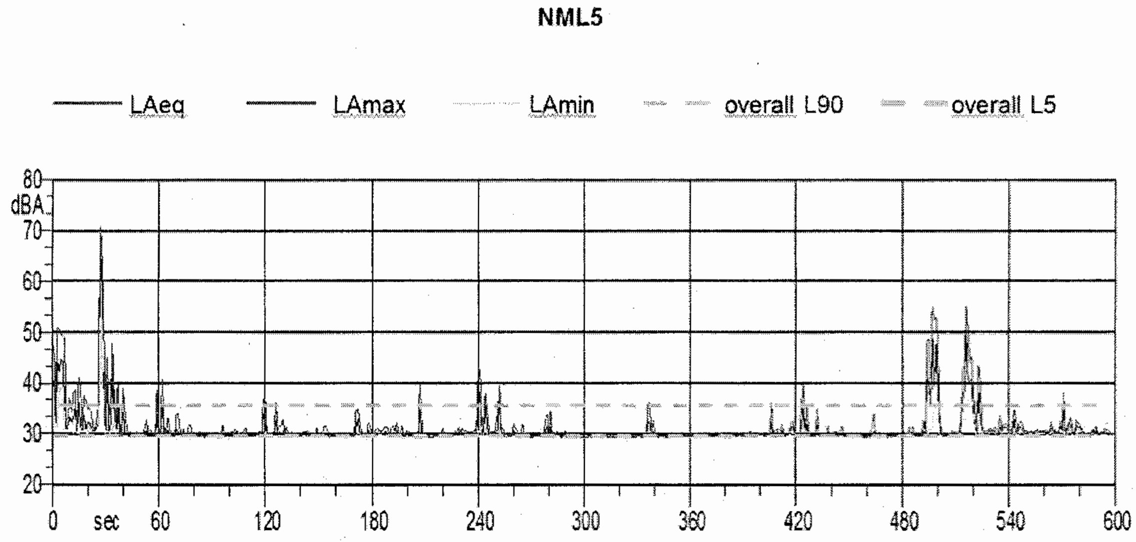



*Figure 2.9* *Receptor NML6*

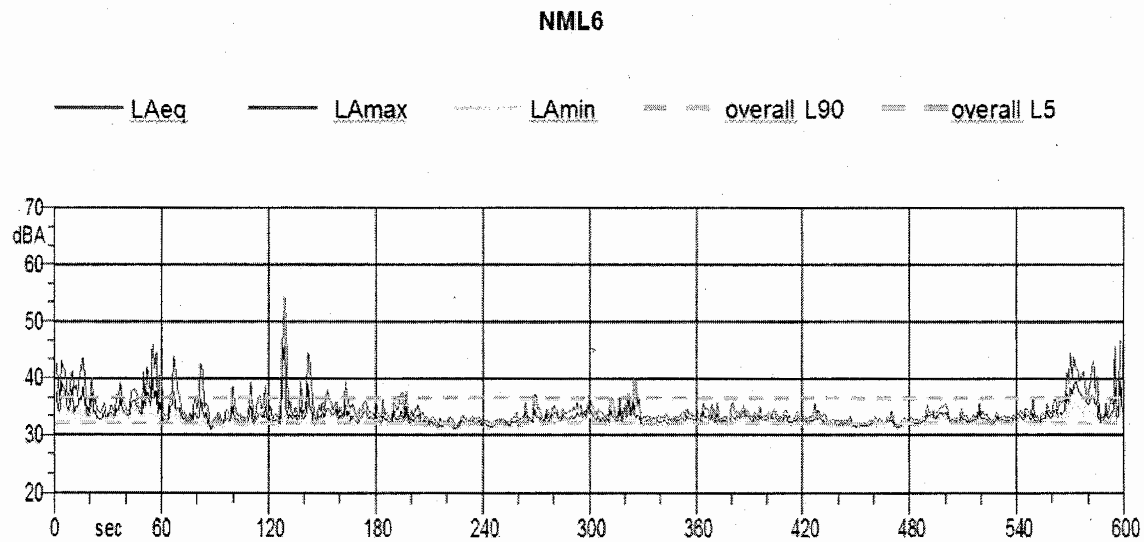


*Figure 2.10* *Receptor NML7*

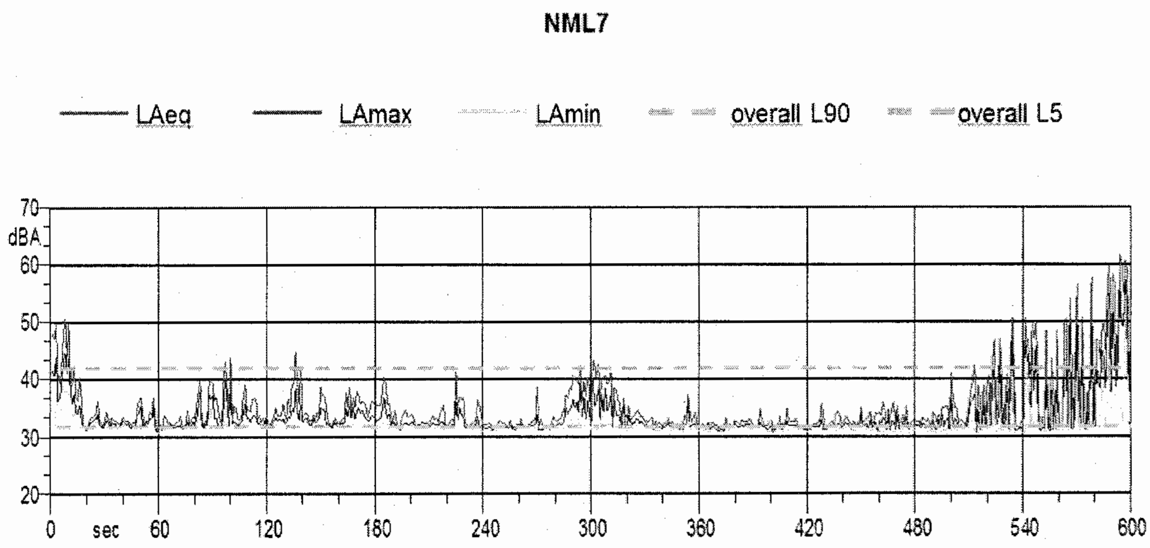



*Table 2.3* summarizes the daytime ambient noise levels at each of the the measurement on the site boundary.

*Table 2.3* ***Results of Attended Measurements. Site Boundary***

| Location | Coordinates (a) | | $L_{Aeq}$ [dBA] | $L_{A90}$ [dBA] | $L_{A5}$ [dBA] | $L_{A, min}$ [dBA] | $L_{A, max}$ [dBA] |
|---|---|---|---|---|---|---|---|
| | X [m] | Y [m] | | | | | |
| NML1 | 396661.01 | 2010941.59 | 34.1 | 29.3 | 31.3 | 29.2 | 58.5 |
| NML2 | 396804.68 | 2010942.38 | 35.0 | 29.3 | 34.1 | 29.2 | 59.4 |
| NML3 | 396953.11 | 2010942.38 | 32.0 | 29.5 | 32.2 | 29.4 | 52.3 |
| NML4 | 396954.70 | 2010755.85 | 31.4 | 29.4 | 31.6 | 29.3 | 50.4 |
| NML5 | 396956.29 | 2010573.29 | 40.3 | 29.4 | 35.3 | 29.3 | 66.4 |
| NML6 | 396815.00 | 2010574.08 | 33.7 | 32.0 | 36.4 | 31.1 | 45.8 |
| NML7 | 396657.04 | 2010573.29 | 38.4 | 31.3 | 42.2 | 30.8 | 57.2 |

Notes:
(a) Coordinate System: WGS 84 UTM 28N

### 2.5.2 *Noise Measurement Results. Near Receptors*

The following series of graphs shows the results of measurements recorded at both attended short-term noise monitoring locations undertaken at the nearest potential sensitive receptors. Annex 1 reports the noise datasheet for each measurement.

*Figure 2.11* *Receptor NML8*

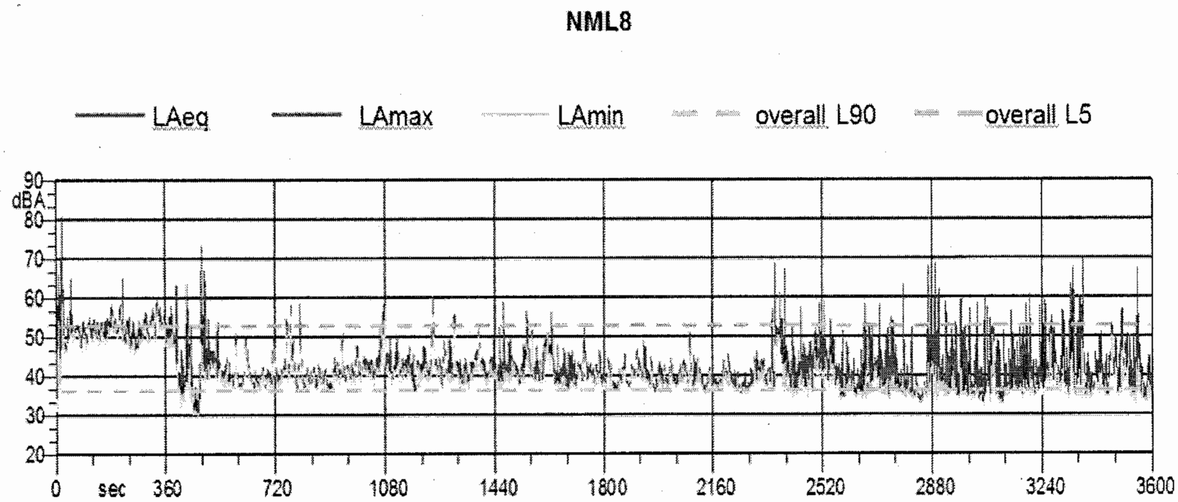



*Figure 2.12* *Receptor NML9*

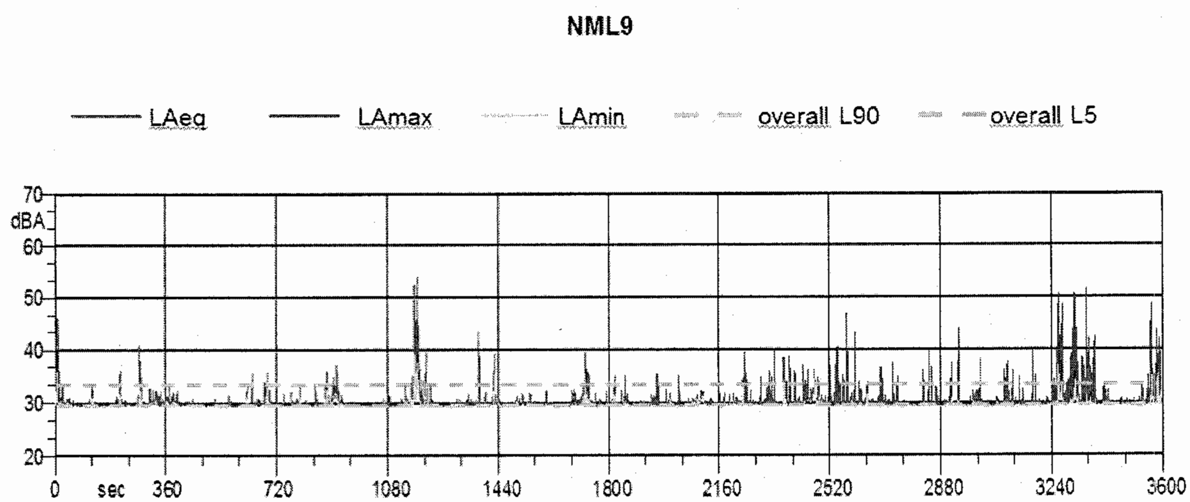



*Table 2.4* summarizes the daytime ambient noise levels at the identified nearest receptors.

*Table 2.4* ***Results of Attended Measurements. Near Receptors***

| Location | | Coordinates (a) | | $L_{Aeq}$ | $L_{A90}$ | $L_{A5}$ | $L_{A,min}$ | $L_{A,max}$ |
|---|---|---|---|---|---|---|---|---|
| | | X [m] | Y [m] | [dBA] | [dBA] | [dBA] | [dBA] | [dBA] |
| NML8 | Settlement near Nouakchott-Nouadhibou road (3.8km northwest of the Project site) | 392757.87 | 2011623.77 | 47.0 | 36.1 | 52.2 | 30.6 | 75.2 |
| NML9 | University (2.7km southwest of the Project site) | 395021.29 | 2008307.89 | 30.8 | 29.3 | 32.0 | 29.2 | 50.1 |

Note:
(a) Coordinate System: WGS 84 UTM 28N

# 3 NOISE IMPACT ASSESSMENT

## 3.1 INTRODUCTION

This section presents an assessment of the impacts expected to result from the noise emissions associated with the onshore component of the Banda Gas Project. It considers the noise levels expected at identified receptors generated from construction and operation phases of the Project.

The broad objectives are to implement a Project that in an environmentally, economically and socially sustainable manner is consistent with the requirements of the IFC Noise Guidelines and Performance Standards.

A noise modelling is performed to predict the noise levels for the area surrounding the gas processing plant and the impact significance is assessed based on key factors, as receptor sensitivity, magnitude of impact, duration and likelihood of occurrence.

The remainder of the chapter is structured as follows:

- *Section 3.2* describes the assessment methodology;
- *Section 3.3* presents the initial impact assessment prior to mitigation; and
- *Section 3.4* and *Section 3.5* describes the planned approach to mitigation and the resulting residual impacts.

Detailed supporting information is provided in the following Sections:

- *Section 1* - Acoustics: Glossary of Terms and Definitions; and
- *Appendix 1* – Baseline Noise Monitoring Results.

## 3.2 ASSESSMENT METHODOLOGY

### 3.2.1 *Study Area*

The Banda gas processing plant will be located approximately 9 km north the town of Nouakchott, in a sparsely populated desert area.

Along the pipeline and in proximity of the gas plant the nearest identified buildings have been the new University of Nouakchott and some scattered dwellings, which have been assessed as Noise Sensitive Receptors (NSR).

Existing ambient and background noise levels within the Project area and surrounds were also measured to inform the impacts assessment. The methodology in determining representative existing noise levels are described in *Section 2.4*.

An overview of the Project area highlighting the location of the plant facility and baseline noise measurement locations are shown in *Figure 3.1* and are listed in *Table 3.1*.

In the present study, the noise sensitive receptors (NSR) considered to estimate Project noise impact are consistent with the noise measurement locations.

*Figure 3.1* ***Noise Sensitive Receptors considered in this Impact Assessment***

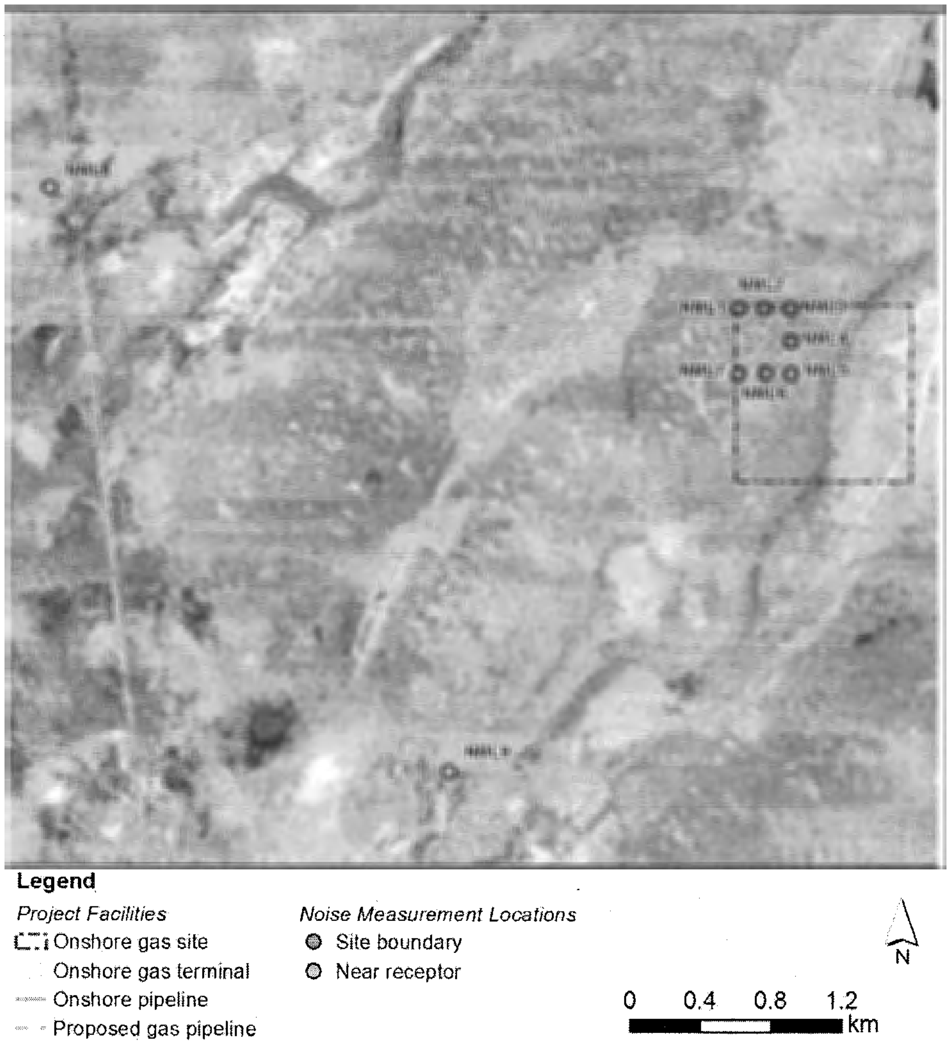


*Table 3.1* ***Locations and Characteristics of Noise Sensitive Receptors Considered in this Impact Assessment***

| NSR ID | Easting (m) (a) | Northing (m)(a) | Minimum distance to gas plant boundary (m) |
|---|---|---|---|
| NSR1 | 396661.01 | 2010941.59 | Site boundary |
| NSR2 | 396804.68 | 2010942.38 | Site boundary |
| NSR3 | 396953.11 | 2010942.38 | Site boundary |
| NSR4 | 396954.70 | 2010755.85 | Site boundary |
| NSR5 | 396956.29 | 2010573.29 | Site boundary |
| NSR6 | 396815.00 | 2010574.08 | Site boundary |
| NSR7 | 396657.04 | 2010573.29 | Site boundary |
| NSR8 | 392757.87 | 2011623.77 | 3900 |
| NSR9 | 395021.29 | 2008307.89 | 2700 |

Note:
(a) Coordinate System: WGS 84 UTM 28N

### 3.2.2 *Impact Prediction*

*Noise Prediction Methodology – Gas Processing Plant*

During construction and operation phases, impacts are related to machinery noise emissions that have the potential to affect the area adjacent to the Project Footprint Area. Construction noise sources are generally intermittent and impacts depend on the number and types of machinery used for each activity. An increase in the noise level in the area adjacent to the Project site is also expected during the operational phase, mainly characterized by steady equipment.

Noise level predictions must take into account all significant noise sources associated with the proposed operations. One method of determining the impact of numerous noise sources at a receiver is to develop a computer model of the proposed operations using a commercially available software package. An acoustic model has been developed using the environmental noise modelling program "SoundPLAN", version 7.1, developed by Braunstein + Berndt GmbH. The model has been used to generate expected noise contours for the area surrounding the gas processing plant and also to predict noise levels at the nearest noise sensitive receptors, for the following scenarios:

- gas treatment facility construction; and
- normal gas processing plant operation.

The model has been used to implement the methods identified within ISO 9613 Part 2 for noise propagation. SoundPLAN uses the following information to predict noise levels attributable to the gas processing plant at nearby receivers:

- three-dimensional digital terrain map of site and surrounding area;
- frequency-based sound power level noise source data (*Section 3.2.3*) for plant and equipment operating at the site;
- intervening ground cover;

- shielding by barriers, intervening buildings or topography; and
- atmospheric conditions.

*Meteorology*

The model has been used to predict noise levels and produce noise contours considering the following environmental conditions (as per ISO 9613-2):

- air Pressure 101,325 Pa;
- air Temperature 299.15 K (26 °C); and
- humidity 60 .

The noise propagation is carried out under down wind conditions (from source to receptor). Downwind propagation conditions for the method specified in ISO 9613 are:

- wind direction within an angle of ±45° of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver; and

- wind speed between 1 m/s and 5 m/s, measured at a height of between 3 m to 11 m above the ground.

The meteorological parameters have been set up for the whole calculation domain, to represent as the probable atmospheric conditions of the Project area.

*Topography and Land Cover*

Topographical information for the acoustic model was extracted from 1m ground contours available in electronic format [1] for the area surrounding the gas processing plant. A 3-D representation of the terrain's surface has been calculated through the generation of a digital ground model (DGM) in SoundPLAN.

The screening effects of buildings and barriers at the site have been excluded from the acoustic model to represent a conservative calculation methodology.

The attenuation due to the ground between the noise sources and the receptors has been included in the noise model; an absorption coefficient value of 0.1dB has been applied for surfaces covered by shrub and desert.

### 3.2.3 *Modelling Scenarios*

*Construction Phase*

Noise associated with construction of the gas processing plant will be variable in nature and will depend on the particular activities being undertaken as

[1] ASTER Global Digital Elevation Model (GDEM), developed by the National Aeronautics and Space Administration (NASA) and the Ministry of Economy, Trade and Industry of Japan (METI).

well as the equipment in operation. The construction phase is expected to be approximately 12 months and is anticipated to begin in early 2015.

The overall noise produced during the construction phase comes from several types of equipment and from specific activities. Therefore, the noise impact related to this phase can be variable and it is difficult to accurately predict construction noise emissions throughout the entire construction period. Hence, to facilitate the noise assessment, two 'worst case' scenarios have been developed:

- **Site Preparation Scenario**: this scenario includes significant noise-producing activities such as vegetation clearance, topsoil removal, earthworks. These activities will require heavy construction vehicles and equipment (excavators, dozers, rollers, dump trucks).

- **Civil Works and Plant Utilities Construction Scenario**: this scenario includes significant noise-producing activities such as installation of concrete and asphalt batch plants, installation of foundation structures and paved areas within the gas treatment facilities, assembly of plant items. These activities will require equipment such as concrete trucks, cranes, side-booms.

Considering that construction activities will extend throughout the Project site, each scenario has been simulated to represent a 'typical' maximum activity with all equipment operating in the area closest to noise sensitive receptors.

The predicted noise levels from the model are based on the assumption that all equipment is operating simultaneously and at full load. The equipment simulated and their acoustic performances for each scenario are shown in *Table 3.2* and *Table 3.3*.

*Table 3.2* *Site Preparation Equipment List*

| Equipment | N. | Octave Band (Hz) Sound Power Level, dBA (a) | | | | | | | | Lw (dBA) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | |
| Excavator | 2 | 91 | 95 | 99 | 102 | 105 | 103 | 98 | 93 | 110 |
| Dozer | 1 | 99.6 | 103.6 | 106.6 | 109.6 | 107.6 | 102.6 | 97.6 | 93.6 | 114 |
| Roller | 1 | 89 | 68.5 | 73 | 74 | 71 | 69 | 64 | 56 | 106 |
| Dump truck | 2 | 96 | 100 | 104 | 107 | 110 | 108 | 103 | 98 | 115 |
| Truck | 2 | 76 | 92 | 93 | 103 | 101 | 100 | 95 | 89 | 107 |
| Drill rig | 1 | 66.4 | 96.4 | 101.4 | 96.4 | 105.4 | 96.4 | 90.4 | 83.4 | 108 |
| 4WD vehicle | 2 | 43 | 56 | 66 | 73 | 76 | 73 | 70 | 64 | 80 |

Note: (a) Sound spectra derives from noise datasheets of similar equipment.

*Table 3.3* *Civil Works Equipment List*

| Equipment | N. | Octave Band (Hz) Sound Power Level, dBA (a) | | | | | | | | Lw (dBA) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | |
| Concrete mixer truck | 1 | 91.5 | 95.5 | 99.5 | 102.5 | 105.5 | 103.5 | 98.5 | 93.5 | 110 |
| Dump truck | 2 | 96 | 100 | 104 | 107 | 110 | 108 | 103 | 98 | 115 |
| Truck | 2 | 76 | 92 | 93 | 103 | 101 | 100 | 95 | 89 | 107 |
| Excavator | 1 | 91 | 95 | 99 | 102 | 105 | 103 | 98 | 93 | 110 |
| Crane | 2 | 100 | 102.2 | 105 | 105 | 104 | 102 | 99 | 90 | 111 |
| Pipelayer/ Side-boom | 1 | 97.6 | 99.6 | 102.6 | 102.6 | 101.6 | 99.6 | 96.6 | 87.6 | 109 |
| Pipe bending machine | 1 | 92.8 | 86.4 | 70 | 75.8 | 72.8 | 70.8 | 70.8 | 71.8 | 94 |
| 4WD vehicle | 4 | 43 | 56 | 66 | 73 | 76 | 73 | 70 | 64 | 80 |

Note: (a) Sound spectra derives from noise datasheets of similar equipment.

*Operation Phase*

It is anticipated that the operational life of the facility will be 20-25 years and the Plant will run 24 hours a day, 7 days a week and the main noise sources will be located within:

- the gas processing plant and utilities areas, characterized by engine generator, flash gas and processing pumps; and

- the flare area, due to the necessity during normal plant operations to occasionally and intermittently burn unwanted gas from the flare tower. The flare will be 30 meters above ground level.

To predict noise emissions from plant processing operations, a typical worst case activity has been assumed based on the assumption that equipment is operating simultaneously and at full load.

According to Project specifications for each equipment a sound pressure level of 80 dBA at 1 meter has been considered; noise sources have been simulated as point or building sources.

The noise emission level for flare system has been defined based on the gas mass flow rate during normal operation (250 kg/h for HP flare and 250 kg/h LP flare). According to Guideline VDI3732 'Characteristic noise emission values of technical sound sources - Flares', the A-weighted sound power level $L_{WA}$ is a function of the design capacity for the flare gas mass flow (Q, in t/h) to be burnt:

*Equation 1*

$$L_{WA} = 112 (\pm 6) + 17 \log Q \quad [dBA]$$

The equipment simulated and their acoustic performances are shown in *Table 3.4* and *Table 3.5*.

*Table 3.4* ***Gas Plant Processing Scenario Equipment List Considered in this Impact Assessment***

| Equipment | Octave Band (Hz) Sound Power Level, dBA (a) | | | | | | | | Lw (dBA) (b) |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | |
| **Gas conditioning** | | | | | | | | | |
| Gas filter | 85.1 | 85.1 | 83.1 | 83.1 | 81.1 | 76.1 | 71.1 | 71.1 | 91 |
| **Condensate treatment** | | | | | | | | | |
| Condensate transfer pump | 84.9 | 84.9 | 83.9 | 82.9 | 79.9 | 76.9 | 73.9 | 69.9 | 91 |
| Lp separator water pump | 84.1 | 84.1 | 82.1 | 82.1 | 80.1 | 75.1 | 70.1 | 70.1 | 91 |
| Condensate rundown cooler | 98.8 | 94.8 | 90.8 | 86.8 | 83.8 | 77.8 | 72.8 | 66.8 | 101 |
| **Condensate export** | | | | | | | | | |
| Condensate loading pump | 85 | 85 | 84 | 83 | 80 | 77 | 74 | 70 | 91 |
| Off-spec condensate pump | 85 | 85 | 84 | 83 | 80 | 77 | 74 | 70 | 91 |
| **Flash gas compression** | | | | | | | | | |

| Equipment | Octave Band (Hz) Sound Power Level, dBA (a) | | | | | | | | Lw (dBA) (b) |
|---|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | |
| Flash gas package (compressor+aircooler) | 77.3 | 79.3 | 84.3 | 90.3 | 94.3 | 96.3 | 96.3 | 104.3 | 106 |
| **MEG regeneration** | | | | | | | | | |
| MEG package (aircooler) | 103.8 | 99.8 | 95.8 | 91.8 | 88.8 | 82.8 | 77.8 | 71.8 | 106 |
| Glycol transfer pump | 84.9 | 84.9 | 83.9 | 82.9 | 79.9 | 76.9 | 73.9 | 69.9 | 91 |
| Glycol accumulator pump | 85 | 85 | 84 | 83 | 80 | 77 | 74 | 70 | 91 |
| Lean meg pump | 84.1 | 84.1 | 82.1 | 82.1 | 80.1 | 75.1 | 70.1 | 70.1 | 91 |
| Rich meg pump | 84.1 | 84.1 | 82.1 | 82.1 | 80.1 | 75.1 | 70.1 | 70.1 | 91 |
| Glycol filter | 85.1 | 85.1 | 83.1 | 83.1 | 81.1 | 76.1 | 71.1 | 71.1 | 91 |
| **Produced water treatment** | | | | | | | | | |
| Produced/recycle water pump | 84.1 | 84.1 | 82.1 | 82.1 | 80.1 | 75.1 | 70.1 | 70.1 | 91 |
| **Fuel gas** | | | | | | | | | |
| Fuel gas start up heater | 102 | 97 | 95 | 89 | 88 | 89 | 85 | 77 | 106 |
| Control valves | 85.1 | 85.1 | 83.1 | 83.1 | 81.1 | 76.1 | 71.1 | 71.1 | 91 |
| **Chemical injection** | | | | | | | | | |
| Corrosion inhibitor injection pumps | 85 | 85 | 83 | 83 | 81 | 76 | 71 | 71 | 91 |
| Methanol injection pumps | 85 | 85 | 83 | 83 | 81 | 76 | 71 | 71 | 91 |
| **Closed drains** | | | | | | | | | |
| Closed drains drum pumps | 85 | 85 | 83 | 83 | 81 | 76 | 71 | 71 | 91 |
| Hazardous open drains sump pump | 85 | 85 | 83 | 83 | 81 | 76 | 71 | 71 | 91 |
| **Service water** | | | | | | | | | |
| Service water pump | 84.1 | 84.1 | 82.1 | 82.1 | 80.1 | 75.1 | 70.1 | 70.1 | 91 |
| **Power generation** | | | | | | | | | |
| Main power (gas engine generator) | 75.8 | 85.9 | 88.4 | 93.8 | 96.9 | 98.2 | 97.9 | 95.9 | 104 |

Notes:
(a) Sound spectra derives from noise datasheets of similar equipment
(b) As per Project Specifications a Sound Pressure Level of 80 dB(A) at 1 meter has been considered from each equipment (included packages).

*Table 3.5* *Elevated Flare Equipment List*

| Equipment | Height (m) | Octave Band (Hz) Sound Power Level, dBA | | | | | | | | $L_{WA}$ (dBA) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | |
| Flare system (HP+LP) | 30 | 108 | 107 | 104 | 99 | 98 | 98 | 100 | 101 | 113 |

### 3.2.4 *Assessment Criteria*

*Overview*

The environmental values to be protected are the qualities of the acoustic environment that are conducive to:

- the wellbeing of the community or a part of the community; or
- the wellbeing of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.

Review of the IFC guidelines indicates that where possible, the overall noise level at a receptor should not exceed the threshold values, as reported in Section 2.2. Hence, the noise emissions from the Project (the Specific Noise Level) should be designed to ensure that compliance with these noise levels is achieved.

*Construction Phase Noise Magnitude Criteria*

There is no relevant national guidance and construction noise is not addressed directly by the IFC EHS guidelines. It is common practice to classify impact magnitude as negligible if the predicted construction noise levels do not exceed the existing ambient noise levels.

In consideration of the construction period, being a period of 12 months, it is considered that the IFC threshold levels of 55 dB(A) for the daytime and 45 dB(A) for the night time would be appropriate for this Project.

Additionally, a $L_{AMax}$ of 85 dBA is a well-accepted action limit for occupational noise management as it is the threshold at which the potential for hearing damage starts to occur. This level has been adopted as the threshold for critical impacts.

The magnitude of construction noise is evaluated by establishing a threshold noise level at which significant impacts start to occur and higher levels for ***medium*** and ***large*** magnitude impacts. Using these standards and guidelines for reference, usually it is appropriate to set significance thresholds for day and night time according to the duration of the noise, on the basis that temporary construction (<1 month) will have lesser impact than short term (1-6 months) or long term (> 6 months).

*Table 3.6* presents the magnitude criteria for noise impacts during the construction phase. Given the duration of construction for this Project, a conservative approach has been taken, adopting the most stringent (> 6 months duration) long term criteria.

*Table 3.6* ***Noise Impact Magnitude for Residential Receptors. Construction Phase***

| Operating Period | Daytime Noise Level, dBA | | | Night time Noise Level, dBA | | |
|---|---|---|---|---|---|---|
| Impact Magnitude | *Small* | *Medium* | *Large* | *Small* | *Medium* | *Large* |
| Construction LAeq,1hr | | | | | | |
| Short exposure < 1 month | < 75 | > 75-80 | > 80 | < 60 | > 60-65 | > 65 |
| Medium term exposure 1 to 6 months | < 70 | > 70-75 | > 75 | < 55 | > 55-60 | > 60 |
| Long term exposure >6 months | < 60 | > 60-65 | > 65 | < 50 | 50-55 | > 55 |

Note: $L_{Aeq}$ = 85 dBA is a well-accepted action limit for occupational noise management as it is the threshold at which the potential for hearing damage starts to occur (critical level)

*Operational Phase Noise Magnitude Criteria*

The IFC EHS guidelines have been considered to set operational phase noise criteria.

These guidelines were developed originally for power generation plant developments which tend to occur in industrial areas or near to roads where ambient noise levels are unlikely to be low. In some cases (e.g., where ambient levels are low, or open space areas have high amenity value), it is necessary to additionally assess noise impacts on an amenity basis. To do this, an approach going beyond IFC EHS guidelines is used (drawn from British Standard 4142 and the Australian New South Wales Industrial Noise Policy) to consider the extent to which the predicted Project noise $LA_{eq,period}$ levels exceed the existing background $LA_{90}$ levels.

