

Environmental and Social Evaluation Report for Lenders: Jubilee Field, Phase 1 Development Offshore Ghana, West Africa

December 2008



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INTRODUCTION

The Jubilee Joint Venture is proposing to develop petroleum resources in the Jubilee Field offshore Ghana, West Africa (**Figure ES.1**). The Jubilee Field includes portions of the Deepwater Tano Contract Area and West Cape Three Points Block. Successful exploration drilling in 2007 resulted in one discovery in each block. The discoveries identified a large accumulation of oil that underlies portions of both blocks. In consultation with the Ghana National Petroleum Corporation (GNPC), the accumulation was named the Jubilee Field. Joint Venture participants include Kosmos Energy Ghana HC, Tullow Ghana Limited, Anadarko WCTP Company, Sabre Oil & Gas, the E.O. Group, and the GNPC.

A Phase 1 Development Plan has been prepared as the first phase of a multi-phase development of the Jubilee Field. The Phase 1 development will consist of nine production wells, five water injection wells, and three gas injection wells. Production will be gathered through subsea manifolds and conveyed by subsea flowlines to a floating production storage and offloading vessel (FPSO), which will be moored in the Jubilee Field area. Development drilling, well completions, subsea equipment installation, and FPSO installation will occur between late 2008 and early 2011. The development plan target for first production is 1 November 2010.

This Environmental and Social Evaluation Report (ESER) for Lenders is one of four environmental/socioeconomic documents prepared in conjunction with the Phase 1 Development Plan. The other documents are as follows:

- **Action, Contingency, and Mitigation Plan (ACMP)** – Provides the details of contingency and mitigation measures cited in the ESER, and presents the basic elements of an Action Plan, the latter of which establishes the priorities, schedules, and reporting requirements for the mitigation measures.
- **Public Consultation and Disclosure Plan (PCDP)** – Outlines a comprehensive approach to public notification regarding the proposed project.
- **Social Reconciliation Plan (SRP)** – Details the available mechanisms for filing of grievances resulting from Jubilee Development operations.

The objectives of the ESER are to evaluate the potential environmental and socioeconomic impacts of the Phase 1 Development and to identify mitigation measures to ensure that the development is conducted in an environmentally sound and sustainable manner. The ESER is intended for internal planning purposes by the Jubilee Joint Venture and for review by financial institutions rather than submission to the Republic of Ghana. A separate Environmental Impact Assessment (EIA) will be prepared later for submission to the Republic of Ghana. The relevant laws and regulations of the Republic of Ghana, including EIA requirements, are discussed in **ESER Chapter 2**.