*Table 3.7* presents the magnitude criteria for noise impacts during the operational phase.

*Table 3.7* *Noise Impact Magnitude for Residential Receptors. Operational Phase*

| Operating Period | Daytime Noise Level, dBA | | | Night time Noise Level, dBA | | |
|---|---|---|---|---|---|---|
| Impact Magnitude | Small | Medium | Large | Small | Medium | Large |
| Plant Operation LAeq,1hr | < 55 | > 55-60 | > 60 | < 45 | > 45-50 | > 50 |
| Amenity Impact Δ LA90 | < 10 | > 10-15 | > 15 | < 8 | > 8 – 15 | > 15 |

Note: $L_{AMax}$ = 85 dBA is a well-accepted action limit for occupational noise management as it is the threshold at which the potential for hearing damage starts to occur (critical level)

For the operational phase, the noise generated by plant activities at the NSRs will be compared with the background noise level monitored during the field survey, taking into account the $L_{A90}$ value that describes the A-weighted sound pressure level exceeded for 90 of the measurement time [1].

*Evaluating Significance of Noise Impacts*

Four key factors are considered when determining the significance of noise effects - receptor sensitivity, magnitude of impact, duration and likelihood of occurrence. Of these factors, three are generally the same for the operation:

- the sensitivity of the receptor - generally all humans hear noise and react to noise similarly and the difference between daytime and night time is addressed by adopting different thresholds;
- likelihood - we know the noise will occur from predictive modelling; and
- duration - the noise is relatively continuous and would be considered to be of a long term duration (except for construction).

For construction noise, however, duration is a more variable factor which is accounted for in the impact assessment matrix by a reduction in the acceptable noise thresholds adopted for the Project.

For both construction and operational noise, impacts are considered to be *Direct* in their nature and of a *Local* extent, whereas *Intensity* is not considered when determining impacts from noise.

Therefore, the deciding factor in determining the significance of an impact is the magnitude of the noise level, expressed as an exceedance of the criterion

(1)ETSU-R-97 Guidelines for Wind Farm Noise Assessment advises using the LA90 noise index for background noise; the LA90 level noise is typically 2 dBA less than the equivalent LAeq,t value.

(*Table 3.6* and *Table 3.7*). The significance assessment matrix is presented in *Table 3.8* and sets out level of significance based on noise levels during construction and operation phases. The definition of the significance ratings are explained below:

- **Negligible** – no need to consider in decision making, no mitigation required.
- **Minor** – an impact that is significant, to be considered by decision makers, but small enough that noise management practices would ensure noise levels are below significance criteria.
- **Moderate** – an impact that is significant and mitigation should be considered. Mitigation is likely to affect design and cost.
- **Major** – an impact that is significant and mitigation must be considered. Mitigation will alter Project design and cost. Impacts are undesirable if not addressed;
- **Critical** – Creating adverse direct and immediate potential health and human comfort effects and should stop the Project proceeding in this form and significant mitigation will be required to alter design.

*Table 3.8* *Noise Significance Matrix*

| Impact Magnitude Classification | | Impact Significance Rating |
|---|---|---|
| Small | Consider other significance factors if necessary (receptor sensitivity, duration and likelihood) | Negligible |
| | | Minor |
| Medium | | Moderate |
| Large | | Major |
| | | Critical |

## 3.3 *Impact Assessment Results*

### 3.3.1 *Noise Impacts During Construction*

This section assesses the likely noise levels and potential impacts at off-site NSRs.

Maximum construction noise levels at receptors have been predicted for the scenarios detailed in *Section 3.2.3*. The noise values reported refer to the maximum noise level predicted at each receptor where the construction equipment is located at the nearest point of the Project to receptor location and all the equipment work simultaneously. This assumption represents a worst case scenario, considering the worst combination in terms of source level and distance.

*Table 3.9* *Predicted Construction Noise Levels*

| Receptor | Predicted Noise Level, from Construction Phase (dBA) | | Noise Limit (dBA) | |
|---|---|---|---|---|
| | Site preparation | Civil works | Day | Night |
| **Site boundary** | | | | |
| NSR 1 | 68.5 | 68.5 | 70 | 70 |
| NSR 2 | 66.0 | 66.0 | | |
| NSR 3 | 62.0 | 62.0 | | |
| NSR 4 | 63.5 | 63.0 | | |
| NSR 5 | 61.0 | 61.0 | | |
| NSR 6 | 64.5 | 64.0 | | |
| NSR 7 | 66.0 | 65.5 | | |
| **Nearest Sensitive Receptors** | | | | |
| NSR 8 | 29.0 | 28.5 | 55 | 45 |
| NSR 9 | 32.5 | 32.0 | | |

For residential receptors (NSR8 and NSR9) a noise limit of 55 dBA for day time and 45 dBA for night time has been assumed. The predicted construction noise levels at both NSRs will comply with the Project's noise construction criteria during both the daytime and night time periods, hence impact magnitude is *Small*, as per criteria reported in *Table 3.6*.

NSR1 to NSR7 are not residential receptors and they are located along the site boundary. In this case the criteria defined in *Table 3.6* cannot be applied, and the noise emissions have been compared to a suitable noise level of 70 dBA, representative of industrial area as per IFC guidelines (*Table 2.1*). Also for these receptors, the predicted construction noise levels will comply with the Project's noise construction limits during both the daytime and night time periods and the magnitude impact for construction phase, in absence of mitigation, will be *Small.*

*Summary - Noise Impacts During Construction*

Without mitigation, noise impact significance associated with the construction of the Project is expected to be *Negligible*, mainly due to the distance of receptors and the temporary duration of construction activities.

### 3.3.2 *Noise Impacts During Operation*

Maximum operational noise levels at receptors have been predicted for the operational phase scenarios detailed in *Section 3.2.3*.

*Table 3.10* *Predicted Operational Noise Levels*

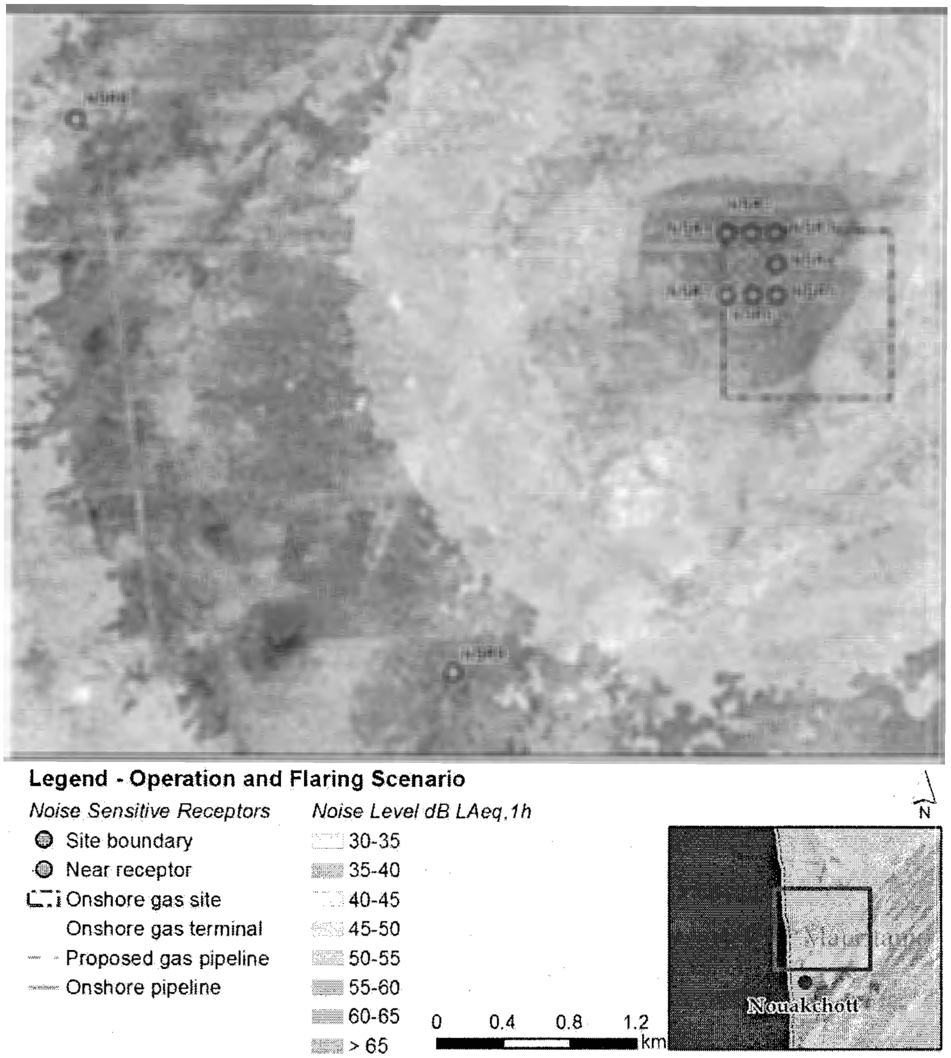
<table>
<tr><th rowspan="2">Receptor</th><th rowspan="2">Predicted Noise Level from Operations Phase (dBA)</th><th colspan="2">Noise Limit (dBA)</th></tr>
<tr><th>Day</th><th>Night</th></tr>
<tr><td colspan="4">Site boundary</td></tr>
<tr><td>NSR 1</td><td>64.5</td><td rowspan="7">70</td><td rowspan="7">70</td></tr>
<tr><td>NSR 2</td><td>66.0</td></tr>
<tr><td>NSR 3</td><td>63.5</td></tr>
<tr><td>NSR 4</td><td>67.0</td></tr>
<tr><td>NSR 5</td><td>63.5</td></tr>
<tr><td>NSR 6</td><td>68.5</td></tr>
<tr><td>NSR 7</td><td>66.0</td></tr>
<tr><td colspan="4">Nearest Sensitive Receptors</td></tr>
<tr><td>NSR 8</td><td>35.0</td><td rowspan="2">55</td><td rowspan="2">45</td></tr>
<tr><td>NSR 9</td><td>38.0</td></tr>
</table>

The noise levels at receptors are influenced predominantly by the fuel gas system and air coolers.

The predicted operational noise levels comply with the IFC noise criteria during both daytime and night time periods for all scenarios. Considering the noise assessment criteria reported in *Table 3.7*, the magnitude impact for operational phase is expected to be *Small*.

Predicted noise contours for operational activities, including flaring, are shown in *Figure 3.2*.

*Figure 3.2* *Predicted Noise Levels Generated by the Project – Operation Phase*




*Increase in Background Noise Levels during Operational Phase*

The IFC General EHS Guideline states that *[..noise impacts should not result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site]*. To assess the noise impact generated by the Project on the environmental noise quality, the increase above background required by IFC guidelines has been evaluated.

Noise modelling has allowed to calculate $L_{Aeq, 1\ hour}$ site contributions for direct comparison to the IFC fixed criteria and as such these values must be converted to a background $L_{A90}$ value (15 hour daytime and 9 hour night time) to assess any potential increase in noise level. ERM has assumed that similar activities will occur for the whole duration of each period and has applied a conservative 1 dB reduction [1] to convert from the $L_{Aeq}$ acoustic

(1) As reported in Section 3.2.4 ETSU-R-97 Guidelines states that the LA90 level noise is typically 2 dBA less than the equivalent LAeq,t value. A reduction of only 1 dBA considered in this study guarantees a more conservative approach of the noise assessment.

parameter to the LA90 statistical parameter as the noise emissions from the gas processing plant are considered to be very continuous in nature.

An increase in the background noise level at a noise sensitive receptor location of more than 3dB would be considered as significant.

The predicted change in LA90 noise levels at each NSR during the operational phase has been compared with the background noise levels as reported in *Table 3.11*, which shows the increase above background noise for the assessment locations. Only residential receptors NSR8 and NSR9 have been considered.

***Table 3.11*** ***Increase in Background Noise Levels - Operational Phase***

| Receptor | Existing Background LA90 Noise Level [dBA] | Operational Phase Noise Level, dBA | | | |
|---|---|---|---|---|---|
| | | Estimated Plant LA90, [dBA] (a) | Cumulative Noise Level [dBA] | Increase in LA90 Background Noise Level | Comply with IFC significance criteria (< 3 dB) |
| NSR 8 | 36.0 | 34.0 (35.0) | 38.1 | 2.1 | Yes |
| NSR 9 | 29.5 | 37.0 (38.0) | 37.7 | 8.2 | No |

Note:
(a) A reduction of 1 dBA of the equivalent LAeq,t value has been considered to estimate the LA90 plant contribution.

Based on the results reported in *Table* 3.11, the increase above background exceeds the IFC limit of 3 dBA at receptor NSR9. According to the noise criteria reported in *Table 3.7*, the amenity impact magnitude at receptor NSR8 is *Small* and at NSR9 is *Medium*.

It is necessary to underline, however, that the impact at NSR9 is mainly due to low background noise, and it is supposed that once the university facilities have been built the noise background will be higher, comparable to levels monitored at receptor NSR8. Hence it is reasonable to consider also for receptor NSR9 a *Small* amenity impact.

A noise monitoring survey at the beginning of the operations is recommended to verify the compliance with IFC guidelines.

*Summary - Operational Noise Impact*

| |
|---|
| Without mitigation, noise impact significance associated with the operational phase of the Project is expected to be *Negligible*. |

## 3.4 *MITIGATION AND MONITORING*

The noise contribution of the construction and operation phase predicted through noise modelling has not identified any significant impacts according to international standards.

A medium amenity impact may occur at receptor NSR9, but it's supposed that once the university facilities have been built the noise background will be higher and no significant impacts will be expected.

Hence no specific mitigation measures will be needed; however, during construction and operation, achievement of Project noise guidelines will be accomplished through good operations management. The management and mitigation measures presented below are considered to be international good practice and are recommended :

- enforcement of appropriate speed limits for heavy vehicles to reduce noise;
- utilisation of modern, well maintained industrial equipment and plant with the appropriate noise mufflers in place;
- operational noise monitoring at established permanent monitoring locations (such as NSR9) to provide additional noise data and ensure compliance with the guidelines; and
- performance of noise modelling in case of modification of the plant, or if ongoing monitoring indicates non compliance with the guidelines.

## 3.5 *RESIDUAL IMPACTS*

Predicted noise levels for construction and operation are expected to comply with the guidelines presented in *Section 2.2* for all conditions during the daytime and night time period.

Construction and operation noise levels have been predicted for scenarios representing a typical worst-case activity with all equipment operating and the plant noise contribution would be lower than the levels predicted in this study.

Conservatively, the residual impacts are considered equal to potential impacts described in *Section 3.3.1* and *3.3.2* and the overall significance of the residual impacts are assessed as *Negligible* both for construction and normal operational phase at all the Noise Sensitive Receptors identified.

# 4 SUMMARY AND CONCLUSIONS

A baseline noise survey for the proposed Tullow Banda Gas Development was undertaken on 6 and 7 November 2012. From observations made and measurements recorded during the site visit it may be concluded that the areas set within and surrounding the Project site are typical of undeveloped area sufficiently far from city centre and infrastructures, with low background noise levels throughout the day time period, and consequently throughout the night time period.

The design of the gas processing plant will need to ensure that operational noise does not increase noise levels at any nearby residential dwelling above the Project threshold criteria of 55 dB(A) daytime, 45 dB(A) night time or a 3 dB(A) rise in existing ambient levels, according to the IFC guidelines.

A full impact assessment from construction and operation noise emissions was carried out as part of the EIA for the proposed development (including modelling of future ambient noise resulting from the Project).

Predicted noise levels for construction and operation are expected to comply with the relevant noise impact assessment criteria for all conditions during the daytime and night time period. The overall significance of the noise impact is assessed as *Negligible* both for construction and operational phases at all the Noise Sensitive Receptors identified.

No specific mitigation measures will be needed; however, during construction and operation, achievement of noise guidelines will be accomplished through good operations management.

## 5 *REFERENCES*


*B. Berglund, T. Lindvall, D.H. Schwela (1999). Guidelines for Community Noise. World Health Organization. Geneva.*

*ETSU-R-97 (1996). Guidelines for Wind Farm Noise Assessment.*

*International Electronic Commission (IEC) 61672-1/2/3 (2002). Electroacoustics – Sound level meters.*

*International Finance Corporation (IFC) EHS Guidelines (2007). Noise Guidelines and Performance Standards.*

*South African National Standards (SANS) 10103 (2004). The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication.*

*South African National Standards (SANS) 10328 (2003). Methods for Environmental Noise Impact Assessment.*

*VDI3732 Guideline (1999 ). Characteristic noise emission values of technical sound sources – Flares.*

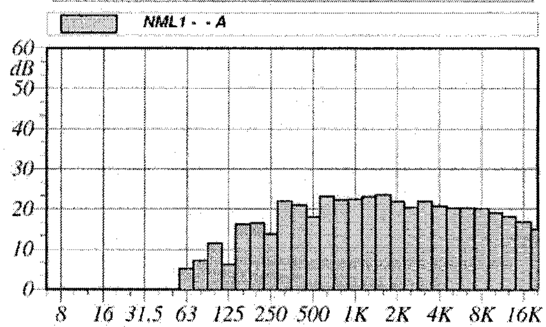
| | |
|---|---|
| **Point:** | **NML1** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396661; Y=2010941** |
| **Date, time:** | **06/11/2012 09:16:16** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

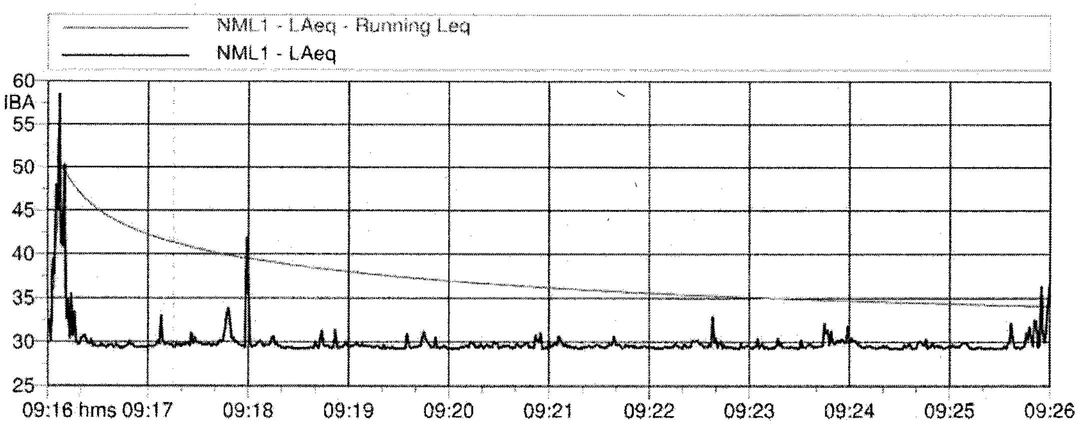
$L_{Aeq}$ = 34.1 dB  $L_{min}$ = 29.2 dB  $L_{max}$ = 58.5 dB

| | |
|---|---|
| L1: 40.9 dBA | L5: 31.3 dBA |
| L10: 30.4 dBA | L50: 29.5 dBA |
| L90: 29.3 dBA | L95: 29.3 dBA |

NML1
- A

| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -35.0 dB | 100 Hz | 11.5 dB | 1600 Hz | 23.6 dB |
| 8 Hz | -30.5 dB | 125 Hz | 6.2 dB | 2000 Hz | 21.8 dB |
| 10 Hz | -31.4 dB | 160 Hz | 16.1 dB | 2500 Hz | 20.4 dB |
| 12.5 Hz | -25.3 dB | 200 Hz | 16.5 dB | 3150 Hz | 21.9 dB |
| 16 Hz | -19.2 dB | 250 Hz | 13.8 dB | 4000 Hz | 20.8 dB |
| 20 Hz | -13.7 dB | 315 Hz | 22.0 dB | 5000 Hz | 20.2 dB |
| 25 Hz | -13.4 dB | 400 Hz | 21.1 dB | 6300 Hz | 20.3 dB |
| 31.5 Hz | -9.1 dB | 500 Hz | 18.0 dB | 8000 Hz | 20.1 dB |
| 40 Hz | -6.5 dB | 630 Hz | 23.1 dB | 10000 Hz | 19.1 dB |
| 50 Hz | -1.3 dB | 800 Hz | 22.3 dB | 12500 Hz | 18.1 dB |
| 63 Hz | 5.1 dB | 1000 Hz | 22.4 dB | 16000 Hz | 16.8 dB |
| 80 Hz | 7.2 dB | 1250 Hz | 23.0 dB | 20000 Hz | 15.0 dB |



| | |
|---|---|
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| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396804;Y=2010942** |
| **Date, time:** | **06/11/2012 09:28:23** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

$L_{Aeq}$ = 35.0 dB

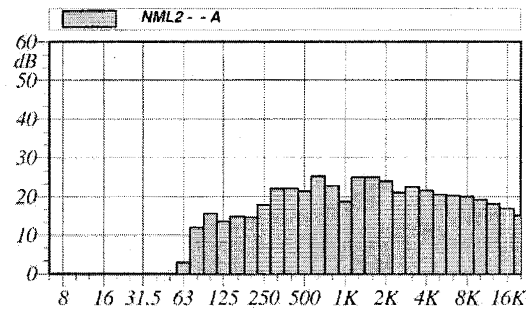
$L_{min}$ = 29.2 dB

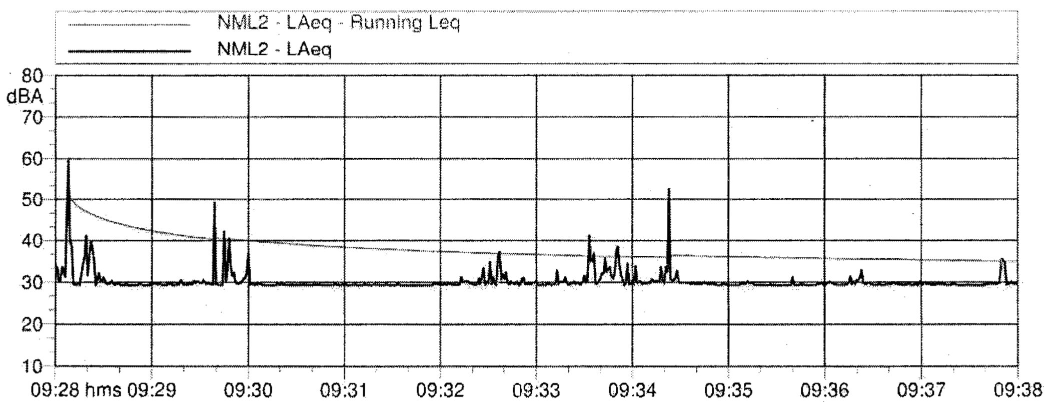
$L_{max}$ = 59.4 dB

| | |
|---|---|
| L1: 41.1 dBA | L5: 34.1 dBA |
| L10: 31.4 dBA | L50: 29.5 dBA |
| L90: 29.3 dBA | L95: 29.3 dBA |

NML2 - A

| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -34.6 dB | 100 Hz | 15.5 dB | 1600 Hz | 25.1 dB |
| 8 Hz | -32.8 dB | 125 Hz | 13.6 dB | 2000 Hz | 24.0 dB |
| 10 Hz | -34.7 dB | 160 Hz | 14.8 dB | 2500 Hz | 21.0 dB |
| 12.5 Hz | -30.0 dB | 200 Hz | 14.6 dB | 3150 Hz | 22.5 dB |
| 16 Hz | -24.6 dB | 250 Hz | 17.8 dB | 4000 Hz | 21.6 dB |
| 20 Hz | -19.7 dB | 315 Hz | 22.0 dB | 5000 Hz | 20.5 dB |
| 25 Hz | -19.9 dB | 400 Hz | 22.1 dB | 6300 Hz | 20.2 dB |
| 31.5 Hz | -11.2 dB | 500 Hz | 21.4 dB | 8000 Hz | 20.0 dB |
| 40 Hz | -8.2 dB | 630 Hz | 25.3 dB | 10000 Hz | 19.2 dB |
| 50 Hz | -1.4 dB | 800 Hz | 22.8 dB | 12500 Hz | 18.2 dB |
| 63 Hz | 2.9 dB | 1000 Hz | 18.7 dB | 16000 Hz | 16.9 dB |
| 80 Hz | 12.0 dB | 1250 Hz | 25.0 dB | 20000 Hz | 15.0 dB |



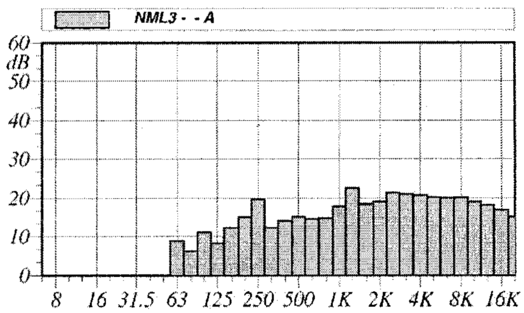



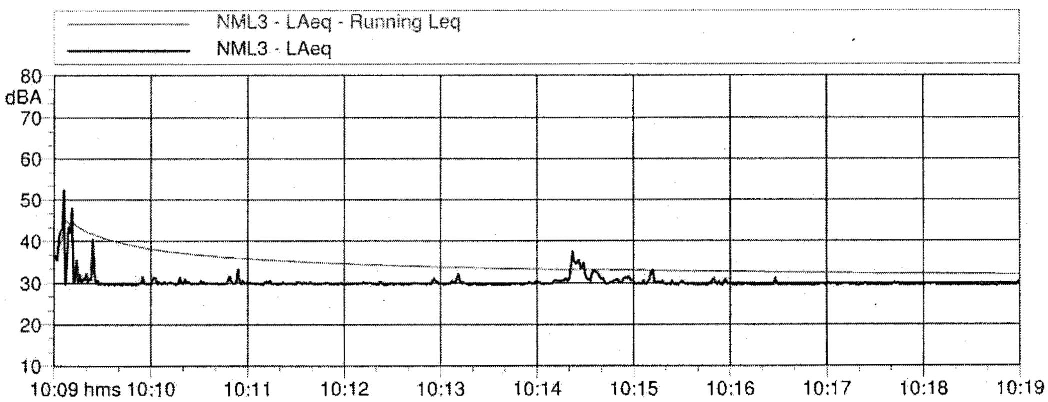
| | |
|---|---|
| **Point:** | **NML3** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396953; Y=2010942** |
| **Date, time:** | **06/11/2012 10:09:13** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

**$L_{Aeq}$ = 32.0 dB**  **$L_{min}$ = 29.4 dB**  **$L_{max}$ = 52.3 dB**

| NML3 - A | | | | | |
|---|---|---|---|---|---|
| | dB | | dB | | dB |
| 6.3 Hz | -32.7 dB | 100 Hz | 11.0 dB | 1600 Hz | 18.4 dB |
| 8 Hz | -32.2 dB | 125 Hz | 8.2 dB | 2000 Hz | 19.0 dB |
| 10 Hz | -31.1 dB | 160 Hz | 12.3 dB | 2500 Hz | 21.3 dB |
| 12.5 Hz | -26.0 dB | 200 Hz | 15.0 dB | 3150 Hz | 20.9 dB |
| 16 Hz | -20.5 dB | 250 Hz | 19.6 dB | 4000 Hz | 20.7 dB |
| 20 Hz | -17.6 dB | 315 Hz | 12.3 dB | 5000 Hz | 20.1 dB |
| 25 Hz | -15.3 dB | 400 Hz | 14.0 dB | 6300 Hz | 20.0 dB |
| 31.5 Hz | -12.1 dB | 500 Hz | 15.1 dB | 8000 Hz | 20.0 dB |
| 40 Hz | -10.1 dB | 630 Hz | 14.5 dB | 10000 Hz | 19.0 dB |
| 50 Hz | -2.3 dB | 800 Hz | 14.7 dB | 12500 Hz | 18.1 dB |
| 63 Hz | 8.8 dB | 1000 Hz | 17.8 dB | 16000 Hz | 16.8 dB |
| 80 Hz | 6.2 dB | 1250 Hz | 22.5 dB | 20000 Hz | 15.1 dB |

| | |
|---|---|
| L1: 41.0 dBA | L5: 32.2 dBA |
| L10: 30.9 dBA | L50: 29.8 dBA |
| L90: 29.5 dBA | L95: 29.5 dBA |



| | |
|---|---|
| **Point:** | **NML4** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396954;Y=2010755** |
| **Date, time:** | **06/11/2012 10:34:06** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

**$L_{Aeq}$ = 31.4 dB**

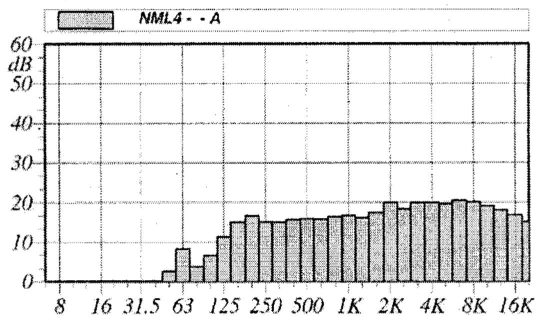
**$L_{min}$ = 29.3 dB**

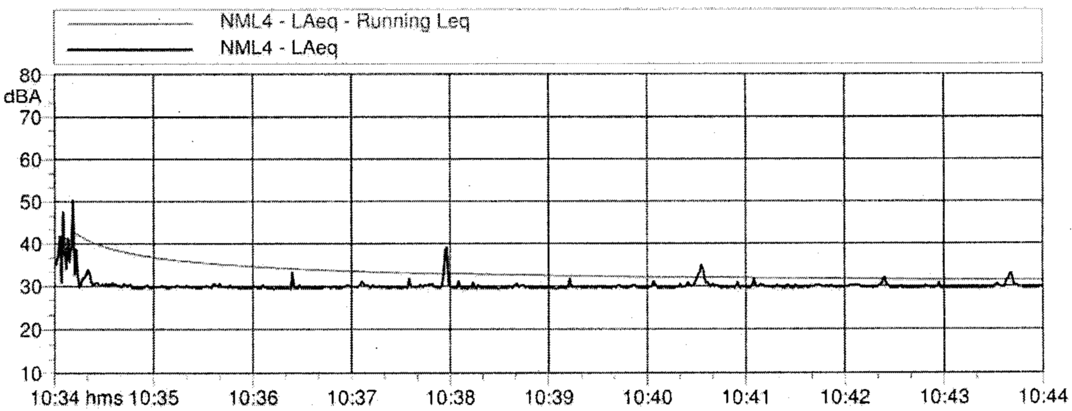
**$L_{max}$ = 50.4 dB**

| | |
|---|---|
| L1: 38.7 dBA | L5: 31.6 dBA |
| L10: 30.5 dBA | L50: 29.7 dBA |
| L90: 29.4 dBA | L95: 29.4 dBA |

NML4 - A

| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -36.4 dB | 100 Hz | 6.6 dB | 1600 Hz | 17.5 dB |
| 8 Hz | -35.3 dB | 125 Hz | 11.4 dB | 2000 Hz | 20.0 dB |
| 10 Hz | -36.2 dB | 160 Hz | 15.0 dB | 2500 Hz | 18.4 dB |
| 12.5 Hz | -30.8 dB | 200 Hz | 16.6 dB | 3150 Hz | 19.9 dB |
| 16 Hz | -16.9 dB | 250 Hz | 15.0 dB | 4000 Hz | 19.9 dB |
| 20 Hz | -12.2 dB | 315 Hz | 15.0 dB | 5000 Hz | 19.6 dB |
| 25 Hz | -1.3 dB | 400 Hz | 15.6 dB | 6300 Hz | 20.4 dB |
| 31.5 Hz | -1.3 dB | 500 Hz | 15.9 dB | 8000 Hz | 20.1 dB |
| 40 Hz | -2.9 dB | 630 Hz | 15.8 dB | 10000 Hz | 19.1 dB |
| 50 Hz | 2.5 dB | 800 Hz | 16.4 dB | 12500 Hz | 18.1 dB |
| 63 Hz | 8.2 dB | 1000 Hz | 16.7 dB | 16000 Hz | 16.9 dB |
| 80 Hz | 3.7 dB | 1250 Hz | 16.3 dB | 20000 Hz | 15.0 dB |



| | |
|---|---|
| **Point:** | **NML5** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396956; Y=2010573** |
| **Date, time:** | **06/11/2012 11:16:00** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

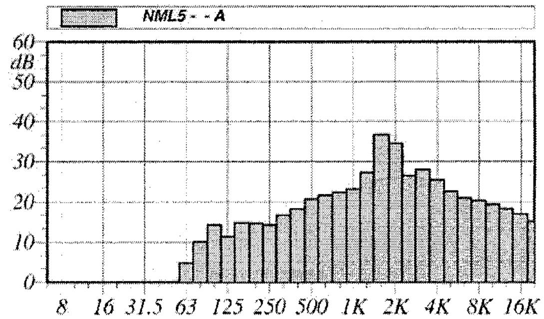
**$L_{Aeq}$ = 40.3 dB**

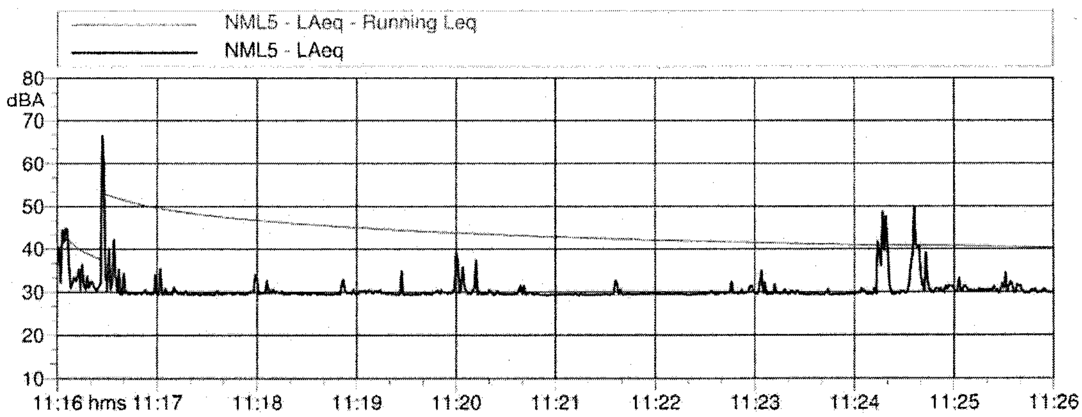
**$L_{min}$ = 29.3 dB**

**$L_{max}$ = 66.4 dB**

| NML5 - A | | | | | |
|---|---|---|---|---|---|
| | dB | | dB | | dB |
| 6.3 Hz | -26.4 dB | 100 Hz | 14.2 dB | 1600 Hz | 36.6 dB |
| 8 Hz | -23.2 dB | 125 Hz | 11.3 dB | 2000 Hz | 34.4 dB |
| 10 Hz | -18.5 dB | 160 Hz | 14.7 dB | 2500 Hz | 26.4 dB |
| 12.5 Hz | -11.1 dB | 200 Hz | 14.6 dB | 3150 Hz | 28.0 dB |
| 16 Hz | -18.8 dB | 250 Hz | 14.2 dB | 4000 Hz | 25.3 dB |
| 20 Hz | -15.1 dB | 315 Hz | 16.6 dB | 5000 Hz | 22.6 dB |
| 25 Hz | -7.8 dB | 400 Hz | 18.2 dB | 6300 Hz | 20.9 dB |
| 31.5 Hz | -3.3 dB | 500 Hz | 20.7 dB | 8000 Hz | 20.2 dB |
| 40 Hz | -0.9 dB | 630 Hz | 21.5 dB | 10000 Hz | 19.4 dB |
| 50 Hz | -0.6 dB | 800 Hz | 22.2 dB | 12500 Hz | 18.2 dB |
| 63 Hz | 4.8 dB | 1000 Hz | 23.1 dB | 16000 Hz | 15.9 dB |
| 80 Hz | 10.0 dB | 1250 Hz | 27.2 dB | 20000 Hz | 15.1 dB |

| | |
|---|---|
| L1: 44.4 dBA | L5: 35.3 dBA |
| L10: 31.9 dBA | L50: 29.7 dBA |
| L90: 29.4 dBA | L95: 29.4 dBA |



| | |
|---|---|
| **Point:** | **NML6** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396815;Y=2010574** |
| **Date, time:** | **06/11/2012 11:51:35** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

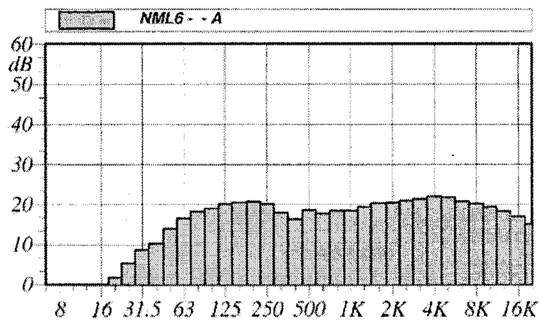
**$L_{Aeq}$ = 33.7 dB**

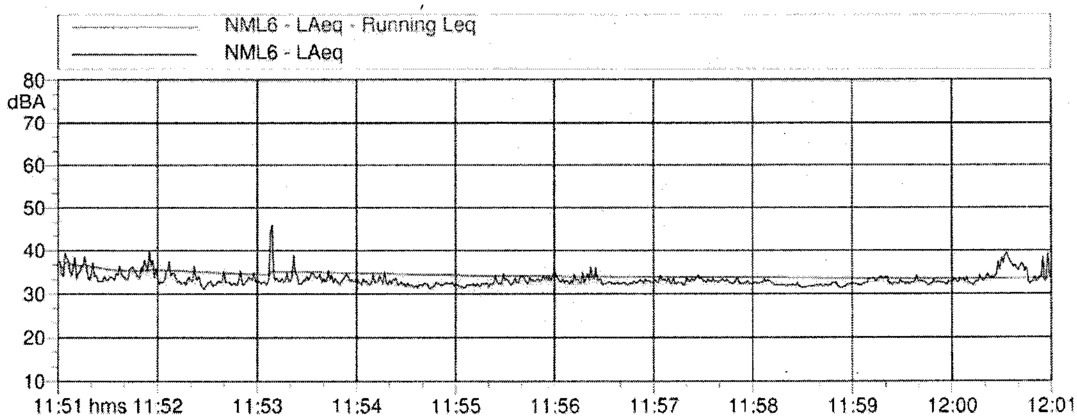
**$L_{min}$ = 31.1 dB**

**$L_{max}$ = 45.8 dB**

| NML6 - A | | | | | |
|---|---|---|---|---|---|
| | dB | | dB | | dB |
| 6.3 Hz | -19.0 dB | 100 Hz | 19.0 dB | 1600 Hz | 20.3 dB |
| 8 Hz | -14.0 dB | 125 Hz | 20.0 dB | 2000 Hz | 20.4 dB |
| 10 Hz | -9.5 dB | 160 Hz | 20.4 dB | 2500 Hz | 20.9 dB |
| 12.5 Hz | -5.0 dB | 200 Hz | 20.6 dB | 3150 Hz | 21.2 dB |
| 16 Hz | -1.3 dB | 250 Hz | 20.0 dB | 4000 Hz | 21.9 dB |
| 20 Hz | 1.7 dB | 315 Hz | 17.9 dB | 5000 Hz | 21.7 dB |
| 25 Hz | 5.3 dB | 400 Hz | 16.3 dB | 6300 Hz | 20.7 dB |
| 31.5 Hz | 8.7 dB | 500 Hz | 18.5 dB | 8000 Hz | 20.2 dB |
| 40 Hz | 10.2 dB | 630 Hz | 17.6 dB | 10000 Hz | 19.3 dB |
| 50 Hz | 13.8 dB | 800 Hz | 18.3 dB | 12500 Hz | 18.3 dB |
| 63 Hz | 16.5 dB | 1000 Hz | 18.3 dB | 16000 Hz | 16.9 dB |
| 80 Hz | 18.2 dB | 1250 Hz | 19.3 dB | 20000 Hz | 14.9 dB |

| | |
|---|---|
| L1: 38.9 dBA | L5: 36.4 dBA |
| L10: 34.9 dBA | L50: 32.9 dBA |
| L90: 32.0 dBA | L95: 31.8 dBA |



| | |
|---|---|
| **Point:** | **NML7** |
| **Site:** | **Site boundary** |
| **Coordinate UTM:** | **X=396657;Y=2010573** |
| **Date, time:** | **06/11/2012 12:07:29** |
| **Period [s]:** | **600.0** |
| **Instrument:** | **LxT1 0002565** |

**$L_{Aeq}$ = 38.4 dB**

**$L_{min}$ = 30.8 dB**

**$L_{max}$ = 57.2 dB**

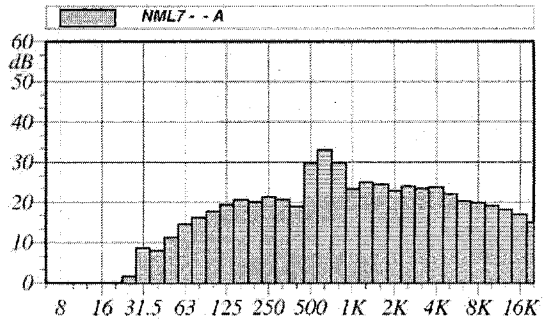
NML7 - A

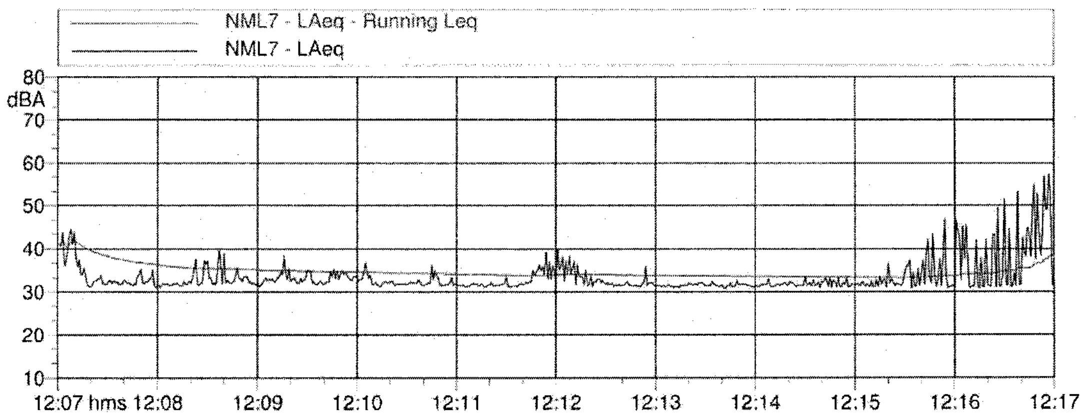
| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -23.9 dB | 100 Hz | 17.7 dB | 1600 Hz | 24.4 dB |
| 8 Hz | -18.6 dB | 125 Hz | 19.4 dB | 2000 Hz | 22.9 dB |
| 10 Hz | -13.6 dB | 160 Hz | 20.6 dB | 2500 Hz | 24.0 dB |
| 12.5 Hz | -9.7 dB | 200 Hz | 20.1 dB | 3150 Hz | 23.4 dB |
| 16 Hz | -5.6 dB | 250 Hz | 21.4 dB | 4000 Hz | 23.7 dB |
| 20 Hz | -2.5 dB | 315 Hz | 20.7 dB | 5000 Hz | 22.0 dB |
| 25 Hz | 1.6 dB | 400 Hz | 18.9 dB | 6300 Hz | 20.2 dB |
| 31.5 Hz | 8.6 dB | 500 Hz | 29.8 dB | 8000 Hz | 19.9 dB |
| 40 Hz | 8.0 dB | 630 Hz | 33.0 dB | 10000 Hz | 19.1 dB |
| 50 Hz | 11.2 dB | 800 Hz | 29.8 dB | 12500 Hz | 18.1 dB |
| 63 Hz | 14.5 dB | 1000 Hz | 23.3 dB | 16000 Hz | 16.9 dB |
| 80 Hz | 16.1 dB | 1250 Hz | 24.9 dB | 20000 Hz | 15.0 dB |

L1: 51.5 dBA L5: 42.2 dBA

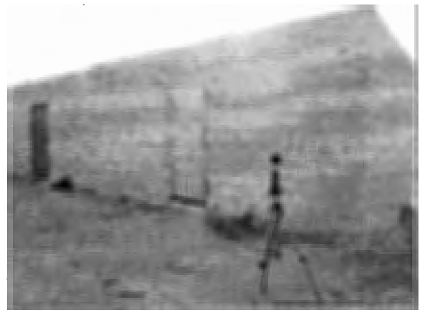
L10: 37.2 dBA L50: 32.1 dBA

L90: 31.3 dBA L95: 31.2 dBA



| | |
|---|---|
| **Point:** | **NML8** |
| **Site:** | **Settlements near road** |
| **Coordinate UTM:** | **X=392757;Y=2011623** |
| **Date, time:** | **06/11/2012 16:03:12** |
| **Period [s]:** | **3683.0** |
| **Instrument:** | **LxT1 0002565** |

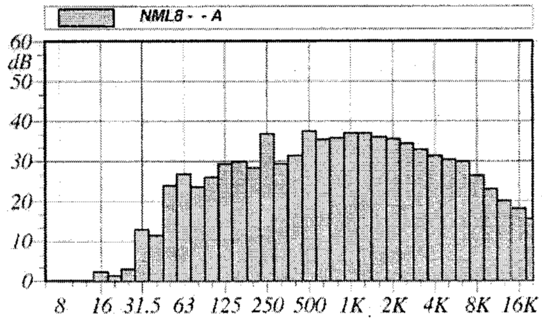


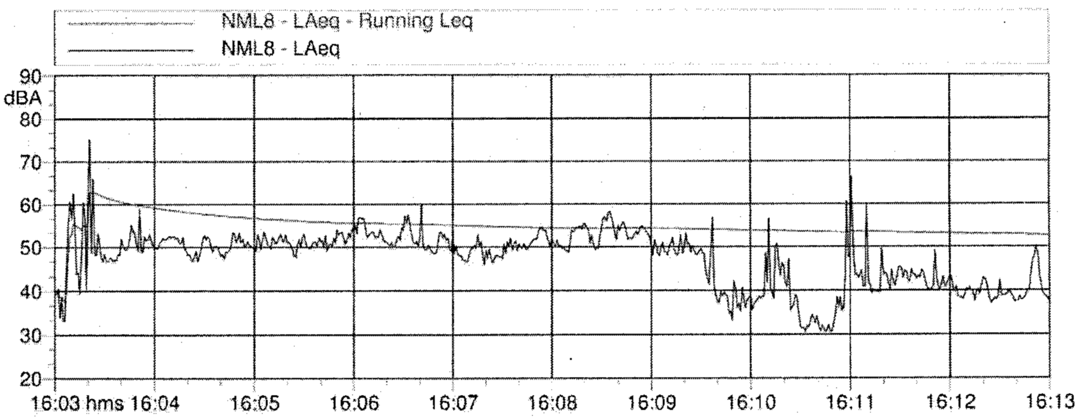
**$L_{Aeq}$ = 47.0 dB** **$L_{min}$ = 30.6 dB** **$L_{max}$ = 75.2 dB**

| | |
|---|---|
| L1: 56.8 dBA | L5: 52.2 dBA |
| L10: 49.9 dBA | L50: 40.1 dBA |
| L90: 36.1 dBA | L95: 35.1 dBA |

NML8 - A

| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -34.1 dB | 100 Hz | 26.0 dB | 1600 Hz | 36.0 dB |
| 8 Hz | -27.6 dB | 125 Hz | 29.3 dB | 2000 Hz | 35.5 dB |
| 10 Hz | -18.5 dB | 160 Hz | 29.7 dB | 2500 Hz | 34.4 dB |
| 12.5 Hz | -3.3 dB | 200 Hz | 28.3 dB | 3150 Hz | 32.9 dB |
| 16 Hz | 2.2 dB | 250 Hz | 36.8 dB | 4000 Hz | 31.3 dB |
| 20 Hz | 1.3 dB | 315 Hz | 29.3 dB | 5000 Hz | 30.4 dB |
| 25 Hz | 2.9 dB | 400 Hz | 31.3 dB | 6300 Hz | 29.9 dB |
| 31.5 Hz | 12.9 dB | 500 Hz | 37.4 dB | 8000 Hz | 26.3 dB |
| 40 Hz | 11.4 dB | 630 Hz | 35.4 dB | 10000 Hz | 23.1 dB |
| 50 Hz | 23.9 dB | 800 Hz | 35.6 dB | 12500 Hz | 20.0 dB |
| 63 Hz | 26.8 dB | 1000 Hz | 36.9 dB | 16000 Hz | 18.0 dB |
| 80 Hz | 23.6 dB | 1250 Hz | 36.9 dB | 20000 Hz | 15.5 dB |



| | |
|---|---|
| **Point:** | **NML9** |
| **Site:** | **University** |
| **Coordinate UTM:** | **X=395021;Y=2008307** |
| **Date, time:** | **07/11/2012 10:46:13** |
| **Period [s]:** | **3607.0** |
| **Instrument:** | **LxT1 0002565** |

**$L_{Aeq}$ = 30.8 dB**

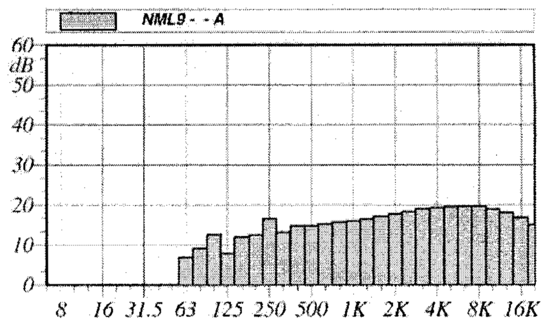
**$L_{min}$ = 29.2 dB**

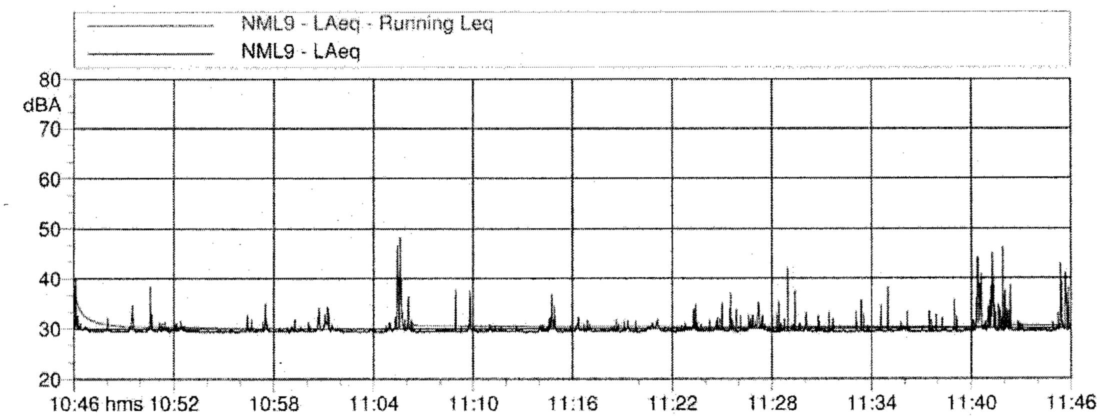
**$L_{max}$ = 50.1 dB**

NML9 - A

| | dB | | dB | | dB |
|---|---|---|---|---|---|
| 6.3 Hz | -30.0 dB | 100 Hz | 12.6 dB | 1600 Hz | 17.1 dB |
| 8 Hz | -29.4 dB | 125 Hz | 7.8 dB | 2000 Hz | 17.7 dB |
| 10 Hz | -30.0 dB | 160 Hz | 12.0 dB | 2500 Hz | 18.2 dB |
| 12.5 Hz | -25.5 dB | 200 Hz | 12.4 dB | 3150 Hz | 19.0 dB |
| 16 Hz | -17.3 dB | 250 Hz | 16.5 dB | 4000 Hz | 19.3 dB |
| 20 Hz | -11.5 dB | 315 Hz | 13.2 dB | 5000 Hz | 19.5 dB |
| 25 Hz | -17.4 dB | 400 Hz | 14.8 dB | 6300 Hz | 19.6 dB |
| 31.5 Hz | -13.4 dB | 500 Hz | 14.7 dB | 8000 Hz | 19.7 dB |
| 40 Hz | -4.6 dB | 630 Hz | 15.3 dB | 10000 Hz | 18.9 dB |
| 50 Hz | 2.9 dB | 800 Hz | 15.6 dB | 12500 Hz | 18.0 dB |
| 63 Hz | 6.9 dB | 1000 Hz | 15.9 dB | 16000 Hz | 16.8 dB |
| 80 Hz | 9.1 dB | 1250 Hz | 16.5 dB | 20000 Hz | 15.0 dB |

| | |
|---|---|
| L1: 37.6 dBA | L5: 32.0 dBA |
| L10: 30.7 dBA | L50: 29.6 dBA |
| L90: 29.3 dBA | L95: 29.3 dBA |



Annex B-4

# Oil Spill Modelling Report

*CONTENTS*

*LIST OF FIGURES*

*LIST OF TABLES*

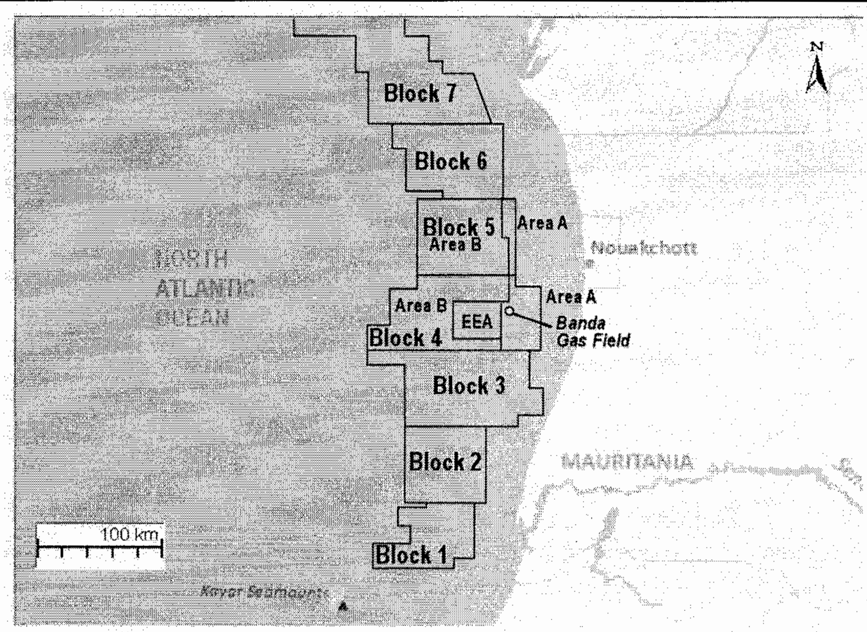
# 1 APPROACH

## 1.1 OVERVIEW

As part of an overall environmental assessment of the Banda field development planned by Tullow Petroleum (Mauritania) Pty Ltd (Tullow) off the coast of Mauritania, ERM's Surfacewater Modelling Group has examined the fate of potential oil spills in Banda field, approximately 50 km west from the Mauritanian coast. This modelling was performed to assess potential environmental and social impacts that may occur as a result of an oil spill.

The location of the Banda field is presented in *Figure 1.1*.

***Figure 1.1 Location of the Banda Field***




## 1.2 MODELLING METHODOLOGY

The modelling was performed using GEMSS (Generalized Environmental Modeling System for Surfacewaters) and its oil spill module, COSIM (Chemical/Oil Spill Impact Module). The theoretical formulation of COSIM can be found in *Kolluru et al. (1994)*. GEMSS and its various software modules have also been used and approved by various regulatory agencies in Australia, the Bahamas, Canada, India, Qatar, the United Kingdom, and the United States. GEMSS modules for oil spill modelling have also been recently used for permitting (Environmental Impact Assessment) in Italy, Morocco, and Argentina.

A GEMSS application requires two types of data: (1) spatial data, primarily the waterbody shoreline and bathymetry, but also the locations, elevations, and configurations of man-made structures and (2) temporal data, that is, time-varying boundary condition data defining tidal elevation, inflow rate and temperature, inflow constituent concentration, outflow rate, and meteorological data. All deterministic models, including GEMSS®, require uninterrupted time-varying boundary condition data. There can be no long gaps in the datasets and all required datasets must be available during the span of the proposed simulation period.

For input to the model, the spatial data are encoded primarily in two input files, the control and bathymetry files. The data in these files are geo-referenced. The temporal data are encoded in many files, each file representing a set of time-varying boundary conditions, for example, meteorological data for surface heat exchange and wind shear, or inflow rates for a tributary stream. Each record in the boundary condition files is stamped with a year-month-day-hour-minute address. The data can be subjected to quality assurance procedures by using GEMSS to plot, then to visually inspect individual data points, trends, and outliers. The set of input files and the GEMSS executable file constitute the model application.

### *1.2.1 Deterministic Model*

Time-varying, numerical hydrodynamic and transport models can be run in either of two modes: deterministic mode and stochastic mode. Deterministic mode means concurrent time-varying boundary condition data are used to step the model from the initial condition through time at steps that are typically on the order of a few seconds to several minutes. The early part of the simulation during which the initial conditions are "washed out" of the model domain and during which the boundary conditions come to dominate the solution is called the spin-up period. Results are taken from the period of simulation following spin-up.

There are only two types of output from deterministic simulations: values of a variable at a specific location through time (time-series plots) and values of a variable throughout the domain at a particular time (synoptic plots). The latter can take the form of tables, vertical profiles, or contour plots. Contour plots can show concentrations on a single plane, most often the horizontal plane at the water surface, but also on a horizontal plane anywhere in the water column, or on a vertical plane. Displays of the latter type are referred to as slice".

### *1.2.2 Stochastic Mode*

An informative kind of contour plot is based on accumulating statistical information on the location of a discharge plume through time. Displays of this type are called probabilistic plots and are derived as described below. At each cell at a specified frequency (eg hourly) the concentration of the constituent in question is saved in a series of bins, one bin for each range. An example might be a bin representing the range 0.0 to 0.2 mg/l. At the end of the simulation the probability of exceeding a value of interest (e.g. a regulatory limit) at each of the cells is computed and the probability is contoured. The contouring can be done only for a specific constituent concentration. For example, a probabilistic plot might show the probability of exceeding 0.5 mg/l and the contours would show areas in which the probability of exceeding this limit is 10 , 50 , and 90 .

Stochastic simulations rapidly query a statistical database (a Markov matrix table) that summarises a limited number of the time-varying forcing functions, typically for a simulated parameter that is largely dependent on only one or two forcing functions. A good example is the simulation of an oil spill. Since the transport of oil at the water surface is primarily dependent on the wind, a stochastic approach is used to incorporate this variable. A long-term wind record is processed to extract wind speed and direction probabilities within specified ranges. The simulation, which uses observed currents, makes random draws on this table based on the associated probabilities, applying the most frequent wind speed and direction combinations most frequently. In order to further randomise the procedure, simulations are repeated so that the order of the random draws changes.

To process the results, for each of the simulations and for each time increment at each surface cell, a count is made if it is determined that a single oil particle reaches that cell. For each iteration, a cell can be counted only once. At the end of the all simulations, results are reported as the percentage of time a particle reached the cell at least once during each of the simulations. Because this table is able to be mapped onto the grid of surface cells, it can be contoured. The resulting contour map can be interpreted as the probability that a single oil particle will reach that location.

# 2 OIL SPILL MODEL SIMULATION DESIGN

## 2.1 INTRODUCTION

Modelling was performed to assess potential environmental and social impacts that may occur in the event of a spill of diesel. The model calculated the spatial extent of a potential spill, the directions the spill may travel, the thickness of the surface slick, and the time of travel. *Table 2.1* shows the simulation scenario.

*Table 2.1* ***Oil Spill Simulation Scenario***

| Scenario | Description | Oil Spilled | Depth (m) | Mass Spilled ($m^3$) | Duration of Release |
|---|---|---|---|---|---|
| 1 | Loss of diesel containment on the rig | Diesel | 0 | 1,200 | 3 hours |

The volume of this release is large and considered to have a low likelihood of occurrence. The loss of all of the diesel fuel contained on the Mobile Offshore Drilling Unit (MODU) is approximately three and a half times the volume that might be lost from a large grounding accident from a freighter (*Michel et al., 1999*).

The two planned wells will be drilled from a single MODU. All the oil spill scenarios have been considered to occur at the following location in the Banda field:

Northing (m): 1965000 N
Easting (m): 334700 E
UTM WGS84 Zone 28 N

The oil spill scenario used 3,000 independent particles to represent the spill mass. Each particle was affected by currents, winds, randomised dispersion factors, and weathering. The duration of the simulation was 14 days.

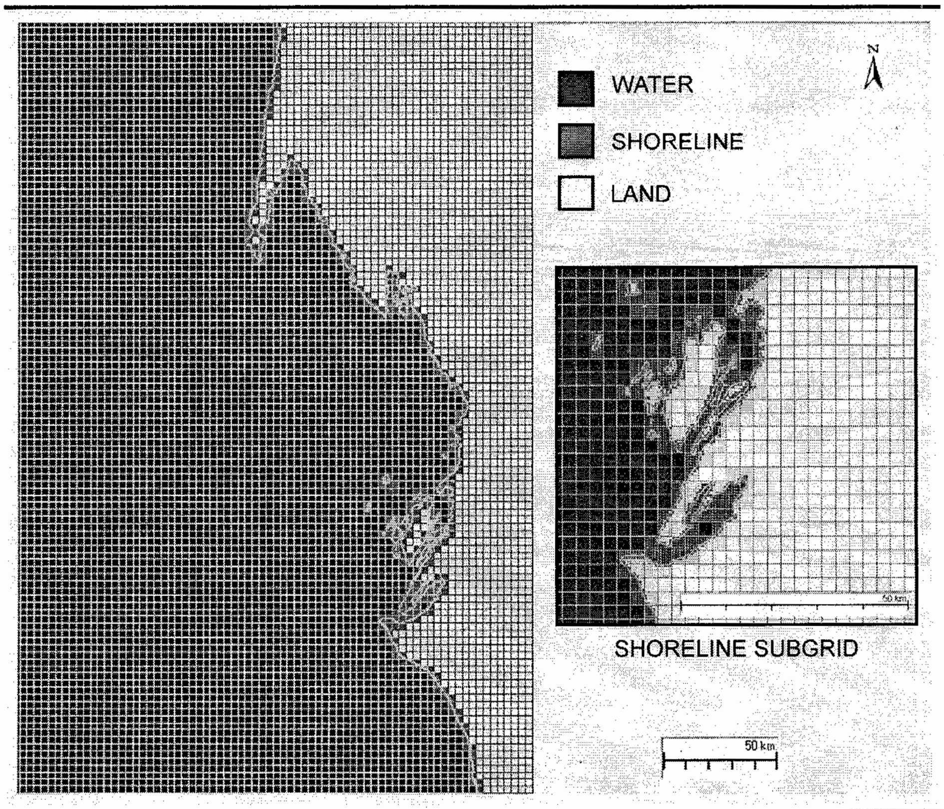
Stochastic mode of simulation was performed to examine the probable locations the spill may travel. The stochastic model results summarize 25 simulations. For each single simulation, the starting date and the selection of wind speed and direction at each time step were chosen stochastically from a database of properties in the selected periods. Summaries of the stochastic analyses are provided in terms of the likelihood of surface oiling, and the potential areas covered. The simulation terminates when the mass of oil is no longer on the water surface, transferring to the water column, atmosphere, or shoreline.

The GEMSS-COSIM modelling system produces time-varying mass balance calculations and tracks the fate of the released chemical constituents into the various phases and forms including the surface slick, shoreline, atmosphere, water column (dissolved or entrained), and sediment deposition. Fate is computed using the following processes: advection, spreading, evaporation, dispersion, dissolution, emulsification, photo-oxidation, sinking, sedimentation, and biodegradation.

COSIM performs simultaneous mass balance calculations for a full suite of specific chemicals or groupings of chemicals with similar properties. This feature enables the oil to be well defined, such that increasing the number of chemical categories improves the model's precision, applying oil component-specific values for parameters such as solubility, vapour pressure, density, evaporation, and solids partitioning. In these simulations, it was assumed that suspended solids concentrations were too small to cause significant solids partitioning.

An oil spill grid with 160 x 315 cells was constructed to cover an area approximately 475.8 km by 945.9 km in the east-west and north-south directions, respectively. Each grid cell was classified as land, water, or shoreline. An excerpt of this grid is shown in *Figure 2.1*. Particles representing the oil may only move in water cells. Every water grid has a depth value assigned to it. Shoreline grid cells, which act as a barrier between water and land cells, were further divided into 25 sub-grid cells to provide a refined delineation of the coast. Shoreline oiling occurs when a particle contacts a shoreline cell.

*Figure 2.1* ***Oil Spill Grid Excerpt and Detail of Subgrid***



## 2.2 *ENVIRONMENTAL DATA*

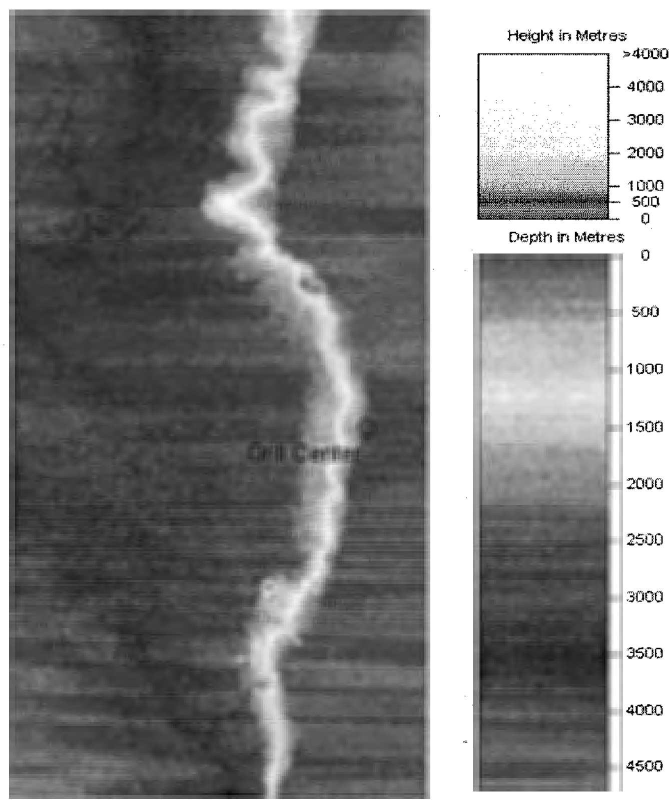
### 2.2.1 *Overview*

This modelling study used environmental data obtained from publically available records and information provided by Tullow.

### 2.2.2 *Spatially Varying Data*

The primary spatial dataset is the bathymetric data, used to describe the depth and shape of the seafloor. The Banda field offshore Mauritania extends from the continental shelf to the foot of continental slope (*Fugro GEOS, 2012*). Bathymetric data are used to develop grids for the oil spill models. The General Bathymetric Chart of the Oceans (GEBCO), a publicly-available source, was used to extract seafloor bathymetry at the study site (*IOC, et al., 2003*). The database used for this study is the GEBCO_08 Grid which has a 30 arc-second resolution. GEBCO bathymetry offshore Mauritania is shown in *Figure 2.2*.

*Figure 2.2* ***GEBCO Bathymetry Map***




Source: GEBCO (IOC et al 2003)

Information such as the location of the Banda field offshore Mauritania and the depths at which activities and release occur, are mapped onto the model grid. Accurate and consistent mapping are possible because all spatial data used by the model and produced in the course of modelling are geo-referenced. In addition, polyline shapefiles of the western African coastline act as a boundary in the model domain between land and water. The locations of shorelines are important because they typically include the most sensitive receptors for spills.

Tullow's navigation assessment for the area estimated the depth of the Banda well will be at 284 m below sea level. Using the GEBCO database, the average depth within the grid cell which includes the Banda drill centre is 284 m.

### 2.2.3 *Time Varying Data*

*Context*

The time-varying data for the modelling includes ocean current speeds and directions, water temperature and salinity; ocean waves, wind speeds and directions; and air temperature. According to a study by Fugro GEOS (*Fugro GEOS, 2012*), the Banda field offshore Mauritania is largely influenced by the Canary currents and by tidal currents at a lesser extent. The report further highlights that wave heights are low in the region and that wind is basically driven by three sources. They are northeastern Atlantic trade winds, high pressure from the Azores (Azores High), and Squalls. Squalls are intense low level winds associated with cumulonimbus storms. Ocean currents, water temperatures, and salinity data are available on a grid whose size and resolution are functions of the global circulation model used to develop this information. Wind data are similarly available from a global climatological circulation model. Monthly averaged air temperature data at Nouakchott in Mauritania was used in simulations. The combination of ocean currents, water temperatures, salinity, wind, and air temperatures is commonly referred to as metocean conditions. The following subsections discuss each of these datasets.

*Wind Data*

The northeasterly trade winds offshore Mauritania, primarily focused between the latitudes of 20° and 35° N during the summer due to Azores High and Squalls, influence the Banda field region offshore Mauritania south (17° 46'N latitude). Wind can be northerly and northeasterly during the rest of the year because the influence of northeasterly trade wind reached the area between latitudes 12° N and 30° N.

There are two common approaches in using wind data for predictive oil spill studies in the ocean. The first is to select a sufficiently long record of wind speed and direction at a selected location (preferably in close proximity to the spill location, for a period over ten years). This statistics of the wind data record are calculated and applied to the stochastic simulations in the form of a Markov matrix table to determine the range of impacts. A complete oil spill simulation is run multiple times using random wind conditions drawn from the Markov table. The second approach is to simulate a small spill every day over a selected historical period. The first approach is preferred over the second approach since the wind data will likely cover a longer period of record, and therefore including more extreme wind events in the statistics; the second approach in these types of simulations may face computational limitations, limiting the number of years in which the model can be run, and the number of Lagrangian particles which can be used.

Wind data at the Banda field offshore Mauritania were extracted from the NCEP/NCAR Reanalysis 1 dataset (*Kistler et al 2001*). This dataset is a joint product of the National Centers for Environmental Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) of the U.S. National Oceanographic and Atmospheric Administration (NOAA). The NCEP/NCAR Reanalysis 1 dataset is globally gridded, includes wind speed and direction, and is updated daily to represent the state of the global atmosphere. Observations and numerical weather prediction (NWP) model output from 9 July to 31 May 2012 are assimilated in the dataset.

*Table 2.2* shows the percentage of wind values from the Reanalysis 1 dataset falling into each wind speed range in each direction for the month of June. The product of the frequency of wind speed records in each range and the average wind speed in each range for the month of June is shown in the *Table 2.3*. The last column in *Table 2.3* shows the summation of the products in each of the direction bins for the month of June. The sums in each direction bin are an indicator of how far an oil slick can move towards the particular direction. *Table 2.4* shows these sums in each direction for all the months in the year. The last column of *Table 2.4* shows the sum of the values in each direction.

*Table 2.4* also shows that the highest speed-weighted count towards the coastline within three months arriving from N, WNW, NW and NNW directions in the Bins 1 (348.75° - 011.25°), 14 (281.25° - 303.75°), 15 (303.75° - 326.25°), and 16 (326.25° - 348.75°) respectively are in June, July and August. This strong wind towards the West African coast is considered as one of the major sources that can cause the fastest oil transport towards the African coast. Monthly wind roses are shown in *Figure 2.3*. Wind roses for the months June, July and August further confirms the facts about wind speed and direction discussed above, and hence winds from these months are used in the analysis.

It is important to demonstrate that the wind data at the Banda field described above is also representative of the wind conditions nearer to the coastline where accurate modelling of the slick is important. The wind data at latitude 17°45′ 00″ N, longitude: 16° 00′ 00″ W at coastal Mauritania was analyzed and compared with the wind data at the Banda field. Similar to *Table 2.4*, the summation of the products of the frequency of wind speed records in each range and the average wind speed in each speed range in each of the direction bins for all the months for this location is shown in *Table 2.5*. Similar to the wind data at the Banda Field, the highest speed-weighted count at coastal Mauritania arrive from the N, WNW, NW and NNW directions in Bins 1 (348.75° - 011.25°), 14 (281.25° - 303.75°), 15 (303.75° - 326.25°), and 16 (326.25° - 348.75°) occurring during the months of June, July, and August. Wind roses shown in *Figure 2.4* for coastal Mauritania for the months June, July and

August further confirm that the wind speed and direction at the Banda Field are similar to those at the coastline.

*Table 2.2* ***Wind Frequency (0 to 1) by Speed and Direction Al Classes for June in the Banda Field Offshore Mauritania (1987 - 2012)***

| Directions (degrees) 0° = from the north | Wind Classes (m/s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.0 - 2.0 | 2.0 - 4.0 | 4.0 - 6.0 | 6.0 - 8.0 | 8.0 - 10.0 | 10.0 - 12.0 | >= 12.0 | Total |
| 348.75 - 011.25 | 0.00122 | 0.00977 | 0.04558 | 0.07937 | 0.05983 | 0.00529 | 0 | 0.20106 |
| 011.25 - 033.75 | 0.00041 | 0.00244 | 0.00651 | 0.01018 | 0.00529 | 0.00041 | 0 | 0.02523 |
| 033.75 - 056.25 | 0 | 0.00081 | 0.00122 | 0.00081 | 0 | 0 | 0 | 0.00285 |
| 056.25 - 078.75 | 0 | 0.00041 | 0 | 0 | 0 | 0 | 0 | 0.00041 |
| 078.75 - 101.25 | 0 | 0.00081 | 0 | 0 | 0 | 0 | 0 | 0.00081 |
| 101.25 - 123.75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123.75 - 146.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 146.25 - 168.75 | 0 | 0 | 0.00041 | 0 | 0 | 0 | 0 | 0.00041 |
| 168.75 - 191.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 191.25 - 213.75 | 0 | 0 | 0.00041 | 0 | 0 | 0 | 0 | 0.00041 |
| 213.75 - 236.25 | 0 | 0.00081 | 0.00041 | 0 | 0 | 0 | 0 | 0.00122 |
| 236.25 - 258.75 | 0 | 0.00407 | 0.00366 | 0 | 0.00041 | 0 | 0 | 0.00814 |
| 258.75 - 281.25 | 0.00041 | 0.00814 | 0.01669 | 0.00692 | 0.00041 | 0 | 0 | 0.03256 |
| 281.25 - 303.75 | 0.00041 | 0.02605 | 0.0464 | 0.02198 | 0.00204 | 0 | 0 | 0.09687 |
| 303.75 - 326.25 | 0.00244 | 0.04151 | 0.11193 | 0.08954 | 0.02116 | 0.00081 | 0 | 0.2674 |
| 326.25 - 348.75 | 0.00081 | 0.03134 | 0.11518 | 0.14489 | 0.06675 | 0.00366 | 0 | 0.36264 |

*Table 2.3* *Product of Wind Frequency and Average Speed for June in the Banda Field Offshore Mauritania (1987 - 2012)*

| Directions (degrees) 0° = from the north | Wind Classes (m/s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0.0 - 2.0 | 2.0 - 4.0 | 4.0 - 6.0 | 6.0 - 8.0 | 8.0 - 10.0 | 10.0 - 12.0 | >= 12.0 | Total |
| 348.75 - 011.25 | 0.00122 | 0.02931 | 0.2279 | 0.55559 | 0.53847 | 0.05819 | 0 | 1.41068 |
| 011.25 - 033.75 | 0.00041 | 0.00732 | 0.03255 | 0.07126 | 0.04761 | 0.00451 | 0 | 0.16366 |
| 033.75 - 056.25 | 0 | 0.00243 | 0.0061 | 0.00567 | 0 | 0 | 0 | 0.0142 |
| 056.25 - 078.75 | 0 | 0.00123 | 0 | 0 | 0 | 0 | 0 | 0.00123 |
| 078.75 - 101.25 | 0 | 0.00243 | 0 | 0 | 0 | 0 | 0 | 0.00243 |
| 101.25 - 123.75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 123.75 - 146.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 146.25 - 168.75 | 0 | 0 | 0.00205 | 0 | 0 | 0 | 0 | 0.00205 |
| 168.75 - 191.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 191.25 - 213.75 | 0 | 0 | 0.00205 | 0 | 0 | 0 | 0 | 0.00205 |
| 213.75 - 236.25 | 0 | 0.00243 | 0.00205 | 0 | 0 | 0 | 0 | 0.00448 |
| 236.25 - 258.75 | 0 | 0.01221 | 0.0183 | 0 | 0.00369 | 0 | 0 | 0.0342 |
| 258.75 - 281.25 | 0.00041 | 0.02442 | 0.08345 | 0.04844 | 0.00369 | 0 | 0 | 0.16041 |
| 281.25 - 303.75 | 0.00041 | 0.07815 | 0.232 | 0.15386 | 0.01836 | 0 | 0 | 0.48278 |
| 303.75 - 326.25 | 0.00244 | 0.12453 | 0.55965 | 0.62678 | 0.19044 | 0.00891 | 0 | 1.51275 |
| 326.25 - 348.75 | 0.00081 | 0.09402 | 0.5759 | 1.01423 | 0.60075 | 0.04026 | 0 | 2.32597 |

*Table 2.4* ***Product of Wind Frequency and Average Speed for all the Months in the Year in the Banda Field Offshore Mauritania (1987 – 2012)***

| Directions (degrees) 0° = from the north | Wind Classes (m/s) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Sum of (Speed x Fraction) (m/s) |
| 348.75 - 011.25 | 0.661 | 1.553 | 2.023 | 2.582 | 2.628 | 1.411 | 0.392 | 0.389 | 1.187 | 2.292 | 1.406 | 0.768 | 17.291 |
| 011.25 - 033.75 | 1.312 | 1.452 | 1.200 | 0.730 | 0.383 | 0.164 | 0.048 | 0.067 | 0.454 | 1.453 | 1.766 | 1.519 | 10.547 |
| 033.75 - 056.25 | 2.096 | 1.133 | 0.580 | 0.114 | 0.033 | 0.014 | 0.012 | 0.025 | 0.110 | 0.539 | 1.361 | 1.901 | 7.918 |
| 056.25 - 078.75 | 1.365 | 0.625 | 0.236 | 0.017 | 0.007 | 0.001 | 0.007 | 0.013 | 0.057 | 0.136 | 0.639 | 1.386 | 4.490 |
| 078.75 - 101.25 | 0.148 | 0.061 | 0.031 | 0.001 | 0 | 0.002 | 0.000 | 0.017 | 0.053 | 0.028 | 0.063 | 0.100 | 0.504 |
| 101.25 - 123.75 | 0.028 | 0.001 | 0.001 | 0 | 0 | 0 | 0.004 | 0.016 | 0.030 | 0.009 | 0.006 | 0.003 | 0.098 |
| 123.75 - 146.25 | 0.015 | 0.001 | 0 | 0 | 0.001 | 0 | 0.003 | 0.028 | 0.049 | 0.008 | 0 | 0.004 | 0.109 |
| 146.25 - 168.75 | 0 | 0 | 0 | 0 | 0 | 0.002 | 0.008 | 0.030 | 0.045 | 0.007 | 0 | 0.000 | 0.093 |
| 168.75 - 191.25 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0.012 | 0.050 | 0.051 | 0.007 | 0.0004 | 0.001 | 0.126 |
| 191.25 - 213.75 | 0.002 | 0 | 0.002 | 0 | 0.002 | 0.002 | 0.031 | 0.056 | 0.076 | 0.010 | 0.001 | 0.001 | 0.184 |
| 213.75 - 236.25 | 0 | 0.001 | 0 | 0.000 | 0.006 | 0.004 | 0.084 | 0.119 | 0.063 | 0.004 | 0 | 0.005 | 0.287 |
| 236.25 - 258.75 | 0.002 | 0.003 | 0.008 | 0.000 | 0.023 | 0.034 | 0.188 | 0.250 | 0.090 | 0.010 | 0 | 0.004 | 0.614 |
| 258.75 - 281.25 | 0.004 | 0.013 | 0.011 | 0.004 | 0.029 | 0.160 | 0.560 | 0.560 | 0.238 | 0.019 | 0.0004 | 0.006 | 1.605 |
| 281.25 - 303.75 | 0.015 | 0.033 | 0.032 | 0.046 | 0.132 | 0.483 | 1.280 | 1.189 | 0.575 | 0.075 | 0.019 | 0.015 | 3.895 |
| 303.75 - 326.25 | 0.661 | 1.553 | 2.023 | 2.582 | 2.628 | 1.411 | 0.392 | 0.389 | 1.187 | 2.292 | 1.406 | 0.768 | 17.291 |
| 326.25 - 348.75 | 1.312 | 1.452 | 1.200 | 0.730 | 0.383 | 0.164 | 0.048 | 0.067 | 0.454 | 1.453 | 1.766 | 1.519 | 10.547 |

*Figure 2.3* *Monthly Wind Roses (direction wind blowing from) in the Banda Field Offshore Mauritania*

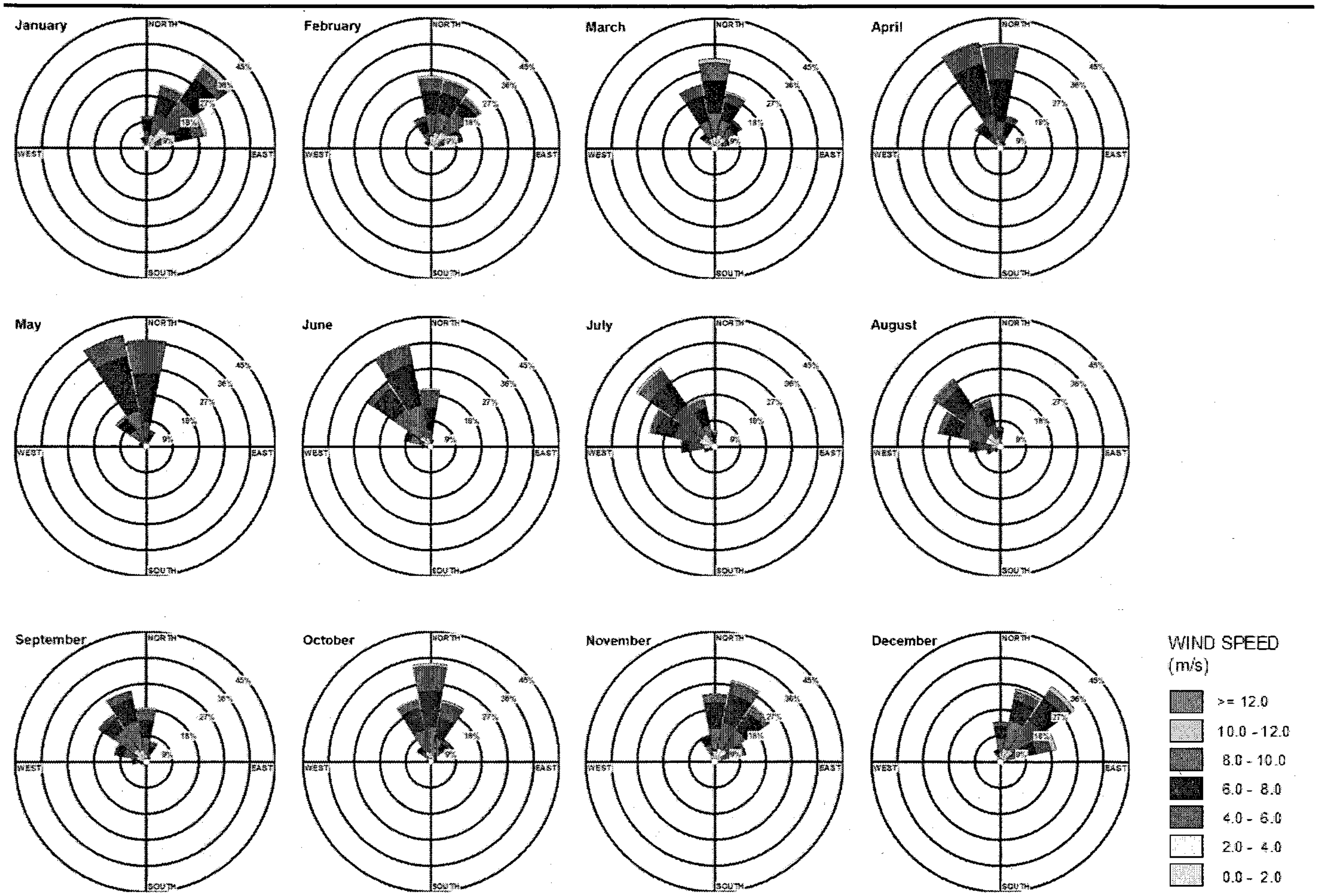
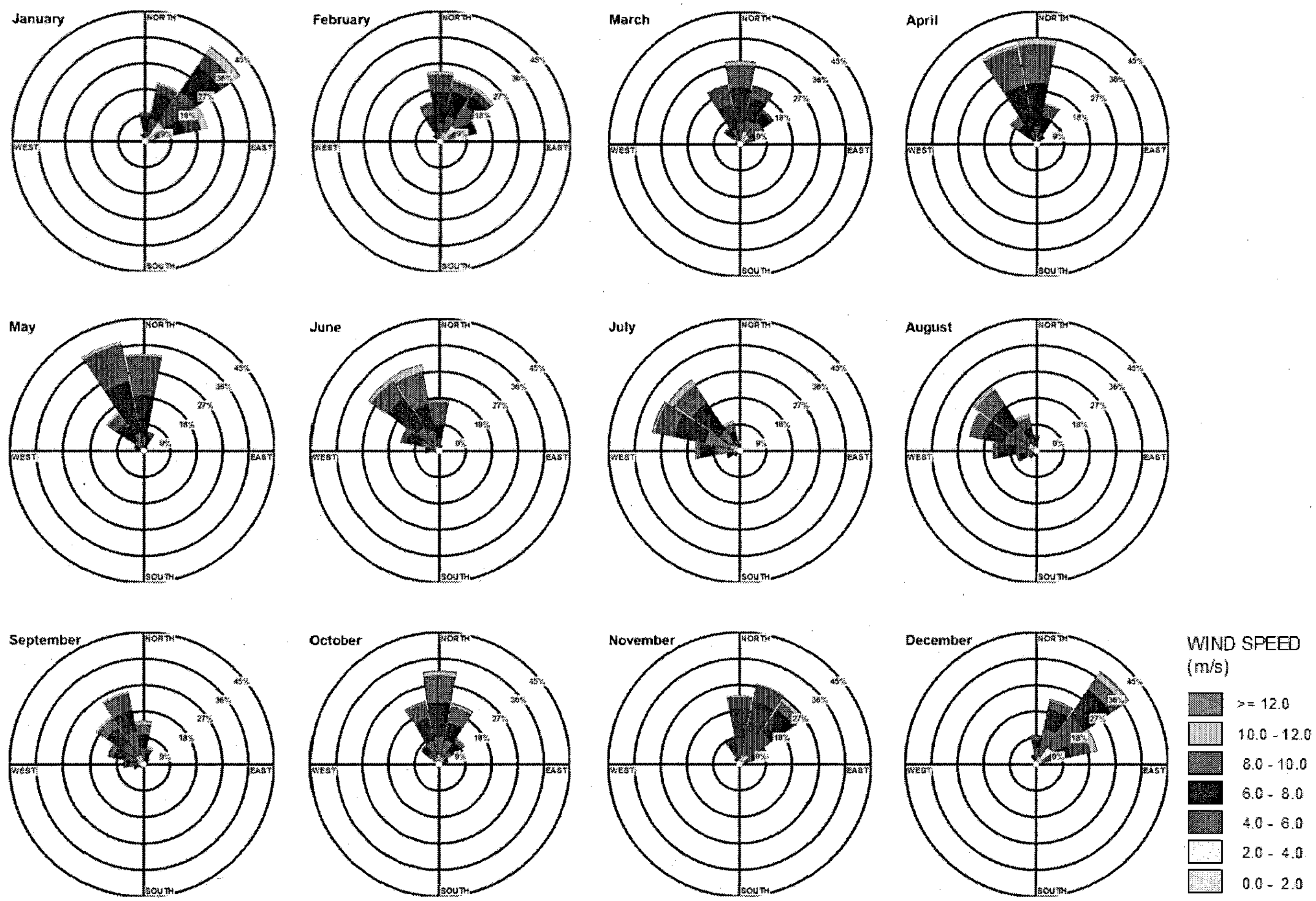


*Table 2.5* ***Product of Wind Frequency and Average Speed for all the Months in the Year for Wind at Coastal Mauritania***

| Directions (degrees) 0° = from the north | Wind Classes (m/s) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Sum of (Speed x Fraction) (m/s) |
| 348.75 - 011.25 | 0.629 | 1.681 | 2.026 | 2.685 | 2.480 | 1.307 | 0.278 | 0.314 | 1.003 | 2.228 | 1.510 | 0.595 | 16.735 |
| 011.25 - 033.75 | 1.331 | 1.379 | 1.261 | 0.991 | 0.481 | 0.140 | 0.052 | 0.081 | 0.435 | 1.433 | 1.794 | 1.374 | 10.751 |
| 033.75 - 056.25 | 2.450 | 1.214 | 0.760 | 0.186 | 0.071 | 0.014 | 0.003 | 0.031 | 0.172 | 0.664 | 1.577 | 2.370 | 9.511 |
| 056.25 - 078.75 | 1.507 | 0.699 | 0.283 | 0.030 | 0.012 | 0.004 | 0.011 | 0.009 | 0.075 | 0.166 | 0.628 | 1.519 | 4.944 |
| 078.75 - 101.25 | 0.203 | 0.050 | 0.034 | 0.006 | 0.008 | 0 | 0.006 | 0.024 | 0.051 | 0.028 | 0.038 | 0.134 | 0.580 |
| 101.25 - 123.75 | 0.044 | 0.004 | 0 | 0 | 0.006 | 0 | 0.005 | 0.013 | 0.030 | 0.009 | 0 | 0.003 | 0.114 |
| 123.75 - 146.25 | 0.018 | 0 | 0 | 0 | 0 | 0 | 0.006 | 0.037 | 0.041 | 0.003 | 0 | 0 | 0.104 |
| 146.25 - 168.75 | 0 | 0 | 0 | 0 | 0 | 0 | 0.011 | 0.015 | 0.045 | 0.006 | 0 | 0.003 | 0.081 |
| 168.75 - 191.25 | 0 | 0 | 0 | 0 | 0 | 0 | 0.015 | 0.033 | 0.066 | 0.007 | 0 | 0 | 0.121 |
| 191.25 - 213.75 | 0 | 0 | 0.004 | 0.001 | 0 | 0.006 | 0.085 | 0.099 | 0.064 | 0 | 0 | 0.007 | 0.266 |
| 213.75 - 236.25 | 0 | 0 | 0 | 0 | 0 | 0.006 | 0.136 | 0.156 | 0.072 | 0 | 0.006 | 0 | 0.375 |
| 236.25 - 258.75 | 0 | 0.009 | 0.013 | 0 | 0.013 | 0.085 | 0.244 | 0.404 | 0.176 | 0.005 | 0 | 0 | 0.949 |
| 258.75 - 281.25 | 0 | 0.009 | 0.023 | 0 | 0.069 | 0.259 | 0.882 | 0.891 | 0.360 | 0.016 | 0.006 | 0.007 | 2.522 |
| 281.25 - 303.75 | 0.012 | 0.034 | 0.061 | 0.029 | 0.204 | 0.825 | 2.005 | 1.453 | 0.733 | 0.056 | 0.036 | 0.013 | 5.461 |
| 303.75 - 326.25 | 0.026 | 0.141 | 0.379 | 0.812 | 1.057 | 2.056 | 2.081 | 1.710 | 1.204 | 0.452 | 0.119 | 0.035 | 10.072 |
| 326.25 - 348.75 | 0.193 | 0.961 | 1.460 | 2.580 | 2.803 | 2.261 | 0.728 | 0.878 | 1.601 | 1.458 | 0.505 | 0.194 | 15.622 |

*Figure 2.4* *Monthly Wind Roses (direction wind blowing from) at Coastal Mauritania*



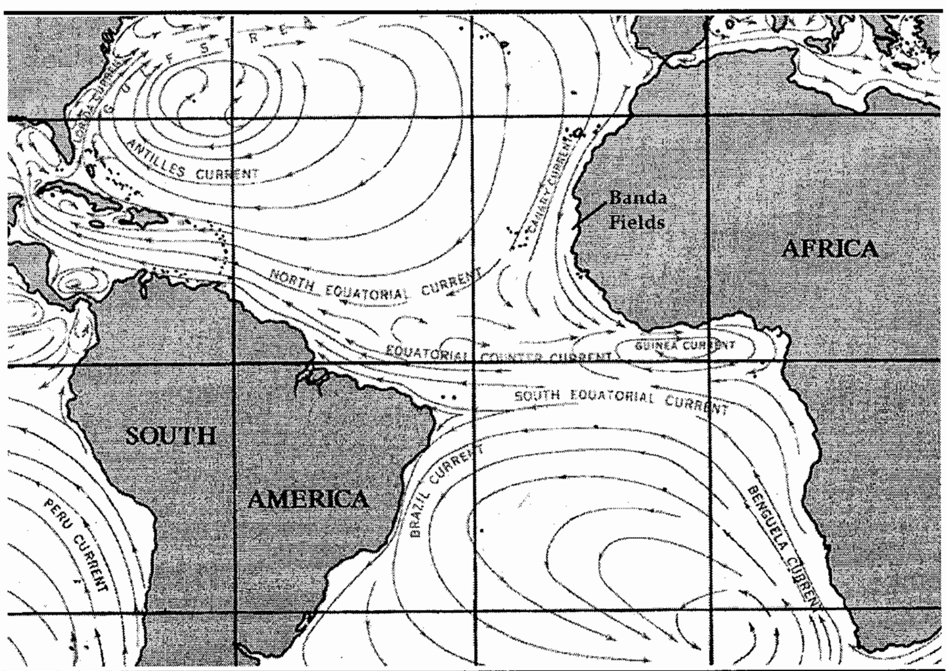
2.2.4 *Air Temperature Data*

Monthly averaged air temperature data at Nouakchott in Mauritania was used in the simulations. The specific location of the data considered was 18°6' N (latitude), 15° 57' W (longitude) at 2 m altitude. Distance between this location and the location where the discharges have been modelled is approximately 65 km.

2.2.5 *Ocean Current, Temperature and Salinity Data*

In the northern Atlantic Ocean, South Drift Currents move southwards towards Canary Islands passing the Bay of Biscay due to the deflection by the European coastline. These currents known as Canary Currents continue southwards till the vicinity of the Cape Verde Islands and divides into two main streams. One stream of it curves toward the west forming the North Equatorial Current. The other stream curves toward the east and follows along the coast of Africa into the Gulf of Guinea. This is known as the Guinea Current. This current gains the strength from the North Equatorial Counter Current. This is further strengthened in summer due to the monsoon winds. It flows parallel to African coast east and southwards till it merges with the South Equatorial Current as shown in *Figure 2.5* (*Bowditch et al., 2002*).

*Figure 2.5* ***Ocean Current, Temperature and Salinity Data***




Source: *Bowditch et al., 2002*

Depth-varying, six-hour average currents (speed and direction), salinity and water temperature data were obtained from the NCEP, an arm of the U.S. NOAA, using oceanographic output from their Climate Forecast System Reanalysis (CFSR) program (*Kistler et al., 2001*). Data are available for the earth's oceans at every 0.5° horizontally (latitude and longitude). Vertically, values of currents, salinity and temperature are available at every 10 m intervals starting from the depth of 5 m until 225 m and continue with increasing depth intervals until 4,478 m. The current, temperature, and salinity for the present simulations were selected from the period from December 1995 through March 2001 because this period includes the effects of both El Nina and La Nina events. Meteorological data examined by Null (*Null, 2012*) shows that these events include an intermediate (neutral) or normal period (1995), a weak La Nina event (1996), a strong El Nino period (from 1997 to early 1998) and moderate La Nina period (from mid-1998 to early 2000).

Current rose diagrams of the NCEP CFSR data for each month are provided in *Figure 2.6*. The diagram is based on surface currents from the NCEP model output nearest to the wellhead location (longitude 16.75° W; latitude 17.75°N).

As evident in the current rose diagrams, the predominant direction of the surface currents between the Banda field and the coastline are towards the southwest throughout most of the year. This is mostly due to the part of the Canary stream curving toward the east and following along the coast of Africa into the Gulf of Guinea (*Fugro GEOS, 2012*). The directions of the currents during June and July stand apart from the rest of the year, with no dominant direction, even though the velocities, on average, are among the strongest of the year (*Figure 2.6*).

Examples of CFSR-modelled currents are provided in *Figure 2.8* and *Figure 2.9* for the u- (east-west) and v-components (north-south) of the current, respectively. Temperature and salinity data, incorporated into the COSIM model, are available at the same resolution as the currents.

*Figure 2.6* *Monthly Current Roses (direction current travelling to) in the Banda Field Offshore Mauritania (1995-2001)*

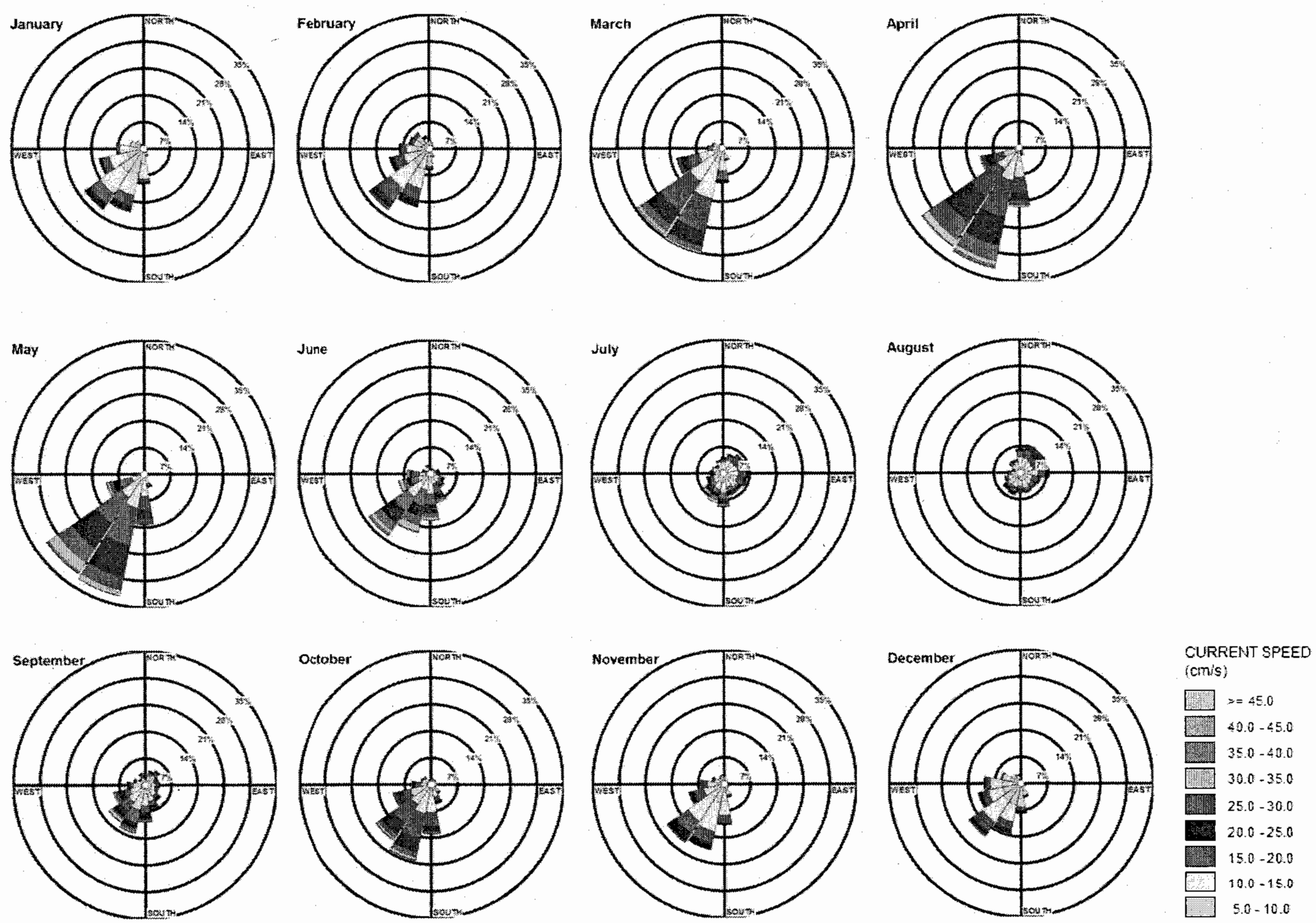


*Figure 2.7* *Monthly Average Surface Currents*

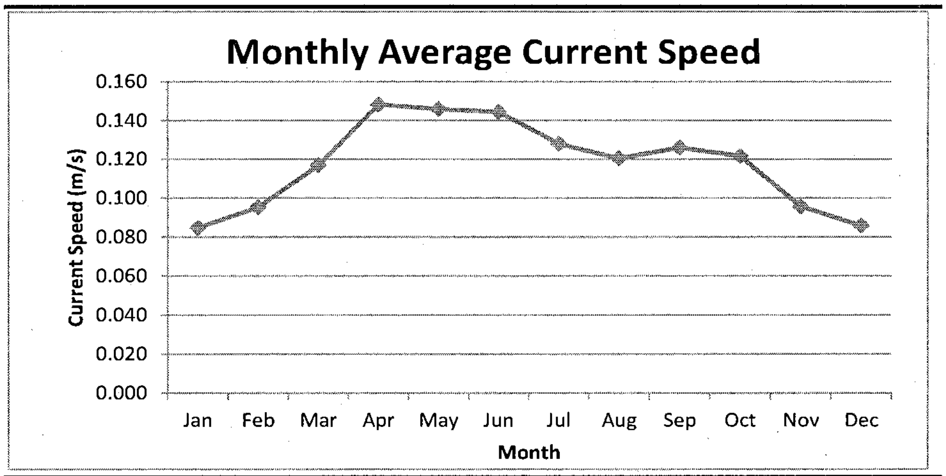



*Figure 2.8* *Example CFSR east-west Component of the Current for 1 June 1996 midnight, 5 m depth (positive is to the east)*

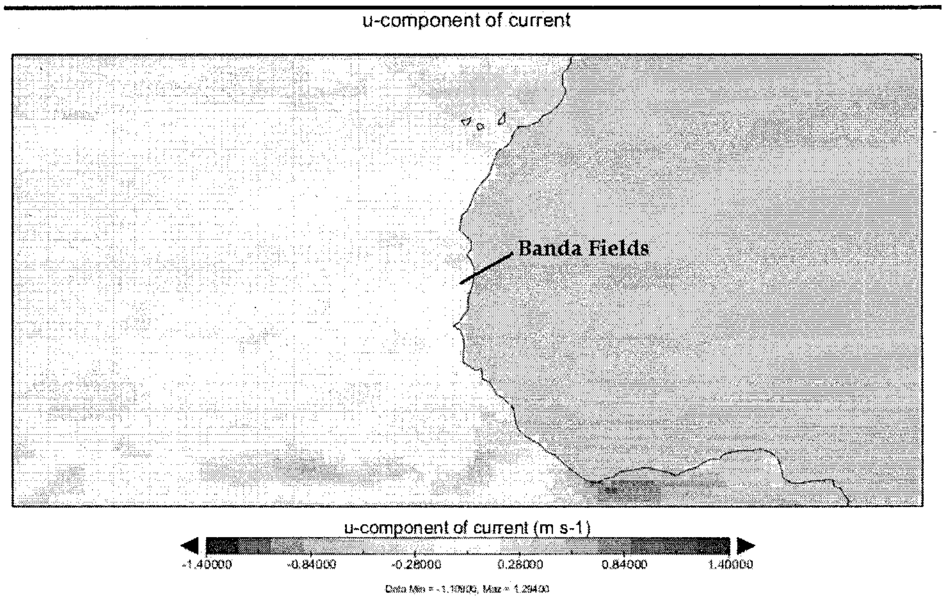
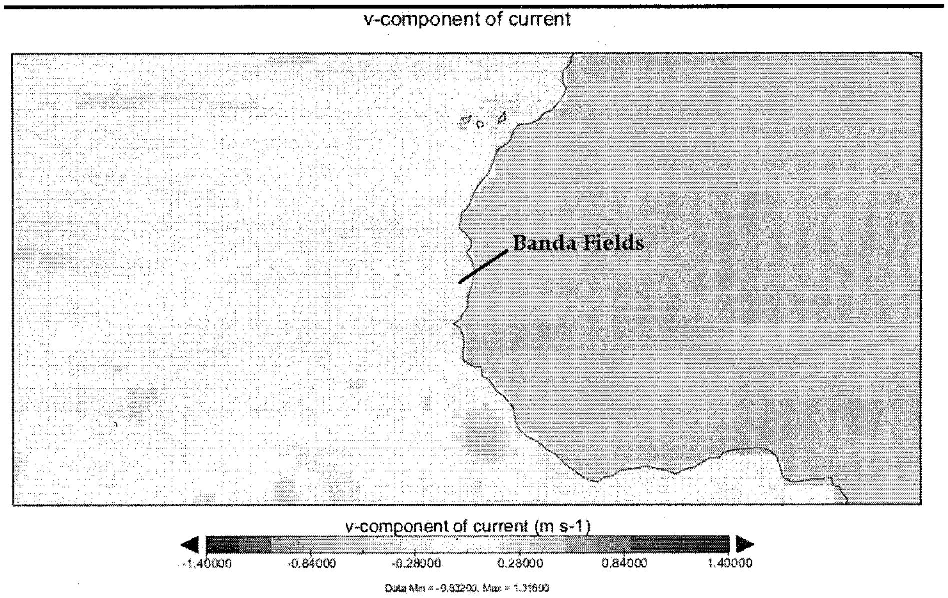


*Figure 2.9* ***Example CFSR north-south Component of the Current for 1 June 1996 midnight, 5 m depth (positive is to the north)***




### 2.2.6 *Summary of Environmental Data*

Modelling oil behaviour in oceanic environments requires consideration of both winds and currents because they are both influential on the oil transport. While it is true that the transport of oil is influenced by about 3 of wind speed and nearly 100 of current speed, it should be noted that the wind speed is much larger than the current speed (10 - 20 times larger). The influence of winds on ocean transport is primarily near the surface, and decreases exponentially with depth. The fate and transport of constituents in the water column below the surface are primarily a function of ambient ocean currents at those depths. Datasets for these forcing functions that represent conditions at the Banda field offshore Mauritania were obtained and used in the modelling effort. Winds are represented stochastically and the currents are represented deterministically. The current dataset varies with depth, and bathymetry data were obtained from the GEBCO database.

The currents in the Banda Field region are mostly directed towards the southwest, away from the shoreline. There is no month when currents predominantly travel towards the shore. The months with the lowest frequency of currents directed away from the shoreline were in July and August. Considering also the months of June, July and August have the highest frequency of winds directed towards the shore, these months were selected as the analysis period. These three months represent the time of the year with the greatest risk for shoreline oiling, providing the shortest response time.

## 2.3 *DIESEL PROPERTIES*

Components of a typical diesel fuel oil were taken from ERM's COSIM database of oil properties. The values for the properties for each compound or group of compounds for diesel fuel were also obtained from ERM's COSIM database. The main components of diesel are presented in *Table 2.6*.

***Table 2.6 Volumetric Proportions of Diesel Fuel***

| Component | Volume | Component | Volume |
|---|---|---|---|
| Benzene | 0.30 | Octane | 9.13 |
| Toluene | 1.50 | Indane | 3.30 |
| Ethylbenzene | 2.50 | Indene | 0.90 |
| Xylenes | 9.20 | Decalin | 5.90 |
| Naphthalenes | 2.70 | Decane | 15.90 |
| Heptane | 9.13 | Pentane | 9.13 |
| Methylcyclohexane | 21.30 | Hexane | 9.13 |
| | | Total | 100.0 |

Though many of the components are soluble, the model tracks the dissolved concentrations of the soluble aromatics as the primary constituents of concern for causing an acute toxicological effect, due to narcosis (*French et al., 2000*). For diesel, the dissolved aromatic hydrocarbons (DAHs) are calculated as the sum of the soluble monoaromatics (the BTEX group: benzene, toluene, ethylbenzene, and xylenes), and the polycyclic aromatics (naphthalenes).

## 3 RESULTS

### 3.1 INTRODUCTION

This section presents the results of the stochastic modelling and a single deterministic case.

### 3.2 STOCHASTIC MODEL

The stochastic model results are presented as probabilistic summaries of multiple iterations (or simulations); each iteration represents a single spill event. The stochastic model considers a total of 25 iterations for each scenario, and then calculates statistical summaries of the results.

The probabilistic summary diagrams depict a composite of the 25 iterations, representing oiled locations from all iterations. A single spill event (one of the 25 iterations) would cover only a portion of the area shown. These probability plots for the surface and shoreline oiling are intended to show the range of locations at risk due to the presence of oil under the conditions of the scenario.

The COSIM model may track diesel on the surface down to insignificantly small quantities. Therefore, a thickness threshold is applied to distinguish between significant and insignificant amounts of diesel. The first clearly visible oil appears as a silvery sheen at thicknesses between 0.04 μm to 0.3 μm based on values cataloged in the 2006 Bonn Agreement Oil Appearance Code (BAOAC) (Lewis, 2007). A minimum threshold thickness value has been chosen at 0.1 μm, translated into units of mass per surface area as 0.08 g/m$^2$. Model output is presented for those locations with surface diesel mass per unit area equal to or above this threshold, and presented in terms of the color classifications. *Table 3-1* summarizes these descriptors.

*Table 3-1* ***Oil thickness descriptors***

| Color | Thickness μm | Diesel g m$^{-2}$ |
|---|---|---|
| Silver sheen | 0.1 | 0.080 |
| Rainbow | 0.3 | 0.24 |
| Metallic | 5 | 4.0 |
| Transitional dark | 50 | 40.0 |
| Dark / true color | 200 | 160.0 |
| Black oil | >200 | >160.0 |

A summary of the scenario results is provided in *Table 3.2* and described in detail in the sections which follow.

*Table 3.2* ***Stochastic Model Results Summary***

| Scenario | Min. Time to Shoreline Contact (days) | Max Aromatic Conc (ppm) | Area of Aromatic Conc > 5 ppb ($km^2$) | Max Thickness (µm) | Region at Risk of Visible Surface Oiling ($km^2$) |
|---|---|---|---|---|---|
| Diesel | 3.0 | 220* | 6,777 | 49 | 11,115 |

*Computed solubility limit reached for sum of mono- and polycyclic aromatic hydrocarbons.

## 3.3 *DETERMINISTIC MODEL*

Sample deterministic model results are shown for a diesel to illustrate what a single model run looks like among the multiple stochastic iterations. For this example, one of the 25 spill events used has been chosen for showing the evolution of the spilled hydrocarbon. In this case, the model output provides the surface trajectory of the spill, time to impact shorelines, and a mass balance for the spill.

Mass balance plots illustrate the fate of the diesel as time-varying percentages of the total mass for the five primary phases: the surface diesel, dissolved diesel, entrained diesel (whole droplets suspended in the water column), diesel stranded on shorelines, and the mass of oil evaporated or volatilized into the atmosphere. The mass balance plots are taken from one of the 25 iterations; other iterations may show the mass of oil transferring from the surface to the shoreline at times sooner or later than the example plots included, but the rates of evaporation, dissolution, and entrainment should be similar between iterations.

## 3.4 *LOSS OF DIESEL CONTAINMENT ON THE MODU*

The scenario modelled represents a hypothetical loss of diesel containment on the MODU resulting in a discharge of 1,200 $m^3$ of diesel over a three-hour period at the surface level.

### 3.4.1 *Stochastic Model*

*Figure 3.1* to *Figure 3.6* show the main graphic results provided by GEMSS-COSIM modelling system.

The following figures are shown below.

- *Figure 3.1* shows the geographical distribution of the probability of surface oiling from the diesel spill. This probability is calculated for each cell in the model grid, by counting the number of iterations in which the surface slick passes through that grid cell for all simulations. At each cell, the probability of finding visible oil (oil above the significantly thick threshold, as described in *Section 3.1*) over a 14-day period after the diesel spill event is shown.

- *Figure 3.2* shows the geographical distribution of the maximum diesel thicknesses over all potential oiling locations.
- *Figure 3.3* shows the probability of diesel impacting the shoreline over a 14-day period, while *Figure 3.4* shows the maximum volume of shoreline oiling.
- *Figure 3.5* shows the maximum dissolved aromatic hydrocarbon (DAH) concentrations in the water column beneath the diesel slick.
- *Figure 3.6* shows the travel time of the diesel slick. This is represented as the shortest time out of all the iterations in which the oil slick contacted a given grid cell.

The protected areas for Senegal and Mauritania are presented on each diagram.

*Figure 3.1* *Diesel Spill: Probability of Visible Surface Oiling*

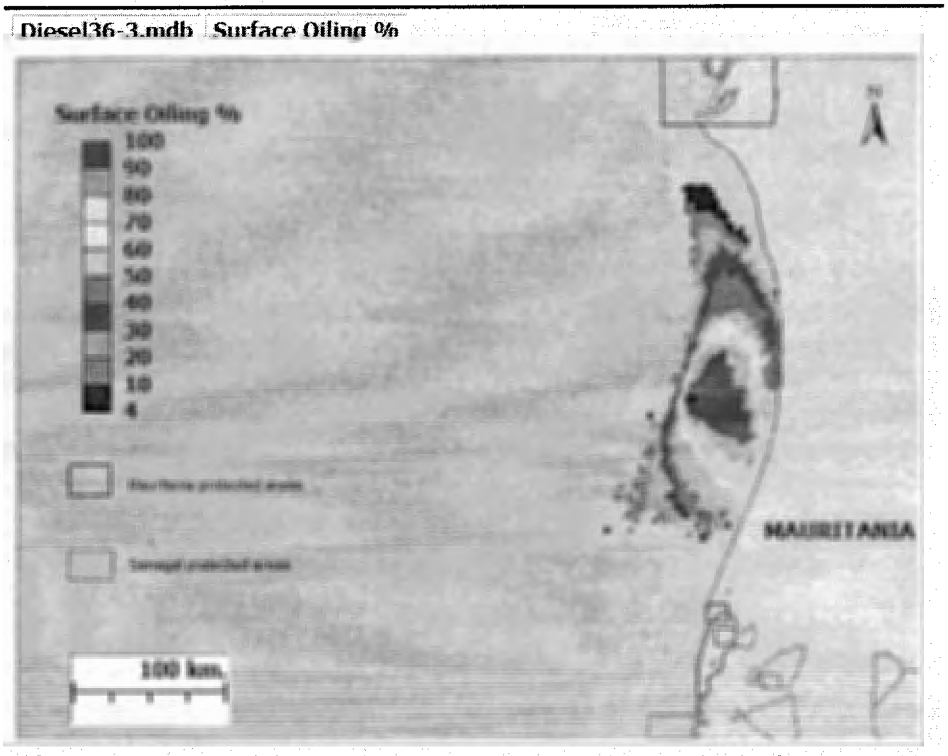


*Figure 3.2* *Diesel Spill: Maximum Oil Thickness*

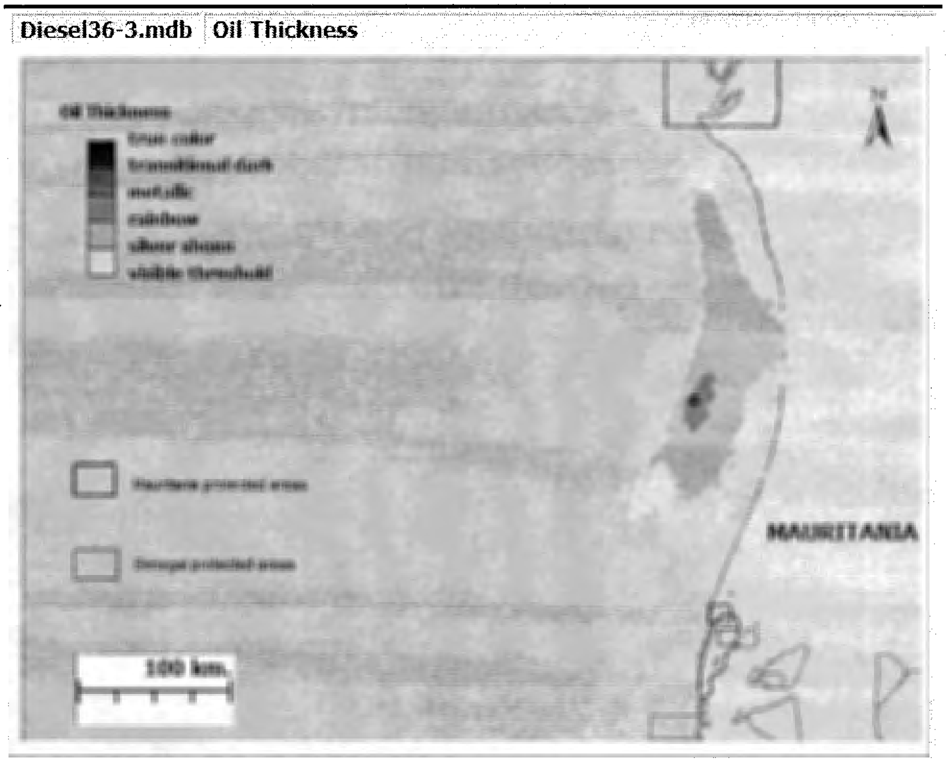



*Figure 3.3* *Diesel spill: Probability of Shoreline Oiling*

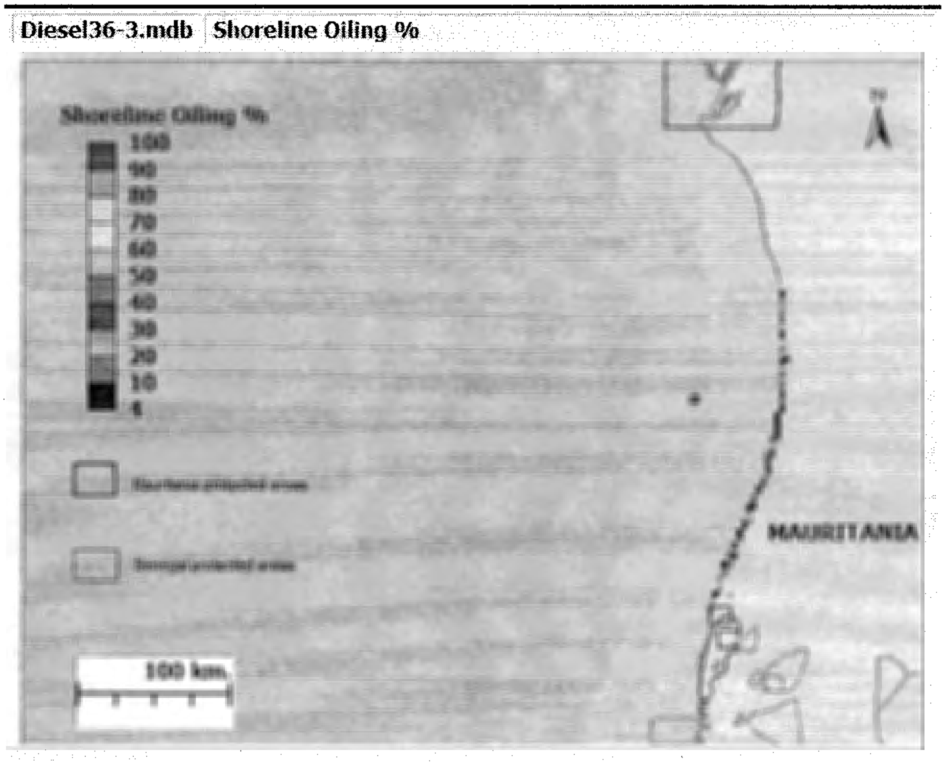


*Figure 3.4* *Diesel spill: Maximum Shoreline Oiling Volume*

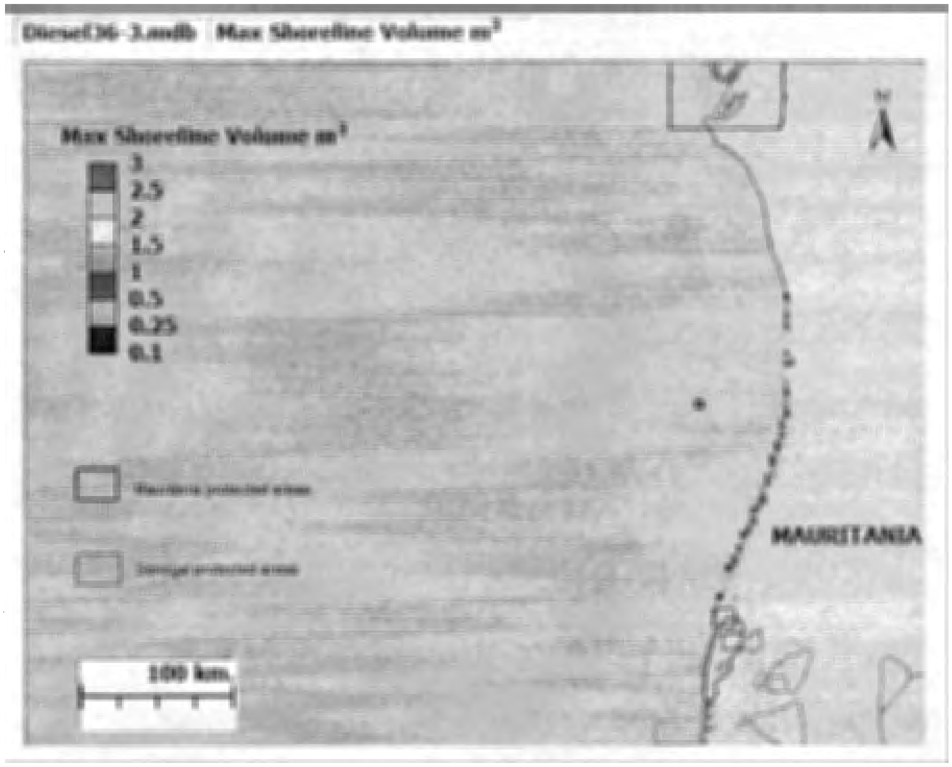



*Figure 3.5* *Diesel Spill: Maximum Dissolved Aromatic Hydrocarbon Concentrations*

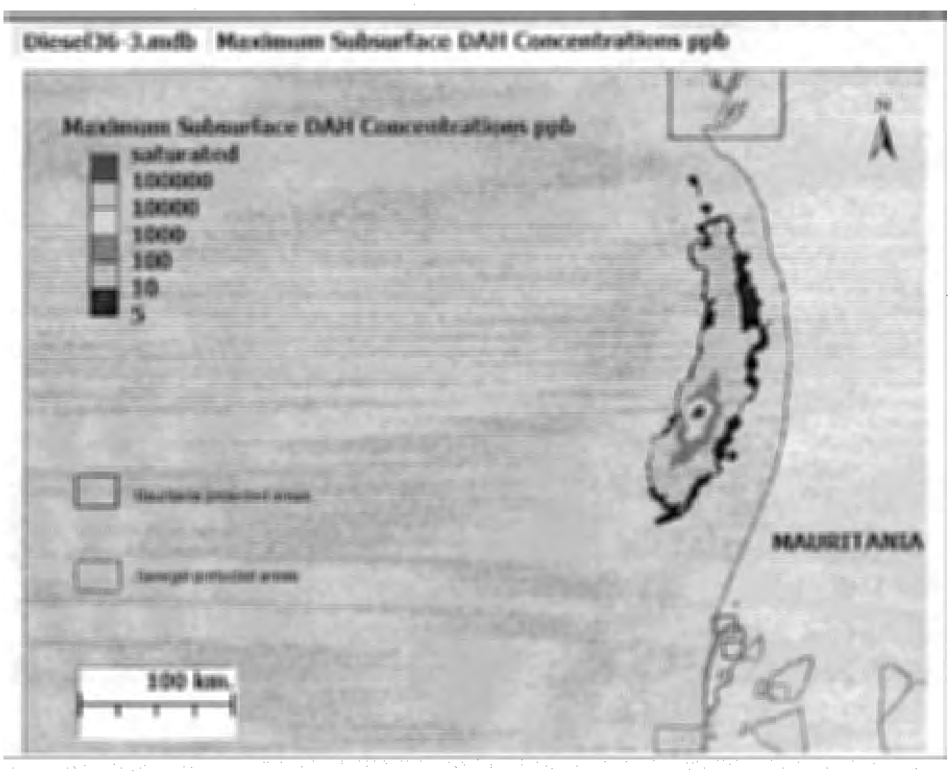
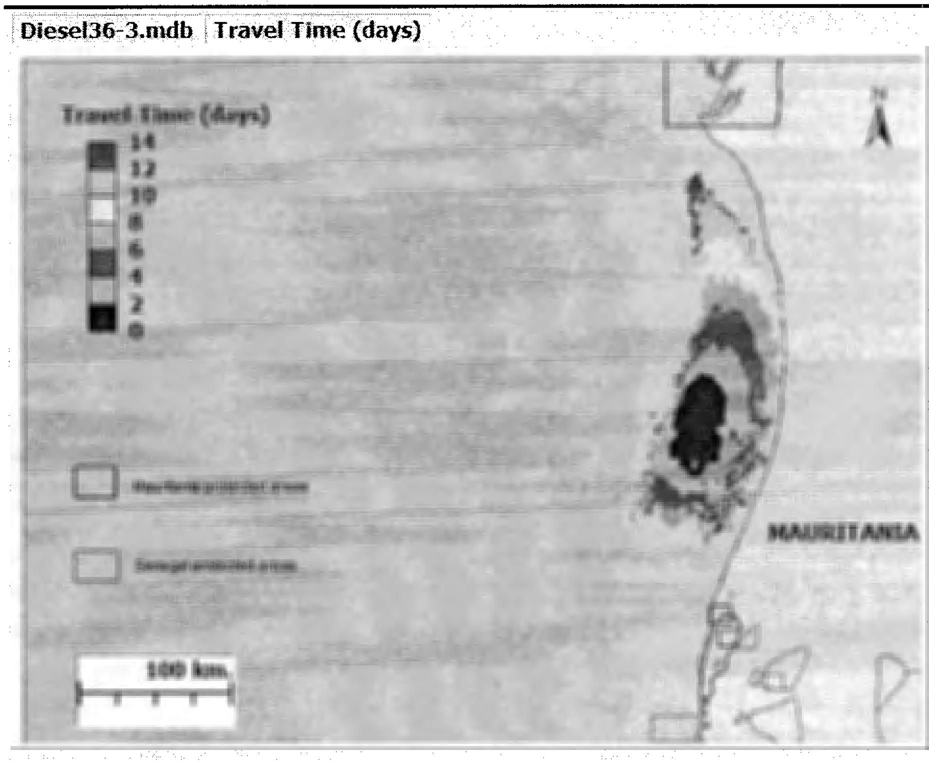


*Figure 3.6* *Diesel Spill: Travel Time for Visible Oil*




The model results show that the water surface region at risk of having a visible surface slick (diesel slick with a thickness over the 0.1 µm threshold) is approximately 11,115 km² around the MODU. This region is delineated as having a probability of visible surface oiling greater than 4 (i.e. occurring in at least one of the 25 iterations).

As shown in *Figure 3.1* the diesel slick tends to move generally towards the coastline potentially travelling northeast to southeast, with the region most likely to be oiled influenced strong by northwesterly summer winds and calm ocean currents. In this scenario, the diesel is expected to spread and evaporate rapidly. Visible sheens of diesel are expected to occur and to move towards the coast.

As shown in *Figure 3.2* the diesel's maximum thickness is initially in the metallic color category around the MODU, but decreases rapidly to a rainbow sheen or silver sheen for the majority of the locations at risk of oiling. For diesel arriving to the coast, the thickest is expected to arrive approximately 60 km northeast of the MODU, with a thickness between 0.3 µm to 5 µm.

The probability of which locations a diesel spills may reach the coast of Mauritania is depicted in *Figure 3.3*. The coastal region potentially affected is a section of 200 km of coastline, from 35km north of Nouakchott to 165 km south of Nouakchott. Note that the 200 km of coastline represents the total coastline length at risk with a probability greater than a 4 likelihood of oiling, and includes any surface mass contacting the shoreline, including some oil thinner than the visible surface threshold in the southern extent of the shoreline oiling region. In *Figure 3.4*, the maximum volume of shoreline oiling is depicted, indicating that the region with the highest potential volume of oil deposited is northeast from the release location. The total volume of diesel potentially impacting the shorelines ranges between 2 $m^3$ and 100 $m^3$ (average of 14 $m^3$) out of the 1,200 $m^3$ of diesel spilled.

DAH in the water column (*Figure 3.5*) have concentrations above 5 ppb in a region directly beneath the spill similar to the region with the rainbow color or thicker, covering a region approximately 6,800 $km^2$ in area. This should not be interpreted that acutely toxic concentrations will persist over this entire region at risk during the entire spill event. Rather, firstly, a single spill event will oil less than this region. In addition, this is the total region at risk of potentially having concentrations at some point in time above a no-effect threshold within the top few meters beneath the oil slick. As the slick passes, the dissolved concentrations attenuate by dilution and eventually by biodegradation. Aquatic biota may avoid this region, travelling to lower depths to avoid narcotic effects. However egg and larval lifestages will be unable to avoid the exposure on their own.

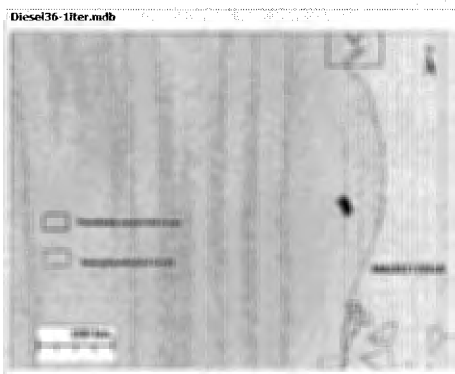
As shown in *Figure 3.6*, the minimum time for a surface slick to reach shoreline ranges from 3 to 7.5 days after the initial release (4.6 day on average).

### 3.4.2 *Deterministic Model*

The deterministic models show the evolution of each of the spill simulations or iterations performed by the model. As explained above, one stochastic model for one scenario is the result of running 25 simulations (or iterations). Therefore, one stochastic model includes a summary of 25 deterministic results.

*Figure 3.7* shows the evolution of one spill event. The figure shows one of the 25 simulations chosen as an example. The figure shows snapshots of the spill at different times after the event. No thickness threshold has been applied to these diagrams.

*Figure 3.7* *Example of the Evolution of a 1,200 m³ Diesel Spill during 2 Weeks*

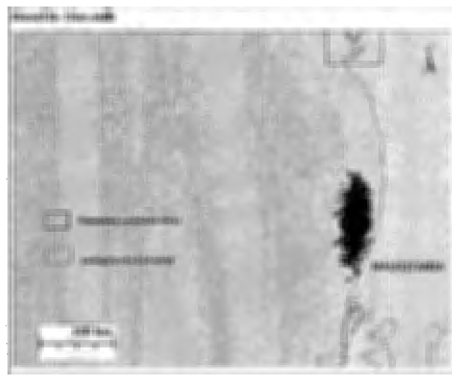



1 day after spill

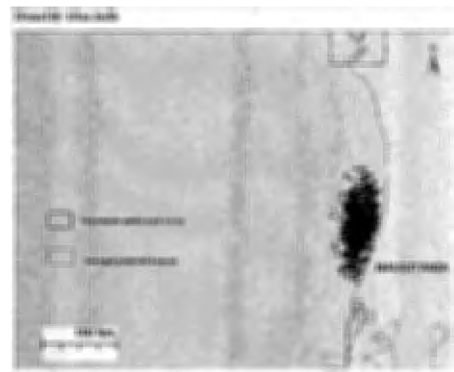

4 days after spill

6 days after spill


8 days after spill



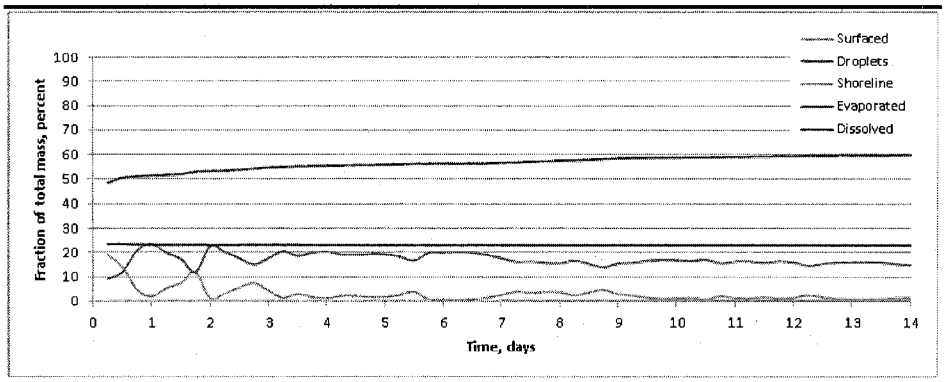
12 days after spill



14 day after spill

For a single spill event, the mass balance plot (*Figure 3.8*) illustrates the fate of the diesel over time into various phases and forms. The mass balance diagram presented below corresponds to one of the 25 simulations.

*Figure 3.8* *Mass Balance Plot: Diesel Spill*




As illustrated in *Figure 3.8* diesel distributes in four primary phases right after the spill occurs:

- water surface: at most almost 20 of the total mass of diesel spilled, decreasing over time after weathering, and oscillating as winds submerge the slick into the water column;
- entrained: slightly over 20 , similar to the surface oil, increasing during times when the wind-wave turbulent mixing is strongest;
- evaporated: reaching 50 during the initial 24 hours and rising at a slower rate subsequently to approximately 60 of the total mass after two weeks; and
- dissolved in water: 22 , approximately of the total mass of diesel spilled.

Diesel presents a high proportion of short chain hydrocarbons, an as a result, a large percentage of the oil evaporates over time. Beyond 14 days, more mass will evaporate, and biodegradation will be more evident in the removal of mass from the water column.

The diesel that does not evaporate stays on the surface and a proportion of this diesel dissolves as the winds and waves entrain the diesel into the water column.

A fraction of diesel may contact the shoreline beginning at 6 days after the release in this iteration. After two weeks, approximately 1 of the total mass (6 tons out of the total 960 tons comprising the 1200 m³ volume released) is estimated to be on the shorelines.

## 4 *SUMMARY AND CONCLUSIONS*

The metocean conditions in the area during the summer months, and in particular the strong winds blowing from the NW tend to move spilled hydrocarbons towards the Mauritanian coast. The coasts that are predicted to be most at risk of being oiled are 200 km in length, located 35 km to the north and 165 km to the south of Nouakchott. These shorelines at risk of oiling are 7 km from the nearest of the protected areas.

The simulations presented in this study represent low probability, high consequence situations relative to potential impacts to the environment. The scenario showed risk to shoreline oiling with varying quantities, depending on the persistence of the oil.

The shortest time for shoreline to be contacted by diesel was within 3 days, and 4.6 days on average. The volume of oil contacting the shoreline was on average 14 $m^3$ from the diesel spill.

Concentrations of soluble aromatic hydrocarbons are considered a potential source of acute toxicity due to narcosis. The oil concentrates directly beneath the slick in the top three meters where wind and wave energy causes entrainment of the slick into the water column.

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Annex C

# Collision Risk Assessment

# Collision Risk Assessment
# Banda Oil Field
# (Technical Note)

| | |
|---|---|
| Prepared by: | Anatec Ltd. |
| On behalf of: | Environmental Resource Management (ERM) |
| Date: | 19th December 2012 |
| Revision No.: | 02 |
| Ref.: | A2863-ERM-RA-0 |


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This study has been carried out by Anatec Ltd (Anatec) for Environmental Resource Management (ERM) on behalf of Tullow Petroleum (Mauritania) Pty Ltd (Tullow). The assessment represents Anatec's best judgment based on the information available at the time of preparation. Any use which a third party makes of this report is the responsibility of such third party. Anatec accepts no responsibility for damages suffered as a result of decisions made or actions taken in reliance on information contained in this report.

# TABLE OF CONTENTS

# 1. INTRODUCTION

## 1.1 *Background*

Tullow is proposing to drill 4 wells at the Banda Oil Field in the Mauritania Block ERM has commissioned Anatec to assess the ship routeing and risk of collision at the proposed Banda drilling location.

The objectives of this assessment are as follows:

- Identify the shipping routes passing the Banda location.
- Calculate passing powered/drifting and infield collision frequencies.
- Review risk mitigation measures.

## 1.2 *Abbreviations*

The following abbreviations are used in this report:

| | | |
|---|---|---|
| AIS | - | Automatic Identification System |
| AtoN | - | Aid to Navigation |
| ARPA | - | Automatic Radar Plotting Aid |
| CPA | - | Closest Point of Approach |
| DWT | - | Dead Weight Tonnes |
| ECDIS | - | Electronic Chart Display and Information System |
| ERRV | - | Emergency Response and Rescue Vessel |
| GMDSS | - | Global Maritime Distress Safety System |
| GT | - | Gross Tonnes |
| HSC | - | High Speed Craft |
| HSE | - | Health and Safety Executive (UK) |
| MJ | - | Megajoule |
| MMSI | - | Maritime Mobile Service Identity |
| nm | - | Nautical Miles (1nm ≡ 1,852 metres) |
| OGP | - | International Association of Oil & Gas Producers |
| PSV | - | Platform Supply Vessel |
| RACON | - | Radar Beacon |
| RoPax | - | Roll on/ Roll off Passenger Ferry |
| RO/RO | - | Roll on/ Roll off |
| SD | - | Standard Deviation |
| SOLAS | - | Safety of Life at Sea |
| UKCS | - | United Kingdom Continental Shelf |
| UKOOA | - | UK Offshore Operators Association |
| UTM | - | Universal Transverse Mercator |
| VHF | - | Very High Frequency |
| WGS | - | World Geodetic System |

# 2. FIELD DETAILS

## 2.1 *Location Details*

The geographical co-ordinates of the proposed Banda Drilling locations are presented in Table 2.1.

**Table 2.1 Location**

| Location | Geographical Co-ordinates (UTM WGS 84 Zone 28 North) |
|---|---|
| | Latitude/Longitude |
| Banda Drill Centre | 17° 46' 20.48" N, 16° 34' 10.95" W |
| Oil Well 1 | 17° 46' 19.92" N, 16° 34' 11.54" W |
| Oil Well 2 | 17° 46' 21.06" N, 16° 34' 11.55" W |
| Oil Well 3 | 17° 46' 21.07" N, 16° 34' 10.36" W |
| Oil Well 4 | 17° 46' 19.93" N, 16° 34' 10.35" W |

It is noted that the individual wells are all approximately 25m from the drill centre point. Therefore, the drill centre location will be used for the calculations throughout this report.

General and detailed chart overviews of the location are presented in Figure 2.1 and Figure 2.2, respectively. The positions of nearby navigational features referenced from the Banda location are presented in Table 2.2.

**Table 2.2 Nearby Features referenced from Banda Drill Centre**

| Feature | Distance (nm) | Bearing (°) |
|---|---|---|
| Berge Helene FPSO | 10.3 | 248 |
| Nearest Point of Land | 29.5 | 090 |
| Nouakchott | 38 | 061 |

The nearest charted water depth to the location is 284m (lowest astronomical tide).

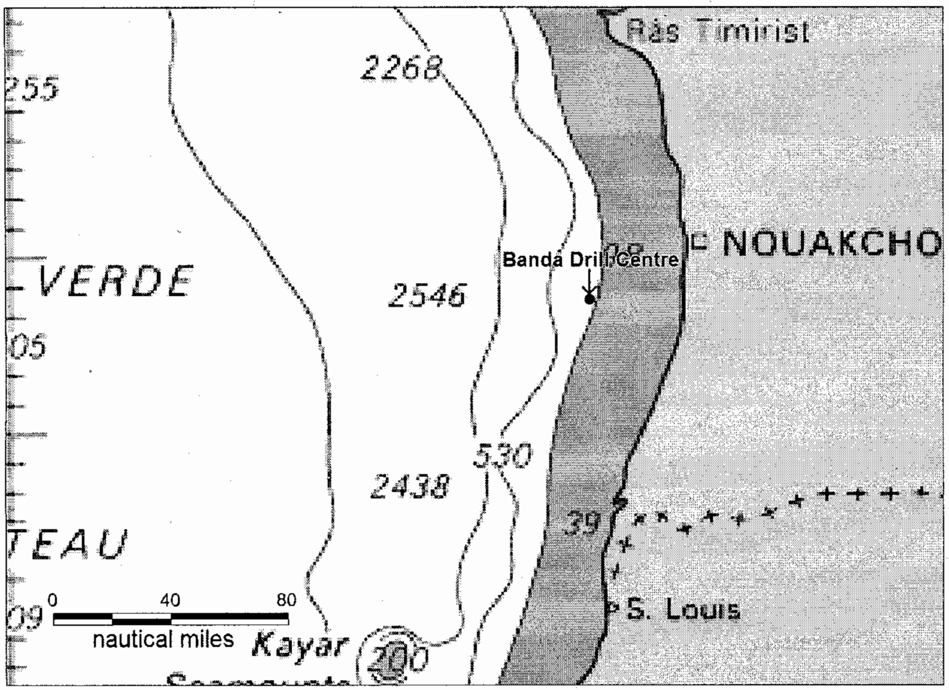


**Figure 2.1 General Chart Overview of the Banda Location**

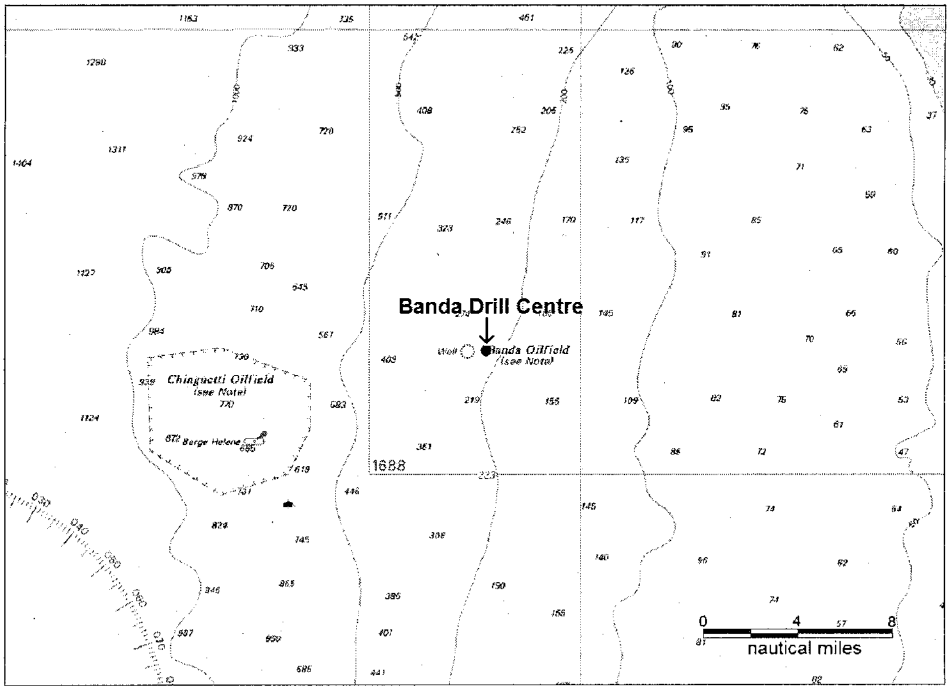


**Figure 2.2 Detailed Chart Overview of the Banda Location**

## 2.2 *Installation Details*

Tullow will be using a moored semi-submersible rig. For the purpose of this study the Atwood Hunter has been assumed. The installation dimensions used for the analysis are provided below:

- Name: Atwood Hunter
- Type: Semi-Submersible
- Length: 88.39m
- Breadth : 75.22m
- Orientation: 0°(Not provided)

Two Supply vessels will be supporting the drilling rig for the duration of the operation, one of which will perform as an ERRV for collision risk management. It is assumed this will be equipped with ARPA radar and AIS for collision risk management purposes.

## 2.3 *Meteorological Data*

### 2.3.1 Wind & Wave

Meteorological wind and wave data for the area has been taken from the Banda area (Ref. i). This data was based on 6 hourly intervals for the 9 year time period between January 2001 and December 2009.

The mean wind direction distribution for the Banda sea area is presented in Figure 2.3. It can be seen that the most likely wind direction is from the N.

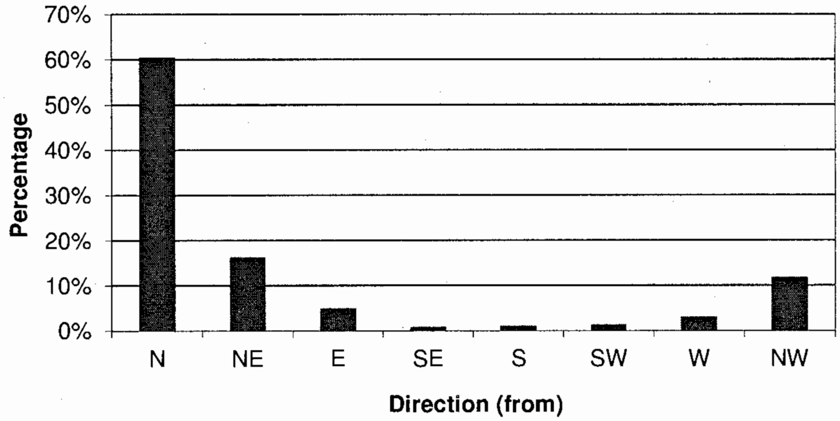


**Figure 2.3 Annual Wind Direction Distribution for the Banda Area (Ref. i)**

The percentage exceedence distribution of significant wave height for the Banda area is presented in Figure 2.4.

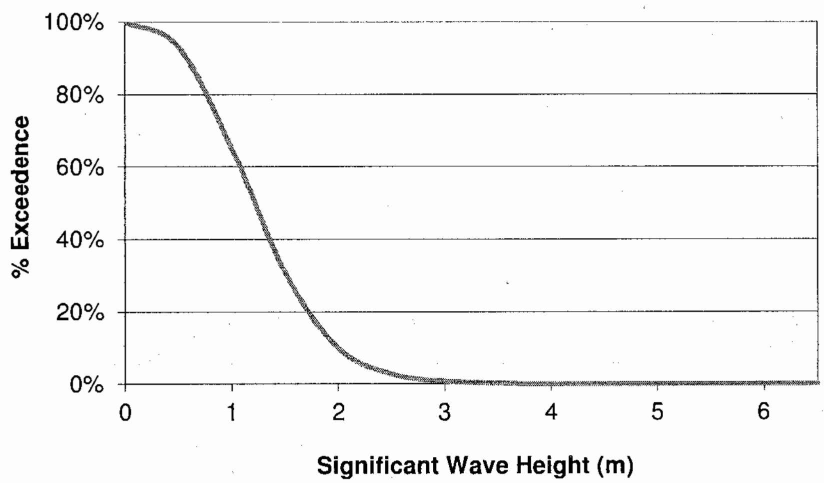


**Figure 2.4 Annual Wave Height Exceedence Curve for the Banda Area (Ref. i)**

Therefore, the frequency of significant wave height exceeding 5m is approximately 0 %.

### 2.3.2 Visibility Data

Historically, visibility has been shown to have a major influence on the risk of ship collision. As visibility data was not provided, data from the Admirality North Atlantic Routeing Chart (5124) was used. The annual probability of visibility less than 1 km for this location is approximately 0.02, i.e., 2% of the year.

# 3. SHIPPING DATA

## 3.1 *Introduction*

This section discusses the shipping movements data and routeing information which has been used to create the shipping route database for the area of interest.

## 3.2 *Annual Shipping Movements*

Anatec holds worldwide shipping movement data. The data is weighted seasonally to account for variations in traffic levels during the year. The figures (overleaf) provide an overview of the ports covered within the data set.

As well as identifying the annual number of vessels using each route, the vessels were categorised by type and size as follows:

**Table 3.1 Ship Type and Size Categories**

| Type Code | General Type | Subtypes (examples) |
|---|---|---|
| 1 | Cargo | General Cargo, Container Carrier, Reefer, Bulk Carrier, Gas Carrier, Ro/Ro (Freight) |
| 2 | Tanker | Crude Oil, Product, Chemical, Bunkering, Vegetable Oil |
| 3 | Ferry | Passenger Ferry, HSC, RoPax |
| **Size Code** | **Deadweight Tonnes (DWT)** | |
| 1 | < 1,500 | |
| 2 | 1,500-5,000 | |
| 3 | 5,000-15,000 | |
| 4 | 15,000-40,000 | |
| 5 | ≥ 40,000 | |

It is noted that the port callings data used does not have comprehensive information on fishing vessels, pleasure craft, naval vessels and other vessels termed as "non-routine" (non-route based), therefore, these vessels have been excluded from this study. However, due to the high number of fishing vessels present in the area this has been analysed separately in Section 8. Also, there are limitations in the disclosure of callings information at some ports which can lead to under-reporting.

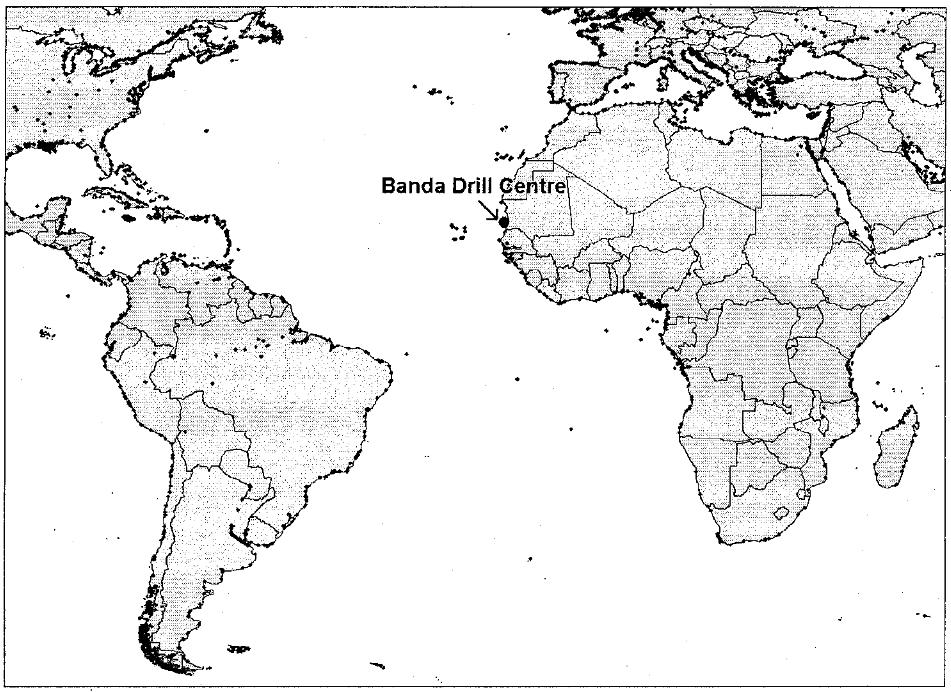


**Figure 3.1 Banda location relative to Global Ports**

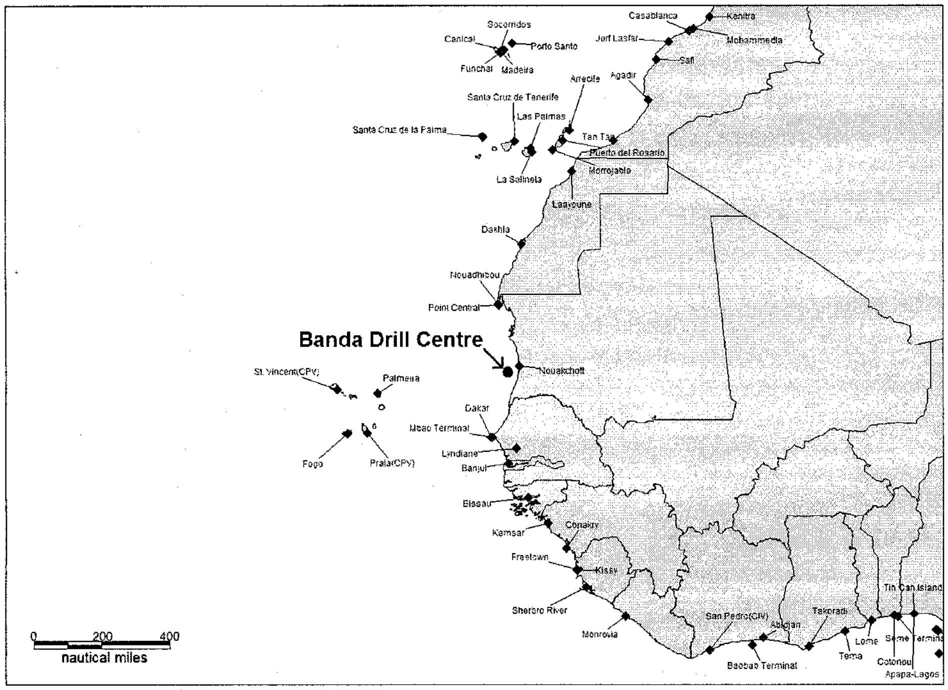


**Figure 3.2 Local Ports near to Banda location**

## 3.3 *Ship Routeing Information*

Following the identification of all the unique routes passing through the area, the route positions and widths were defined.

A desktop study was performed using the best available data. The following sources of information were used:

- Satellite AIS data 2011/12;
- Satellite tracking of ships 2004/05.

Satellite AIS data were analysed to define the positioning of routes offshore, in the area of interest. A plot of the satellite AIS data for the area of interest is presented in Figure 3.3, which illustrates the routeing in the vicinity of the Banda location.

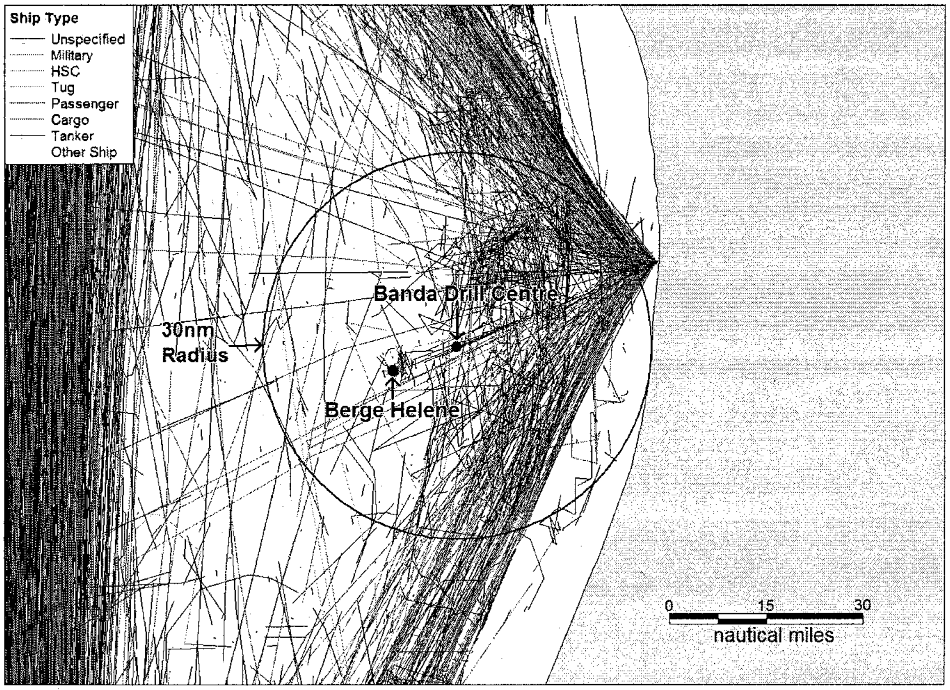


**Figure 3.3 Sample Satellite AIS Data (fishing removed)**

The available AIS tracking data was supplemented by further satellite tracking data for the area. An extract of this data for the area of interest is presented in Figure 3.4. This did not provide significant additional data however it is useful to validate the AIS based data. It is noted that individual tracks are subject to inaccuracy due to rounding of latitude/longitude position (1 decimal degree) and time interval between polling (3 hours).

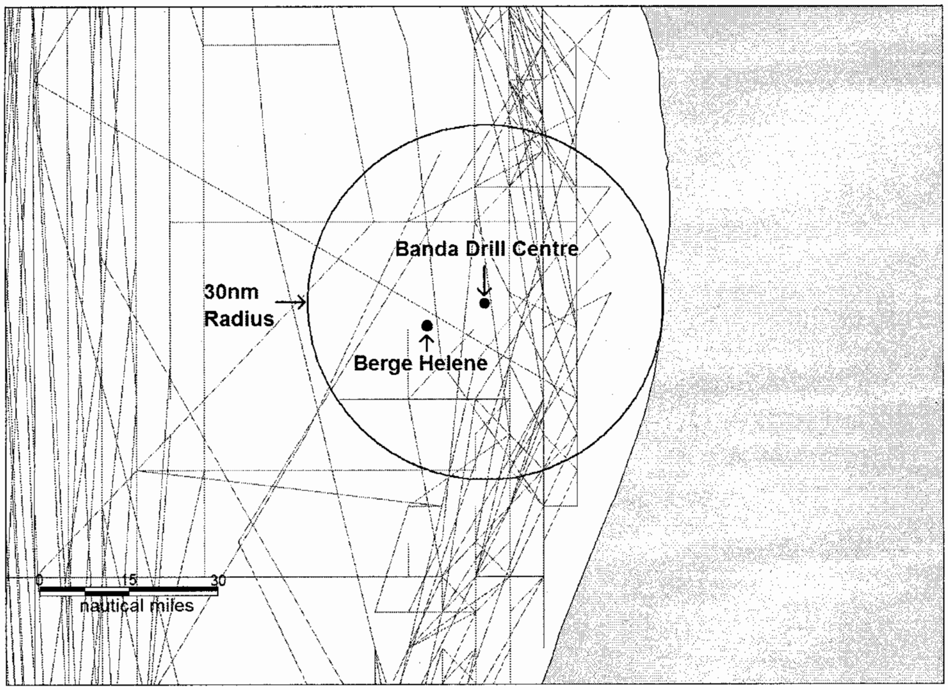


**Figure 3.4 Sample Ship Satellite Tracks for African Waters**

# 4. FINALISED SHIPPING DATABASE

## 4.1 *Introduction*

The shipping route database (ShipRoutes) for the area was developed by combining the movements analysis (see Section 3.2) with the routeing analysis (see Section 3.3), with each route having a detailed distribution of shipping levels and characteristics.

The search results for the Banda location are presented in the following subsections.

## 4.2 *Routeing Pattern at Banda*

The shipping routes identified by a 30nm search of around the Banda location are presented in Table 4.1 in ascending order of Closest Point of Approach (CPA).

**Table 4.1 Ship Routes Passing within 10nm of Banda**

| Route No. | Description | CPA (nm) | Bearing (°) | Ships Per Year |
|---|---|---|---|---|
| 1 | Berge Helene FPSO-Nouakchotte* | 0.2 | 337 | 208 |
| 2 | Nouakchott-South America* | 2.5 | 153 | 30 |
| 3 | Cape Verde-Nouakchott* | 9.6 | 354 | 20 |
| 4 | Nouakchott-South* | 19.0 | 115 | 300 |
| 5 | North America-Nouakchott* | 21.3 | 17 | 30 |
| TOTAL | | | | 588 |

* Where two or more routes have identical Closest Point of Approach (CPA) and bearing they have been grouped together. In this case, the description lists the sub-route with the most ships per year.

Plots of the mean route positions relative to Banda are presented in Figure 4.1

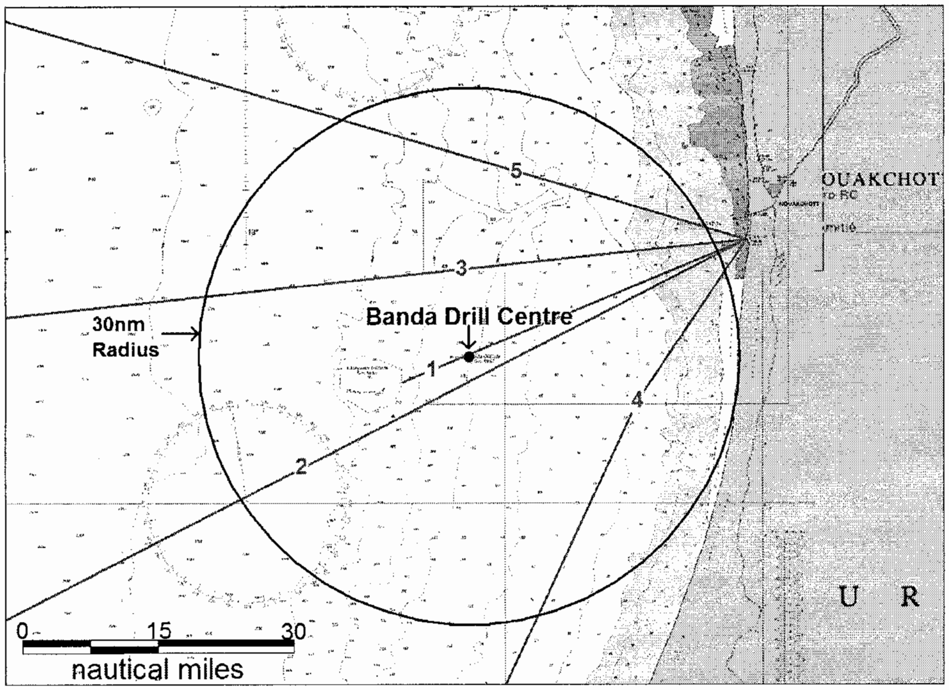


**Figure 4.1 Shipping Route Positions within 10nm of Banda**

## 4.3 *Vessel Type/Size Distributions*

The composition of the traffic on each route distributed by vessel type and size (deadweight tonnage) is presented in the following tables.

**Table 4.2 Cargo Vessel Size Distribution**

| Route No. | Size Distribution (DWT) | | | | | Ships Per Year |
|---|---|---|---|---|---|---|
| | < 1500 | 1500–5000 | 5000–15000 | 15000–40000 | ≥ 40000 | |
| 2 | 0% | 0% | 0% | 30% | 80% | 20 |
| 3 | 0% | 0% | 25% | 50% | 25% | 16 |
| 4 | 0% | 0% | 15% | 30% | 55% | 200 |
| 5 | 0% | 0% | 0% | 63% | 25% | 16 |
| **Total** | 0% | 0% | 13% | 33% | 53% | 252 |

**Table 4.3 Tanker Size Distribution**

| Route No. | Size Distribution (DWT) | | | | | Ships Per Year |
|---|---|---|---|---|---|---|
| | < 1500 | 1500–5000 | 5000–15000 | 15000–40000 | ≥ 40000 | |
| 2 | 0% | 0% | 0% | 40% | 40% | 10 |
| 3 | 0% | 0% | 0% | 50% | 50% | 4 |
| 4 | 0% | 0% | 10% | 40% | 50% | 100 |
| 5 | 0% | 0% | 0% | 71% | 43% | 14 |
| **Total** | 0% | 0% | 8% | 44% | 48% | 128 |

**Table 4.4 Offshore Vessel Size Distribution**

| Route No. | Size Distribution (DWT) | | | | | Ships Per Year |
|---|---|---|---|---|---|---|
| | < 1500 | 1500–5000 | 5000–15000 | 15000–40000 | ≥ 40000 | |
| 1 | 0% | 100% | 0% | 0% | 0% | 208 |
| **Total** | 0% | 100% | 0% | 0% | 0% | 208 |

## 4.4 *Discussion of Routeing Pattern*

There are 5 shipping routes trafficked by an estimated 588 ships per year passing within 10nm of the Banda Location. This corresponds to an average of 1 to 2 vessels per day.

The overall breakdown of traffic by vessel type and size is presented in Figure 4.2 and Figure 4.3, respectively. It can be seen that almost half of all vessels passing within 10nm of the Banda location are cargo vessels. Tankers and Offshore support vessels make up the remainder of other shipping in the area. It can also be noted that the offshore vessels fall into the size range 1500-5000 DWT, while the remaining tankers and cargo vessels tend to be larger vessels over 15,000 DWT.

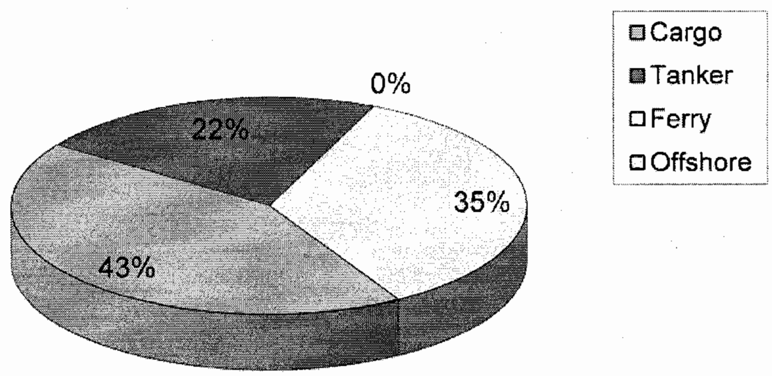


**Figure 4.2** **Vessel Type Distribution within 10nm of Banda**

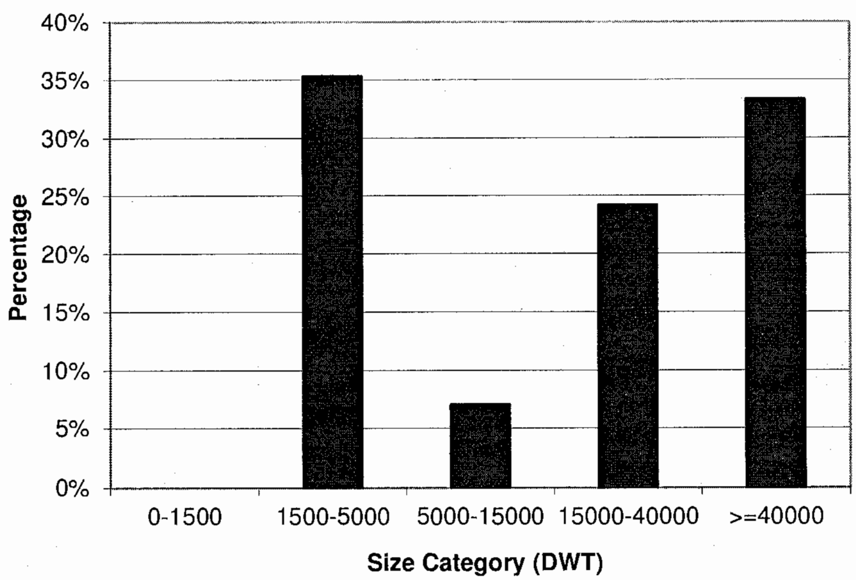


**Figure 4.3** **Vessel Size Distribution within 10nm of Banda**

## 4.5 *Ship Density*

Anatec's ship density model was used to calculate the density of shipping with each cell based on the ship routeing database. A thematic map showing the estimated variation in shipping density around the location is presented in Figure 4.4.

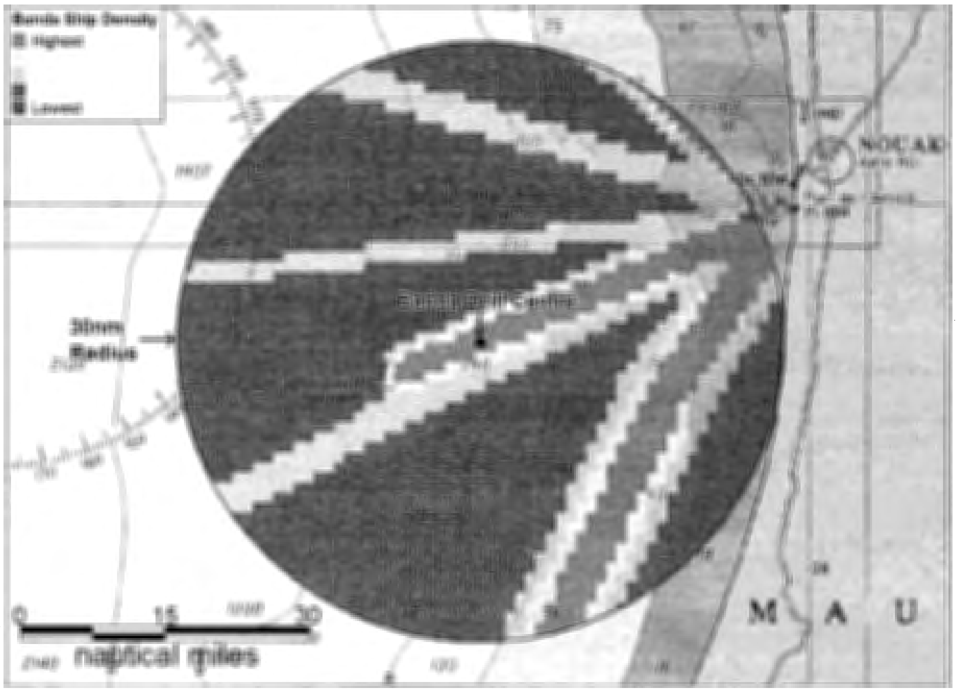


**Figure 4.4 Shipping Density Grid at Banda**

It can be seen that the higher density areas in the vicinity of the Banda location are representative of the passing routes discussed previously. Higher density routes include route 4 heading south out of Nouakchott and the offshore support traffic on route 1 supporting the Berge Helene FPSO. In general the traffic levels are relatively low in the surrounding area.

It is noted that there is a high density of fishing vessels in the area; this is discussed later in Section 8.

# 5. PASSING POWERED COLLISION RISK

## 5.1 *Introduction*

This section describes the modelling methodology used to assess passing powered ship collisions and presents the results in terms of estimated collisions per year. It is assumed that risk reduction will be provided by a PSV acting as an ERRV equipped with ARPA Radar. This is considered a minimum requirement to set the base case risk levels. Further review of additional mitigation measures are discussed under Section 9.

## 5.2 *Ship/Installation Collision Risk Model*

### 5.2.1 Collision Frequency Calculation

Anatec's COLLRISK is recognised as industry-leading software in the specialist field of collision risk assessment. It is referenced to by OGP in the Risk Assessment Data Directory report for Ship/Installation Collisions under "Best practice collision risk modelling for passing vessels" (Ref. ii).

The current version (Version 2.7) is used worldwide for assessing the risk of ship collisions with offshore structures such as oil & gas platforms, drilling rigs and offshore renewable developments.

The model is based on the premise that the collision frequency is proportional to the volume of traffic interacting with the structure. This stems from a review of historical data which indicated that ship watch-keeping failure tends to be the cause of passing vessel collisions with offshore installations (Ref.iii).

COLLRISK can take input from most shipping databases as well as local survey data. Within the model, the annual traffic levels, mean position and standard deviation of each route is used as a basis for determining the level of shipping that interacts with the installation.

The number of vessels on a collision course is calculated using the distribution algorithm for shipping around a route mean. Using this equation the model calculates the geometrical target area for each of the routes, giving account to the installation size, route standard deviation and mean CPA, and also the size distribution of the ships passing on each of the routes. The calculation is illustrated in Figure 5.1.

This assessment is performed for each of the routes passing the installation and the number of ships interacting with the installation is determined. These are summed to provide the total number of interactions that can be expected, which forms the basis of the calculating the collision frequency.

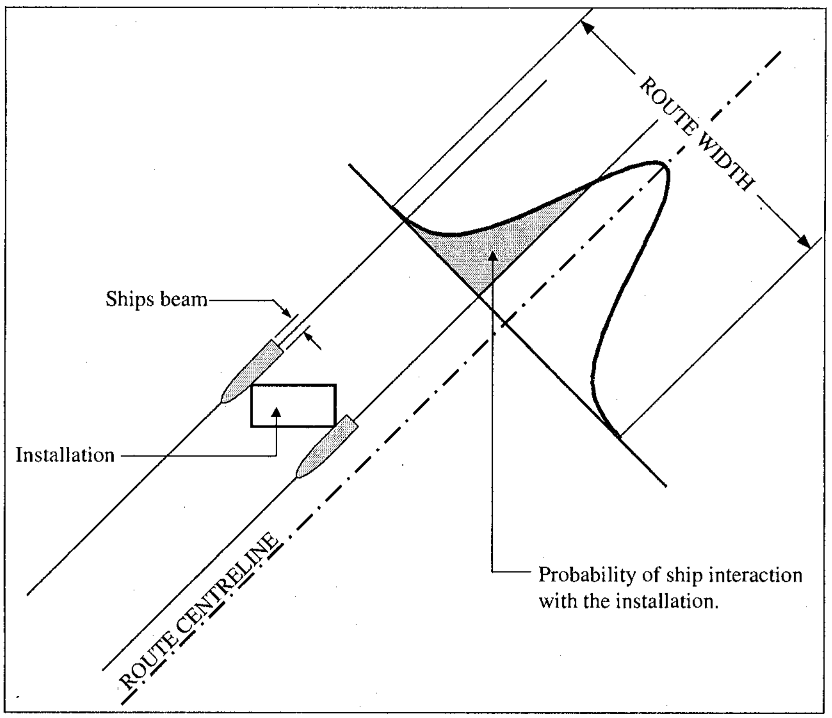


**Figure 5.1 Geometrical Probability of a Collision Course**

The model uses location-specific data to take into account the effect of the following influencing factors on collision frequency based on HSE research (Ref.iv):

- Emergency Response and Rescue Vessel coverage and specification, e.g., radar type
- Visibility
- Wave height
- Vessel speed distribution
- Shipping data (traffic density, type and size)
- Installation dimensions and orientation

### 5.2.2 Collision Energy

COLLRISK assesses the likely impact energies that will be generated on the event of ship collision. This is based on the laws of kinetic energy giving account to the hydrodynamic mass factor associated with ship impacts. The general equation is:

$$E = \frac{1}{2} m \, (1 + a) \, v^2$$

where,

E = total kinetic energy (kJ)
m = displacement of the vessel (tonnes)
a = hydrodynamic mass factor
v = velocity of the vessel (m/s)

Within the model, the velocity of vessels on each route has been extracted from survey data and representative vessel displacements have been applied based on the vessel types and deadweight tonnage. A standard hydrodynamic mass factor of 0.1 has also been applied based on historical data, which shows that bow-on collisions are most likely to occur in a powered vessel collision scenario (Ref. iv).

Using this information a site-specific impact energy distribution has been generated for Banda.

## 5.3 *Passing Powered Collision Risk Results*

COLLRISK was run using the operational details (Section 2) and shipping information (Section 0) for the Banda operation as input.

### 5.3.1 Installation Collision Frequency Results

Table 5.1 presents the ship/ collision frequencies distributed by impact energy. Results are presented on an annual basis.

**Table 5.1 Passing Powered Collision Frequencies**

| Impact Energy (MJ) | Annual Collision Frequency | % |
|---|---|---|
| 0 - 20 | Negligible | 0 |
| 20 - 50 | 3.8E-04 | 44 |
| 50 - 100 | 3.8E-04 | 44 |
| 100 - 200 | 9.5E-05 | 11 |
| ≥ 200 | 1.2E-05 | 1 |
| **Total** | 8.6E-04 | 100 |

Therefore, the annual ship collision frequency for at Banda is estimated to be 8.6 $x10^{-4}$, corresponding to a collision return period of approximately 1,150 years.

The full collision frequency versus impact energy exceedence spectrum for passing powered ship collisions is presented below. It can be seen that the 1 x $10^{-4}$ annual collision frequency is crossed at 112 MJ.

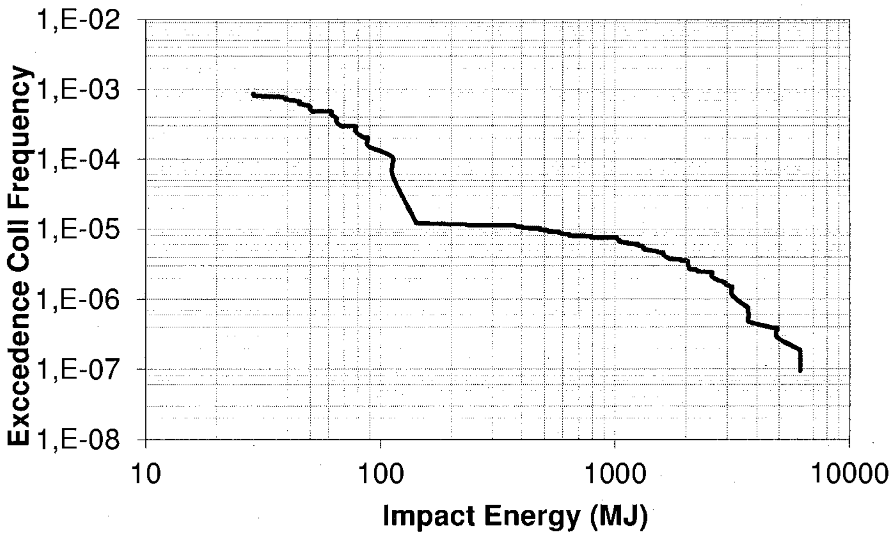


**Figure 5.2 Passing Powered Impact Energy Spectrum for Banda**

The main routes contributing to the collision frequency are presented in Figure 5.3.

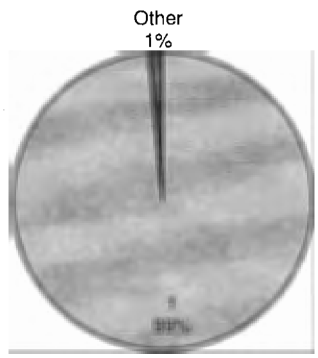


**Figure 5.3 Route Contributors to Banda Collision Frequency**

# 6. PASSING DRIFTING COLLISION RISK

## 6.1 *Introduction*

This section assesses the risk of a passing vessel losing power and drifting into the drilling rig at the Banda location. The COLLRISK drifting risk model has been used in the assessment.

The model is based on the premise that the engine(s) on a vessel must fail before a vessel will drift. The model takes account of the likelihood of vessels having multiple engines based on fleet data for different ship types and sizes.

Using this information it is possible to estimate the overall rate of breakdown in proximity to the location. The probability of a vessel drifting towards the installation and the drift speed are estimated using the wind rose for the area. Finally, the probability of a ship repairing itself before reaching the location is estimated based on the time available. Ships that do not recover within the time to reach the drilling rig are assumed to collide.

It is noted that the PSV/ERRV may be able to assist a drifting vessel, depending on its tow capacity, the size of the drifting vessel and the prevailing conditions, but given the uncertainty this has been neglected in the analysis.

## 6.2 *Exposure Grid*

For modelling the risk of passing ships losing power and drifting into the drilling rig at the Banda location a ship exposure grid has been used. The grid covers a minimum 30nm around Banda to take into account the fact that vessels from several miles away that lost power could pose a collision risk.

Figure 6.1 shows the annual ship-hours within each cell of the grid per year.

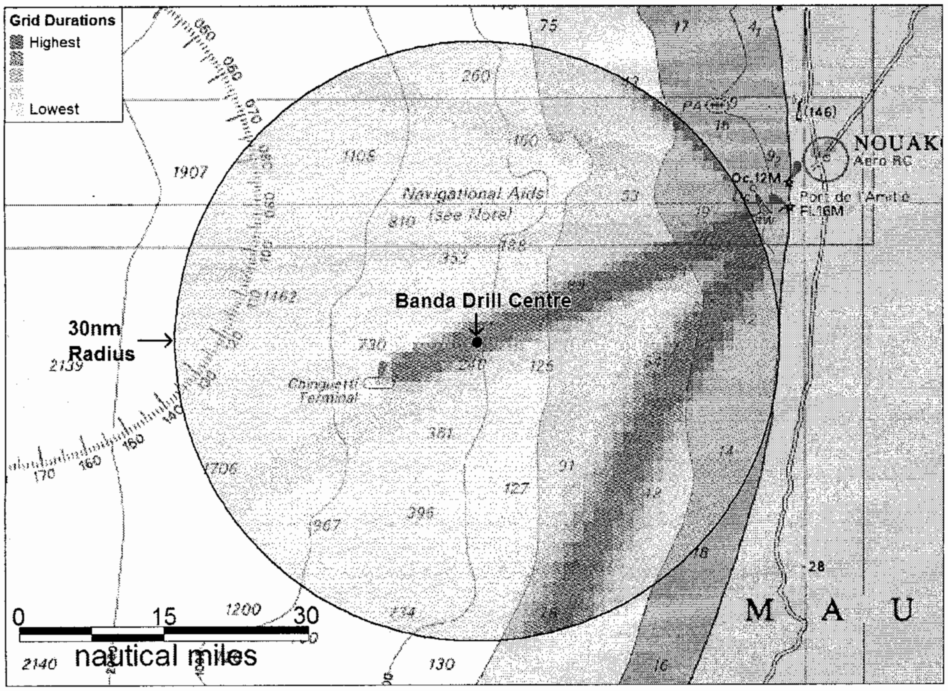


**Figure 6.1 Passing Shipping Exposure Grid at Banda**

## 6.3 *Passing Drifting Collision Risk Results*

The overall estimates of passing drifting vessel collision frequency for Banda are presented in the following table, distributed by impact energy.

**Table 6.1 Passing Drifting Collision Frequencies Banda**

| Impact Energy (MJ) | Annual Collision Frequency |
|---|---|
| 0 - 20 | 3.7E-08 |
| 20 - 50 | 7.2E-08 |
| 50 - 100 | 7.5E-08 |
| 100 - 200 | 6.4E-08 |
| ≥ 200 | 4.9E-09 |
| **Total** | 2.5E-07 |

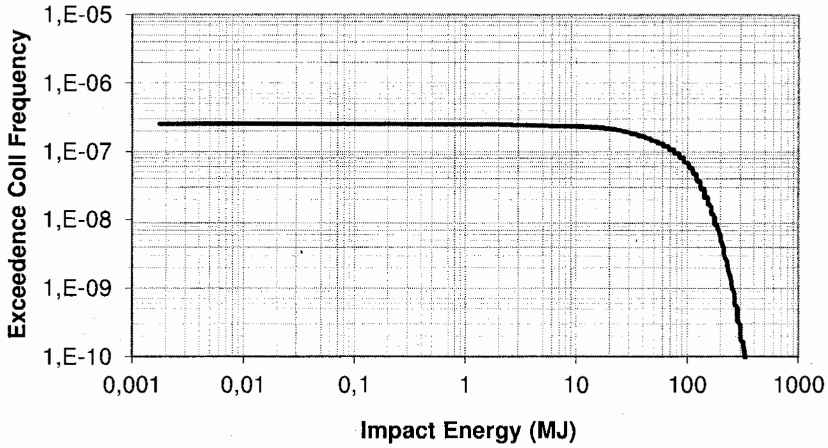


**Figure 6.2** **Passing Drifting Impact Energy Spectra**

## 6.4 *Closing Discussion*

It can be seen that the overall drifting ship collision frequency for the Banda location is very low. This frequency corresponds to a collision return period of approximately 3,939,774 years.

The collision frequency versus impact energy exceedence spectrum for overall drifting vessel collisions at Banda is presented in Figure 6.2.

# 7. INFIELD VESSEL COLLISION RISK

## 7.1 *Introduction*

Ship collisions involving infield (visiting) vessels tend to be more frequent than passing ships and occur with little or no warning. The consequences associated with these types of impacts tend to be less severe due to the size and speed of the vessels, therefore, the risk to personnel is generally low although there have been a number of catastrophic incidents involving infield vessels, including the Mumbai High North disaster in 2005 (Ref. v). Particular focus needs to be placed on assessing infield vessel risks when risers are exposed. Even minor incidents can lead to significant cost due to repair and production downtime.

## 7.2 *Model Calibration*

The collision frequency analysis has been based on models calibrated against UK HSE incident data for ship/installation collisions, which is comprehensive (Ref. iii). There have been over 500 reported incidents in the UK between 1975 and 2001. For the vast majority of incidents, detailed information is available for analysis, such as vessel type, mode of operation, impact orientation, etc. There is also good quality data on operational experience (installation-years and infield vessel exposure) in the UK to allow frequencies to be estimated per exposure time. The model also takes into account the clear trend of improved safety in more recent years when determining the current best-estimate collision frequencies, thereby avoiding overly conservative estimates.

The reported causes of infield vessel collisions in the UK are presented in Figure 7.1.

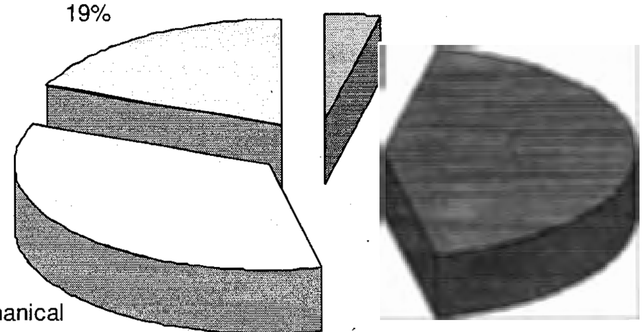


**Figure 7.1 Reported Causes of Infield Vessel Impacts**

The main causes were human error and mechanical failure, e.g., engine control, electrical failure, etc. Weather contributed to just under one-fifth of accidents (although this may also be partly attributable to human error).

### 7.3 *Infield Vessel Exposure*

Two Supply vessels will be supporting the drilling rig at the Banda location; they will operate simultaneously, one performing as an ERRV and one acting as a traditional supply vessel. These vessels may alternate their roles; however, there will always be one performing as an ERRV giving 24hr protection.

It is assumed that a supply boat will visit the drilling rig on average twice a week for a period of 6hrs each. The supply vessel used for the analysis was based on similar vessels used in the North Sea as this gives a good representation of a typical PSV.

Details on the estimated sizes and attendance of these vessels are summarised in Table 7.1.

**Table 7.1 Infield Vessel Exposure assumed for the Banda**

| Vessel Type | DWT | Displacement (approx) | Estimated Attendance |
|---|---|---|---|
| ERRV | 4100 | 7572 | Supply vessel acting as ERRV onsite 24/7 |
| Supply Vessel | 4100 | 7572 | Twice per week (average 6 hours per visit) |

### 7.4 *Collision Frequency Analysis*

#### 7.4.1 Historical Analysis

Within the period 1 January 1975 to 31 October 2001 the average infield ship collision frequency was 0.10 per installation-year (a return period of 10 years).

In terms of installation type, just under half of all reported infield vessel collisions have been with fixed installations. Giving account to their operating experience the collision frequency associated with fixed installations is 0.06 per installation-year.

This lower collision frequency may be due to different exposure times and also vessels gaining experience working at permanent installations, e.g., familiarity with local tide and weather conditions, installation layout, installation personnel, etc., which is not the case for temporary, mobile installations such as MODUs e.g, jack-ups.

The variation in infield vessel collision frequency per installation-year (fixed installations) from 1975 to 2001 is presented in Figure 7.2.

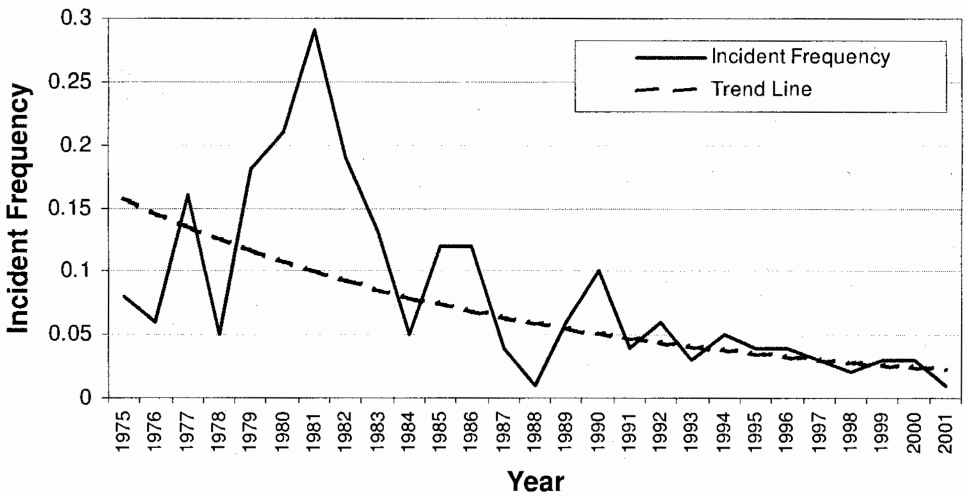


**Figure 7.2 Infield Ship Collision Frequency with Fixed Installations**

This illustrates a falling trend of collision incidents per installation-year. The trendline value for 2001 was 0.022 incidents per year and extrapolating to 2011 the forecast is 0.010.

The present-day level of incidents is estimated to be just under one-fifth of that calculated from the analysis of the complete data set. Therefore, it is considered appropriate to factor the historical frequencies by one-fifth to obtain current best-estimates.

Taking into account the proportion of the historical collision frequency which is contributed by supply vessels, the installation population and estimated typical exposure to supply vessels per installation, and the improving trend shown above, the average collision frequency per hour of exposure for supply vessels has been estimated to be $2.4 \times 10^{-5}$, corresponding to one collision in 42,000 hours. By similar reasoning the average collision frequency per year of exposure for ERRVs has been estimated to be $2.6 \times 10^{-3}$, corresponding to one collision in 386 years.

It is noted this improved safety record is likely to have been achieved from experience of past accidents leading to improved safety procedures and more reliable equipment. For example, lessons from past incidents have been used to define industry best-practice, with new guidelines specifying safety procedures such as steering an offset course on approach, performing a pre-entry check to ensure manoeuvring equipment is functioning correctly and operating on the lee-side of an installation whenever possible.

### 7.4.2 Collision Frequency Results

Based on the estimated exposure of the Banda drilling rig to infield vessels (Table 7.1) and the current best-estimate collision frequencies from accident data analysis, the collision frequencies for the Banda drilling operation have been estimated. The results are presented in Table 7.2.

**Table 7.2 Banda Collision Frequencies per Annum**

| Vessel Type | Annual Collision Frequency |
|---|---|
| Supply | 1.4E-02 |
| Supply(ERRV Duties) | 2.6E-03 |
| **Total** | 1.8E-02 |

## 7.5 *Collision Consequences Analysis*

### 7.5.1 Introduction

To estimate the consequences of collision by energy, the displacement, velocity and orientation of infield vessels at the time of impact are required. Studies have shown that the impact velocity of vessels vary with the scenario (Ref.vi & vii).

Although the majority of incidents outlined under Section 7.2 are on approach from HSE research (Ref.iv) it is indicated that 3% of infield vessel impacts are major impacts that require immediate repair (within 1 month). Conservatively Anatec has assumed all these impacts are on approach to the field.

The remaining 97% of impacts are associated with the vessel manoeuvring in proximity to the drilling rig or while alongside.

Infield vessel velocity profiles have been developed based on the referenced study for manoeuvring and drifting with the drifting speeds being based on the weather data for the Banda location. The following profile was prepared:

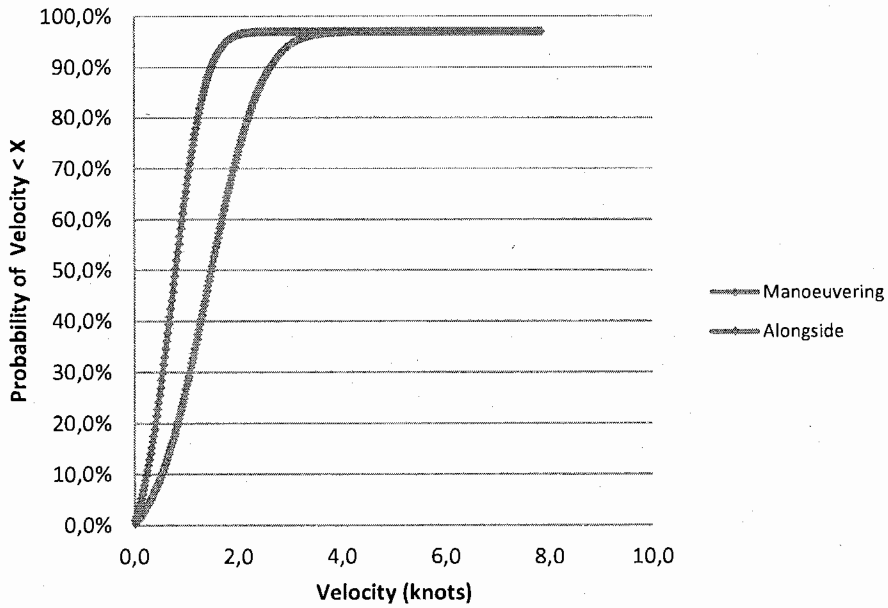


**Figure 7.3 Infield Vessel Velocity Profile**

For powered on approach a Gaussian profile was developed with a mean of 8 knots and a SD of 1.33.

In the absence of detailed marine procedures, it is assumed that attendant vessels operations inside the safety zone will be limited to significant wave heights up to 4m. It is also assumed that the ERRV supporting the drilling rig will be limited to significant wave heights up to 7m. The effect of this is to limit the potential drifting velocity.

The distribution of collisions per scenario (manoeuvring, alongside or drifting) has been determined from the HSE accident data.

Finally, the likely orientation of the vessels at the time of collision will influence the hydrodynamic added mass factor used in the impact energy calculation. An added mass of 10% is assumed for bow and stern collisions, and 40% for side collisions. The distribution by vessel orientation has been obtained from analysis of the UKCS incident data.

### 7.5.2 Platform Supply Vessels

From analysis of UKCS infield vessel collision data for Supply Vessels colliding with fixed installations, the following scenario and vessel orientation has been determined (ref iii).

**Table 7.3 Supply Vessel Collision Distribution by Scenario and Orientation**

| Scenario | Probability | Orientation | |
|---|---|---|---|
| | | Bow/Stern | Side |
| Manoeuvring | 0.184 | 0.80 | 0.20 |
| Alongside | 0.426 | 0.75 | 0.25 |
| Drifting | 0.359 | 0.68 | 0.32 |
| On Approach | 0.030 | 1.00 | 0.00 |

Combining this information with the velocity profiles developed for the Banda drilling operation and information on the supply vessel tonnage, the collision frequency was distributed by impact energy to assist in consequence modelling.

**Table 7.4 Supply Vessel Collision Frequency by Impact Energy**

| Impact Energy (MJ) | Annual Collision Frequency (Manoeuvring/ Alongside/ Drifting) | Annual Collision Frequency On Approach (Powered) | Combined Supply Vessel Annual Collision Frequency |
|---|---|---|---|
| 0 – 1 | 8.1E-03 | Negligible | 8.3E-03 |
| 1 – 4 | 5.4E-03 | 1.25E-09 | 5.6E-03 |
| 4 – 10 | 9.3E-04 | 4.47E-08 | 9.6E-04 |
| 10 – 50 | 1.0E-04 | 7.83E-05 | 1.0E-04 |
| ≥ 50 | Negligible | 3.72E-04 | Negligible |
| **Total** | 1.4E-02 | 4.50E-04 | 1.5E-02 |

Negligible < 1.0E-10

For the Banda drilling operation the supply vessel collision frequency is estimated to be $1.5 \times 10^{-2}$, corresponding to an average collision return period of 67 years. It can be seen from the table that the majority of supply vessel collisions predicted have estimated total impact energies below 10 MJ.

It is noted that the $1 \times 10^{-4}$ annual collision frequency is crossed at 10.1 MJ. The following figures show the infield vessel impact energy exceedence spectras for supply vessels.

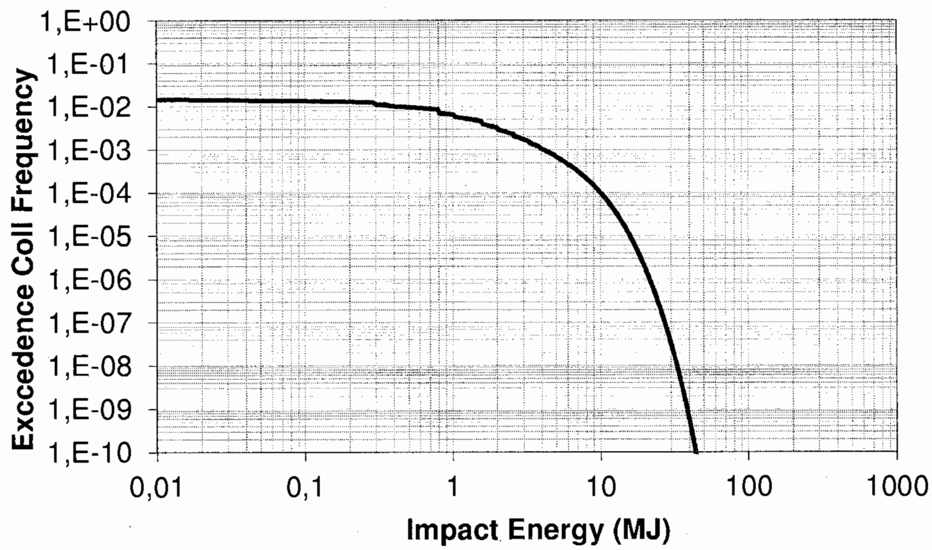


**Figure 7.4** **Annual Collision Frequency (Manoeuvring/ Alongside/ Drifting) Infield Vessel Impact Energy for supply vessels Exceedence Spectra**

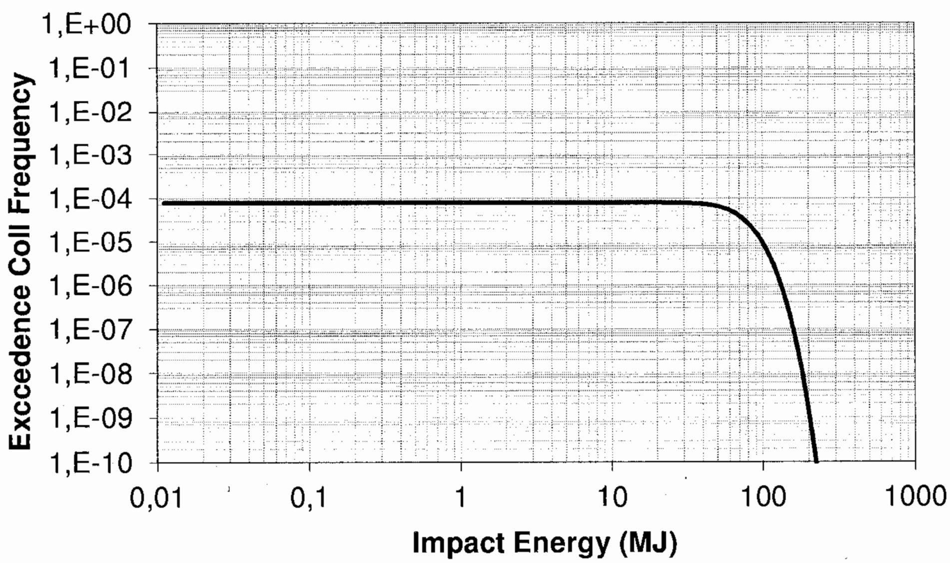


**Figure 7.5** **Annual Collision Frequency On Approach (Powered) Infield Vessel Impact Energy Exceedence Spectra for supply vessels**

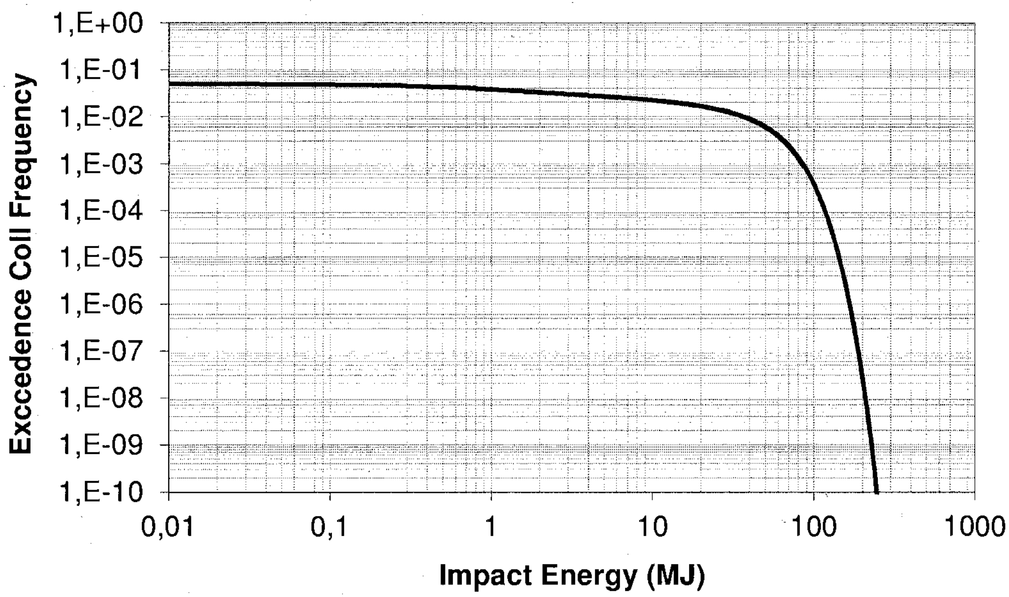


**Figure 7.6 Combined Supply Vessel Annual Collision Frequency Infield Vessel Impact Energy Exceedence Spectra for supply vessels**

### 7.5.3 Supply Vessels performing ERRV Duties

From analysis of UKCS infield vessel collision data for ERRV Vessels colliding with fixed installations, the following scenario and vessel orientation has been determined.

**Table 7.5 ERRV Vessel Collision Distribution by Scenario and Orientation**

| Scenario | Probability | Orientation | |
|---|---|---|---|
| | | Bow/Stern | Side |
| Manoeuvring | 0.57 | 0.29 | 0.71 |
| Alongside | N/A | N/A | N/A |
| Drifting | 0.4 | 0.6 | 0.4 |
| On Approach | 0.030 | 1.00 | 0.00 |

Combining this information with the velocity profiles developed for the Banda location and information on the supply vessel performing ERRV duty tonnage, the collision frequency was distributed by impact energy to assist in consequence modelling.

**Table 7.6 ERRV Vessel Performing ERRV Duties Collision Frequency by Impact Energy**

| Impact Energy (MJ) | Annual Collision Frequency (Manoeuvring/ Alongside/ Drifting) | Annual Collision Frequency On Approach (Powered) | Combined Supply Vessel Annual Collision Frequency |
|---|---|---|---|
| 0 – 1 | 9.7E-04 | Negligible | 1.0E-03 |
| 1 – 4 | 9.9E-04 | 5.75E-07 | 1.0E-03 |
| 4 – 10 | 4.7E-04 | 2.81E-05 | 4.9E-04 |
| 10 – 50 | 8.4E-05 | 4.93E-05 | 8.7E-05 |
| ≥ 50 | Negligible | Negligible | Negligible |
| **Total** | 2.5E-03 | 7.80E-05 | 2.6E-03 |

Negligible < 1.0E-10

For Banda the ERRV/supply vessel collision frequency is estimated to be 2.6 x $10^{-2}$, corresponding to an average collision return period of 386 years. It can be seen from the table that the majority of ERRV vessel collisions predicted have estimated total impact energies below 10 MJ.

It is noted that the $1x10^{-4}$ annual collision frequency is crossed at 9.6 MJ.

The following figures show the infield vessel impact energy exceedence spectras for a supply vessel performing ERRV Duties.

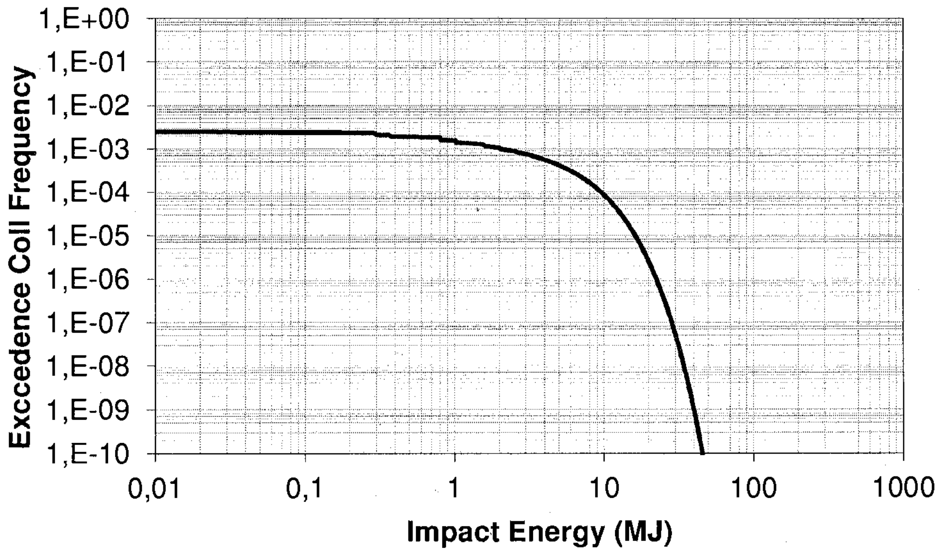


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**Figure 7.7 Annual Collision Frequency (Manoeuvring/ Alongside/ Drifting) Infield Vessel Impact Energy Exceedence Spectra for Supply vessel performing ERRV Duties**

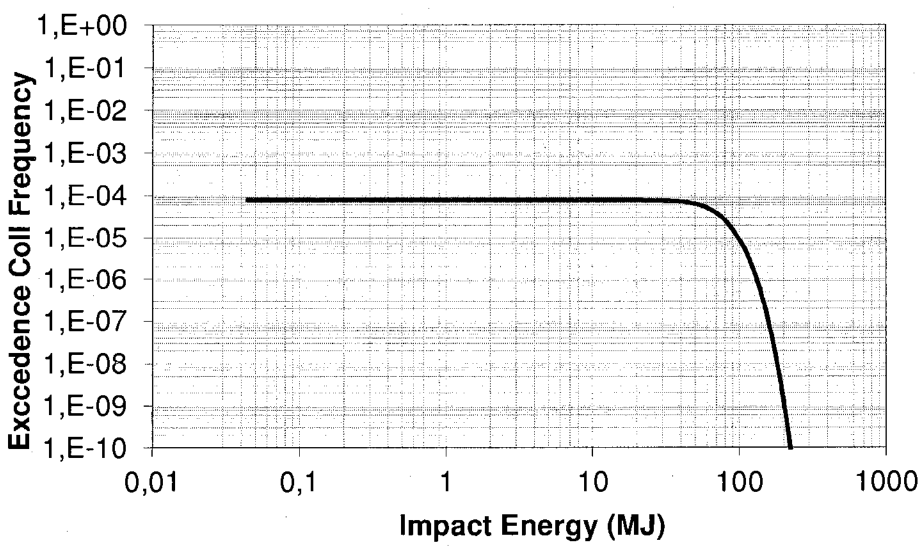


**Figure 7.8 Annual Collision Frequency On Approach (Powered) Infield Vessel Impact Energy Exceedence Spectra for Supply vessel performing ERRV Duties**

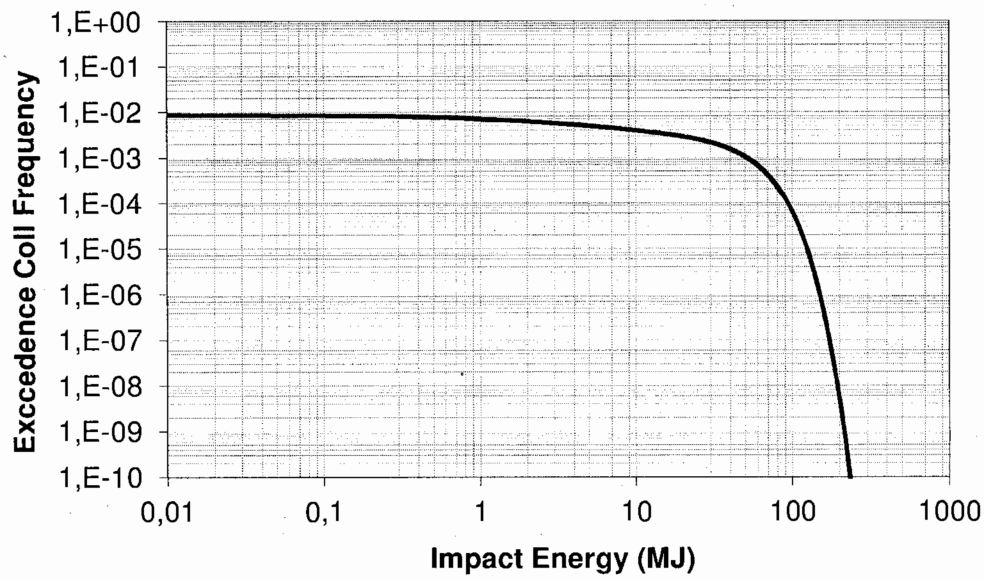


**Figure 7.9** **Combined Supply Vessel Annual Collision Frequency Infield Vessel Impact Energy Exceedence Spectra for Supply vessel performing ERRV Duties**

## 7.6 *Summary of Results*

The infield vessel collision frequency results are summarised in Table 7.7 for Banda.

**Table 7.7** **Infield Vessel Collision Frequency Results for Banda**

| Impact Energy (MJ) | Annual Collision Frequency | | |
|---|---|---|---|
| | Supply | Supply (ERRV Duties) | Total |
| 0 – 1 | 8.3E-03 | 1.0E-03 | 9.3E-03 |
| 1 – 4 | 5.6E-03 | 1.0E-03 | 6.6E-03 |
| 4 – 10 | 9.6E-04 | 4.9E-04 | 1.5E-03 |
| 10 – 50 | 1.0E-04 | 8.7E-05 | 1.9E-04 |
| ≥ 50 | Negligible | Negligible | Negligible |
| **Total** | 1.5E-02 | 2.6E-03 | 1.8E-02 |

Negligible < 1.0E-10

The estimated infield vessel collision return period for a drilling rig at the Banda location is 57years.

The majority of vessel collisions predicted at the Banda location have estimated total impact energies below 10MJ.

The full collision frequency versus impact energy exceedence spectrum for infield vessel collisions for the Banda location is presented in Figure 7.10.

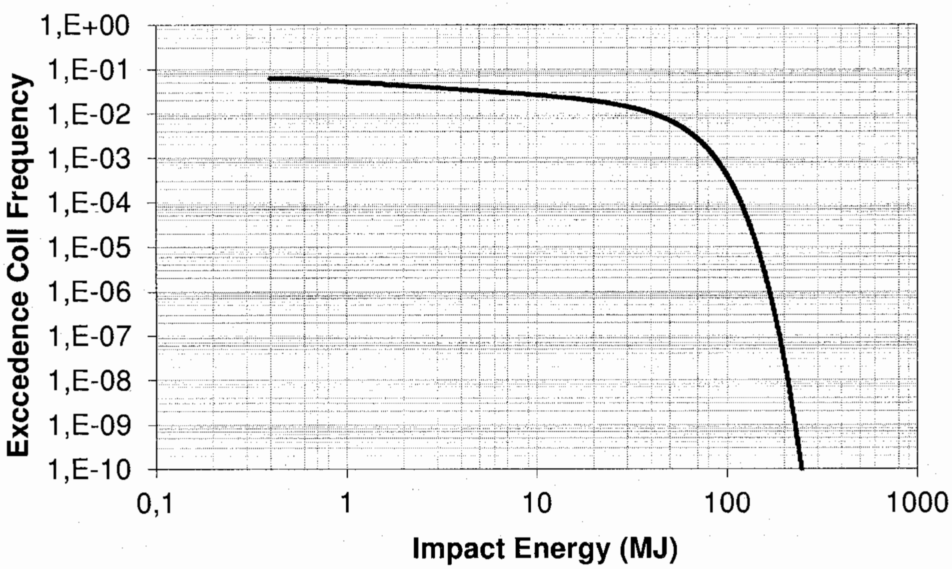


**Figure 7.10 Infield Vessel Impact Energy Exceedence Spectra**

# 8. FISHING

## 8.1 *Introduction*

Due to the high number of fishing vessels present in the vicinity of the Banda drilling location a collision frequency impact assessment has been conducted.

## 8.2 *Fishing Data Analysis*

From the previously analysed AIS data it was observed that 67% of all vessels in the area are fishing vessels. Of these 89% are large industrial sized stern trawlers which tend to pass by the location.

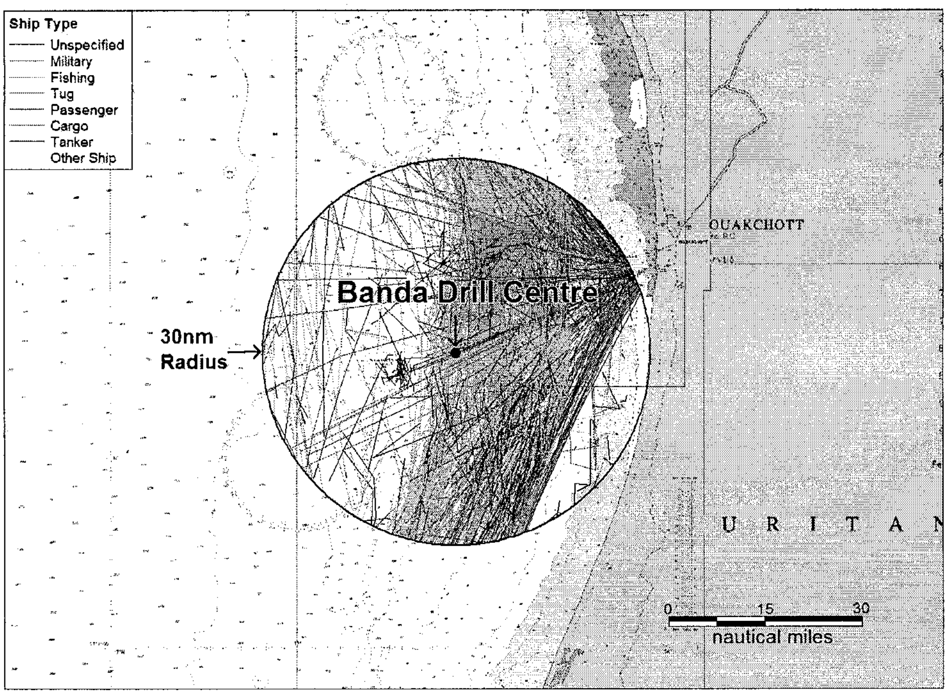


**Figure 8.1 Ship types in Banda Vicinity**

The following figure shows all fishing vessels in the area. From these vessels 91% were travelling over 4 Knots and can be assumed to be passing the location and not actively fishing. The remaining 9% are travelling under 4 knots and could conceivably be fishing in the area. These are presented in Figure 8.3.

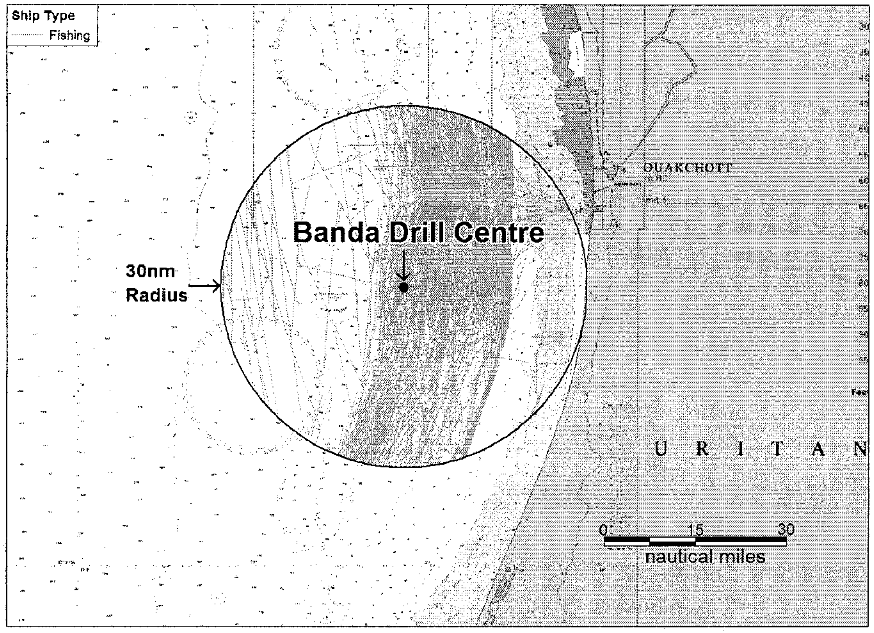


**Figure 8.2 All fishing vessels in vicinity of Banda location**

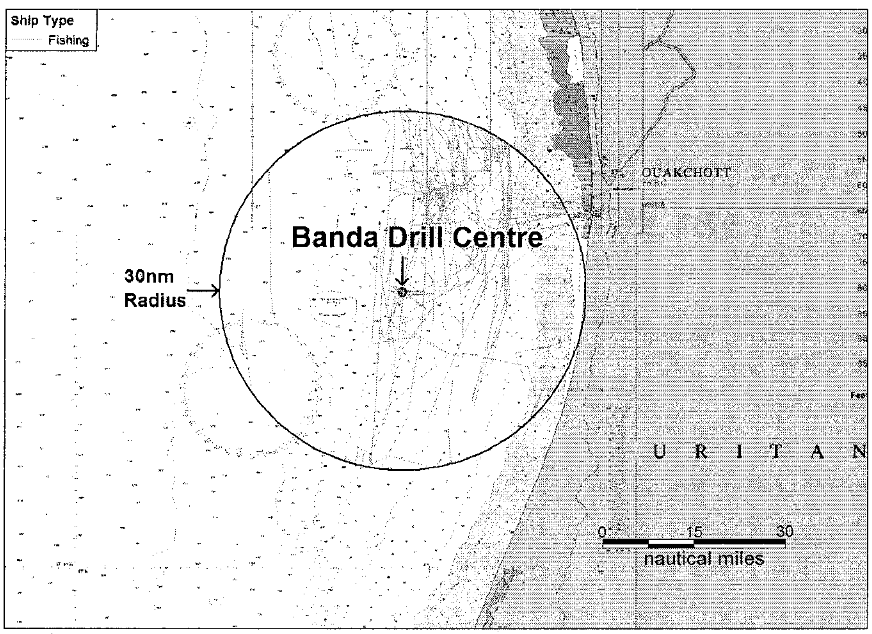


**Figure 8.3 Fishing vessels under 4 Knots (potentially fishing)**

## 8.3 *Fishing Routes*

The fishing routes identified by a 30nm search of ShipRoutes around the Banda Drill Centre location are presented in Table 8.1 in ascending order of Closest Point of Approach (CPA).

**Table 8.1 Fishing Routes Passing within 30nm of Banda Drill Centre**

| Route No. | Description | CPA (nm) | Bearing (°) | Ships Per Year | % of Total |
|---|---|---|---|---|---|
| 1 | North/ Fishing Grounds-South/ Fishing Grounds* | 0.4 | 286 | 90 | 19% |
| 2 | North/ Nouadhibou-South/ Fishing Ground* | 5.2 | 87 | 280 | 58% |
| 3 | Fishing Grounds/ Dakar-North/ Fishing Grounds* | 16.8 | 89 | 110 | 23% |
| TOTAL | | | | 480 | 100% |

* Where two or more routes have identical Closest Point of Approach (CPA) and bearing they have been grouped together. In this case, the description lists the sub-route with the most ships per year.

**Table 8.2 Fishing Vessel Size Distribution**

| Route | Size Distribution (DWT) | | | | | Ships |
|---|---|---|---|---|---|---|
| No. | < 1500 | 1500–5000 | 5000–15000 | 15000–40000 | ≥ 40000 | Per Year |
| 1 | 0% | 100% | 0% | 0% | 0% | 90 |
| 2 | 0% | 100% | 0% | 0% | 0% | 280 |
| 3 | 0% | 100% | 0% | 0% | 0% | 110 |
| **Total** | 0% | 100% | 0% | 0% | 0% | 480 |

There are 3 shipping routes trafficked by an estimated 480 ships per year passing within 30nm of Banda Drill Centre. This corresponds to an average of 1 to 2 vessels per day.

A plot of the mean Fishing route positions relative to Banda Drill Centre is presented in Figure 8.4.

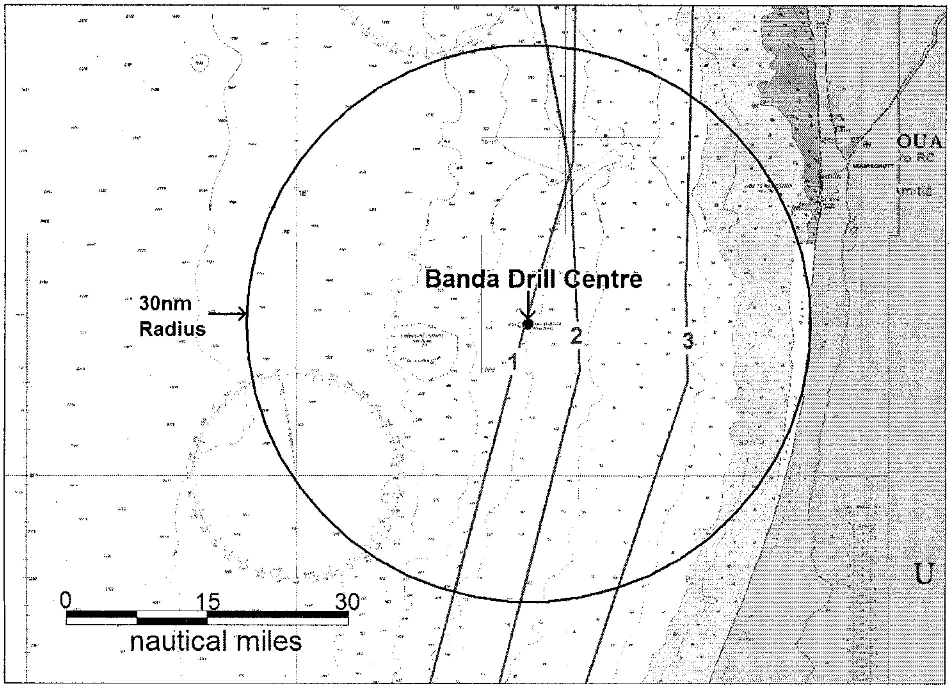


**Figure 8.4 Fishing Route Positions within 30nm of Banda Drill Centre**

All the risk is attributed to route one due to its close proximity to the location. However, it would be anticipated that due to the sea room available these vessels should increase their passing distance to at least 2nm.

### 8.3.1 Installation Collision Frequency Results

Table 8.3 presents the fishing vessel/ installation collision frequencies distributed by impact energy. Results are presented on an annual basis.

**Table 8.3 Fishing Vessel/Installation Collision Frequencies estimated for Banda Drill Centre**

| Impact Energy (MJ) | Annual Collision Frequency | % |
|---|---|---|
| 0 - 20 | 2.3E-05 | 12 |
| 20 - 50 | 6.8E-05 | 34 |
| 50 - 100 | 6.8E-05 | 34 |
| 100 - 200 | 4.5E-05 | 23 |
| ≥ 200 | Negligible | 0 |
| **Total** | 2.0E-04 | 100 |

Therefore, the annual ship collision frequency for a Semisubmersible at Banda Drill Centre is estimated to be 2.0 x $10^{-04}$, corresponding to a collision return period of 4,900 years.

The full collision frequency versus impact energy exceedence spectrum for passing powered ship collisions is presented below. It can be seen that the 1 x $10^{-4}$ annual collision frequency is crossed at 62 MJ.

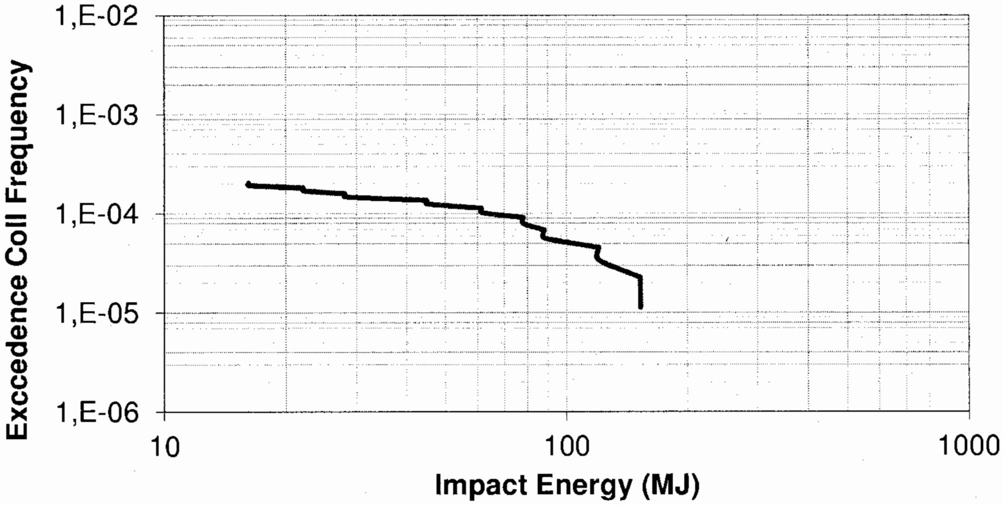


**Figure 8.5 Passing Fishing Impact Energy Spectrum for Banda**

# 9. RISK MITIGATION

## 9.1 *Introduction*

This section reviews the main measures used at offshore installations to manage collision risk. The assessment is based on 4 phases of risk management:

- Prevention
- Detection
- Control
- Mitigation

The following vessel types and scenarios are considered:

- Passing Powered
- Infield support and Shuttle Tanker Collisions
- Submarine Collisions

## 9.2 *Passing Powered*

### 9.2.1 Prevention

In terms of prevention of powered passing vessel collision scenarios, the main methods identified are the following:

- Providing advanced notice to mariners in the area of the proposed development
- Notice to Mariners
- Provision of data for inclusion of nautical charts
- Navigational Marks and Lights on the installation (including Light and Sound)

maintenance of 500 m exclusion zone

These all relate to the provision of information to the mariner to ensure that they are well aware of the installation when undertaking their passage planning or in advance of arriving at the field.

Many of these methods tend to be standard practice with the RACON and an AIS AtoN being the main exceptions. Each of these systems provides a means for other vessels to identify the drilling rig at the Banda location more easily on their radar or AIS display.

A RACON can be observed on all ships radars and provides a strong signal to the watchkeeper, whereas AIS will only provide a "return" to vessels carrying an AIS display. Almost all passing vessels will have the legal requirement to carry an AIS display

There is a legal requirement for all ships of 300 gross tonnage and upwards engaged on international voyages, cargo ships of 500 gross tonnage and upwards not engaged on international voyages and all passenger ships irrespective of size to carry AIS. In addition there is a legal requirement for all fishing vessel ≥24m to carry AIS in the. This will become all vessels ≥15m as of May 2014

Based on this the main vessels that will not carry AIS are:

- Fishing vessels <24m in length
- Small ships of <300GT (assuming that no UK only traffic will be this far from shore)
- Recreational craft
- Warships

As the drilling rig is large, it will naturally provide a strong return to passing vessels and as a result the overall benefits of these two systems are not considered to be significant. However in some instances radar returns at range can be lost in clutter, and as a result of this and the greater auto-alarming possibilities exist with AIS, it is recommended that consideration be given to fitting the structure with an AIS AtoN.

It is noted that the benefits of this will increase over time as more vessels move towards ECDIS based systems as per SOLAS Regulation V/19 (ECDIS (Ref viii).
Detection of a collision scenario in good time is key to its effective management. Vessels travel at speed and radar detection has range limits that require consideration, especially with respect to smaller vessel tracking in sea clutter.

Recent work carried out by Anatec which assessed the benefits of 3 systems indicated that a platform mounted radar with AIS compared to an ERRV mounted radar with AIS performed to a similar level, and that the level of performance offered a 57% benefit when compared to a dedicated ERRV with ARPA alone which is the basis of the collision risk assessment work detailed under Section 5.

This assessment was based on the assumption that all SOLAS vessels >300 gross tonnage are required to carry AIS receivers.

In addition, fishing vessels in the area have been observed to carry AIS and as a result this will offer significant benefits to risk management.

On the basis of the benefits offered it is recommended that AIS tracking be used at the field in support of the radar systems on the ERRV.

### 9.2.2 Control

Controlling a collision scenario following its detection tends to rely on effective procedure. The main function within this is to alert the errant vessel of the pending collision to allow it to alter course. There are two key components to this process:

- Time available, as increased time will provide increased likelihood of recovery
- Improved means of alerting a vessel

AIS systems provide an excellent means of improvement on both these issues. They provide early detection to around 20 to 30 nm, and also provide information on the vessels Name and MMSI which can be used to improve the likelihood of making contact through VHF calling and GMDSS

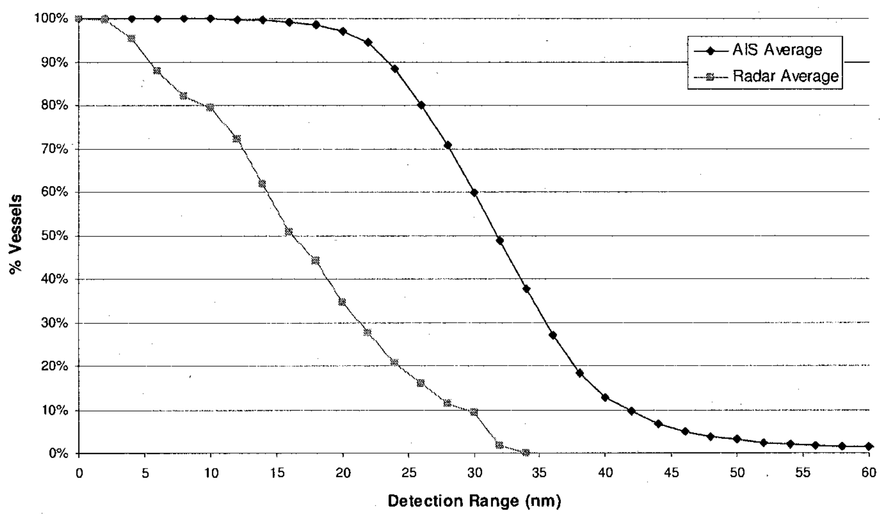


**Figure 9.1 AIS versus Radar Detection Comparison (Anatec live trials)**

Field specific procedures should be developed to ensure there is a high level of Control. These procedures should be based on the shipping data associated with the area.

### 9.2.3 Mitigation

Mitigation of a collision relates to the minimisation of the consequences of the scenario. There are two components to this:

- Making the correct decision on the drilling rig
- Having effective and well trialled emergency procedures in place

## 9.3 *Infield Vessel Collision Risk Management*

The main priority in the management of infield vessels is to ensure the vessels selected for use, are suitable, well equipment and have competent crews onboard. In addition to this, procedures should be put in place at the field to ensure the infield vessels are well coordinated and operate in a safe manner.

The main documents that should form the basis of this management are the Guidelines for Ship/Installation Collision Avoidance (Ref.ix).

By undertaking these measures the likelihood of an infield vessel impact will be effectively managed.

However there is a clear requirement on the Operator to ensure that the vessels operating at the field comply with the procedures in place and monitoring is recommended to confirm this. The AIS systems outlined previously will allow for this.

In terms of detecting infield vessel collisions in good time to avoid the impact, it is noted that available time tends to be limited due to the nature of infield vessel operations, i.e. close proximity work. Due to the short time available the possibilities of controlling infield vessel collision scenarios is limited, and this will mainly lie in the hands of the Master of the vessel. However, for errant infield vessels on approach which pose greatest threat it is highlighted that they can be managed in line with other passing vessels.

# 10. CONCLUSIONS and RECOMMENDATIONS

## 10.1 *Conclusions*

A ship routeing pattern for Banda was created using ShipRoutes database. Five routes were identified to pass within 300 nm of the Banda location trafficked by an estimated 588 ships per year, corresponding to an average of 1-2 ships per day. In terms of ship characteristics, almost half are cargo vessels with tankers and offshore support vessels making up the rest. However, this being said there is also a significant number of industrial sized fishing trawlers in the area.

The routeing pattern was used as input to Anatec's COLLRISK model to estimate the risk of passing ship collision with the drilling rig. Other inputs included the typical supply vessel/ drilling rig characteristics and local metocean data for the area.

The passing powered ship collision risk modelling took into account the collision reduction benefits provided by an ERRV/PSV equipped with ARPA radar. This gave annual collision frequencies as follows:

**Table 10.1 Table 5.1 Passing Powered Collision Frequencies**

| Impact Energy (MJ) | Annual Collision Frequency | % |
|---|---|---|
| 0 - 20 | Negligible | 0 |
| 20 - 50 | 3.8E-04 | 44 |
| 50 - 100 | 3.8E-04 | 44 |
| 100 - 200 | 9.5E-05 | 11 |
| ≥ 200 | 1.2E-05 | 1 |
| **Total** | 8.6E-04 | 100 |

Infield vessel collision risks at the drilling rig were assessed based on estimated exposure to Supply/ERRV and supply vessels. The annual collision frequencies were as follows:

**Table 7.7 Infield Vessel Collision Frequency Results for Banda location**

| Impact Energy (MJ) | Annual Collision Frequency | | |
|---|---|---|---|
| | Supply | Supply (ERRV Duties) | Total |
| 0 – 1 | 8.3E-03 | 1.0E-03 | 9.3E-03 |
| 1 – 4 | 5.6E-03 | 1.0E-03 | 6.6E-03 |
| 4 – 10 | 9.6E-04 | 4.9E-04 | 1.5E-03 |
| 10 – 50 | 1.0E-04 | 8.7E-05 | 1.9E-04 |
| ≥ 50 | Negligible | Negligible | Negligible |
| **Total** | 1.5E-02 | 2.6E-03 | 1.8E-02 |

The majority of infield vessel collisions have impact energies of less than 10 MJ due to the relatively small tonnages of the infield vessels and lower impact speed.

Drifting vessel collision risks at Banda were based on the overall breakdown in the proximity of the drilling rig, the course and speed of the vessel and the probability of the vessel repairing itself before reaching the Banda drilling location. The drifting collision frequencies were estimated as follows:

**Table 6.1 Passing Drifting Collision Frequencies Banda**

| Impact Energy (MJ) | Annual Collision Frequency |
|---|---|
| 0 - 20 | 3.7E-08 |
| 20 - 50 | 7.2E-08 |
| 50 - 100 | 7.5E-08 |
| 100 - 200 | 6.4E-08 |
| ≥ 200 | 4.9E-09 |
| **Total** | 2.5E-07 |

As there is a significant number of large industrial fishing trawlers passing the location a fishing collision frequency assessment was conducted, the results are as follows:

**Table 10.2 Fishing Vessel/Installation Collision Frequencies estimated for Banda Drill Centre**

| Impact Energy (MJ) | Annual Collision Frequency | % |
|---|---|---|
| 0 - 20 | 2.3E-05 | 12 |
| 20 - 50 | 6.8E-05 | 34 |
| 50 - 100 | 6.8E-05 | 34 |
| 100 - 200 | 4.5E-05 | 23 |
| ≥ 200 | Negligible | 0 |
| **Total** | 2.0E-04 | 100 |

Therefore, the annual fishing vessel collision frequency for a Semi-submersible at Banda location is estimated to be 2.0 x $10^{-04}$, corresponding to a collision return period of 4,900 years.

## 10.2 *Recommendations*

The following recommendations are made:

- AIS detection systems should be installed in the field to provide early detection of passing vessels, and improved information to aid in the management of this hazard. There are three possible locations for this: the rig, Berge Helene FPSO or the ERRV. The selection process will depend on the focus of Tullow. The FPSO option is likely to offer the most long term benefit as this would act as a permanent surveillance system following completion of the drilling operations. The 10nm range is not an issue for AIS tracking. If a temporary system was preferable this is best installed on the rig.
- Collision risk management procedures should be developed using the gathered shipping data to ensure they are optimised giving account to the traffic pattern and the evacuation requirements on the installation.
- Consideration should be given to the use of a RACON or AIS AtoN to provide a positive identification of the installation to passing vessels.
- Industry guidelines should form the basis of infield vessel management and a full Marine Operations Manual should be developed for the field. This should give account to factors including: vessel selection and inspection, crewing and competency.
- Compliance checks should be carried out periodically to ensure procedures are followed. Attention is drawn to lessons from the Bombay High North disaster (Ref. v) and from recent passing powered infield vessel collisions that occurred in Norway.
- An AIS based survey should be carried out at the location to confirm shipping pattern in the area. This is a very low cost whilst vessels and rigs are working in the area and will allow for improved decision making in the future.

## 11. References

i Meotocean Characterisation Offshore Mauritania and Senegal, Report No. C50909/7058/R0, February 2012.

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iii Ship/Platform Collision Incident Database, HSE, 2003.

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v http://www.npchse.net/safety/pdf/useful%20information/Mumbai-north-Blow-outreport.pdf.

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vii Statoil/Navion, North Sea Offshore Loading – Reported Collision Incidents 1978-1997.

viii SOLAS, Consolidated Edition, 2007. Consolidated text of the International Convention for Safety of Life at Sea. 1974.

ix UKOOA Guidelines for Ship/Installation Collision Avoidance, 2003.