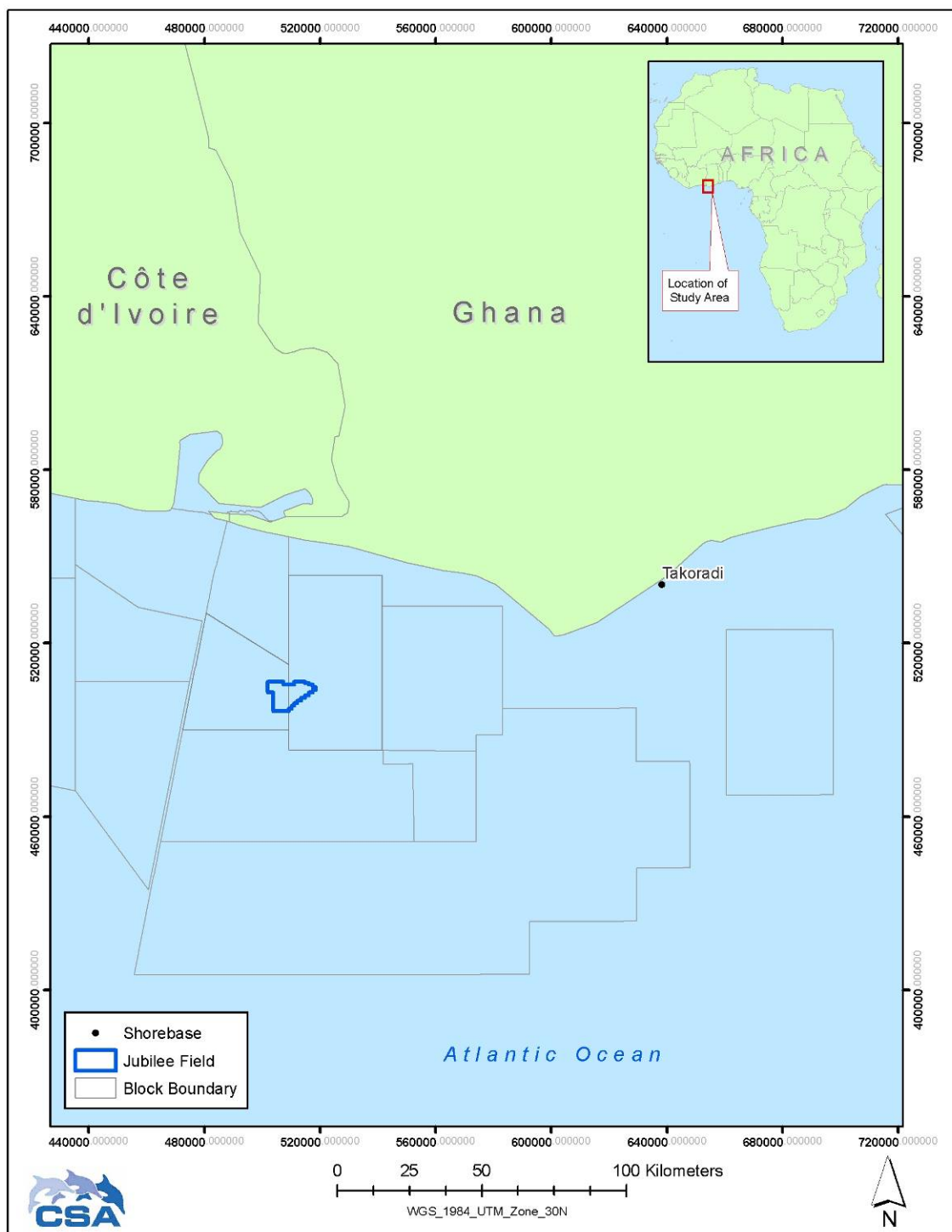


Figure ES.1. Location of the Jubilee Field relative to block boundaries and the coast of Ghana.

PROJECT DESCRIPTION

Development Drilling

During the Phase 1 development, 15 new wells will be drilled, and 2 previously drilled exploratory wells will be completed (Mahogany 1 and Hyudea 1). Drilling and completion activities will be conducted by two mobile offshore drilling units (MODUs) – the *Blackford Dolphin* and *Eirik Raude*. The *Blackford Dolphin* will drill or conduct testing on four wells between the fourth quarter of 2008 and the second quarter of 2009. The *Eirik Raude* will drill 12 wells and conduct 16 well completions on the remaining wells between the first quarter of 2009 and second quarter of 2011.

During drilling, the MODUs will discharge drilling fluids and cuttings in accordance with the project's effluent limits and international industry practice. Both water-based fluids (WBFs) and an enhanced mineral oil based fluid (EMOBF) will be used. The base oil is a highly refined mineral oil that has low aromatic content and low toxicity. The EMOBF will be recovered and returned to the vendor for recycling; it will not be discharged except for small amounts adhering to cuttings. Discharges per well are expected to comprise 1,014 bbl (161.1 m³) of WBFs, 1,497 bbl (237.8 m³) of cuttings drilled with WBFs, and 1,478 bbl (235 m³) of cuttings with residual EMOBF. Cuttings discharged while using the EMOBF system will have an oil retention range of 6% to 8%. Both MODUs will use a cuttings dryer to minimise retention on cuttings.

FPSO and Subsea Facility Installation

The subsea layout is illustrated in **Figure ES.2**. A permanently moored FPSO will serve as the main production and storage facility. The very large crude oil carrier *Ohdoh* has been selected as the vessel for modification to meet the requirements of the project (**Figure ES.3**). The proposed FPSO location is approximately 7 km north-northeast of the Mahogany 1 wellsite, along the northern edge of the Phase 1 development. The water depth at this site is about 1,100 m.

The FPSO will be moored to the seafloor by a taut-leg mooring system consisting of nine anchor legs in a 3 by 3 arrangement, where the groups are 120° apart. Each anchor leg will be composed of a combination of studless chain and polyester rope with a total length of about 1,900 m for each leg. Vertically loaded plate anchors or suction piles will be used at the termination of each anchor chain leg.

Installation of subsea facilities including manifolds, risers, flowlines, injection lines, and umbilicals will require several vessels including tugs, an anchor handling vessel or anchor handling tug supply vessel, pipelaying barge, umbilical barge, and support vessels. Once the FPSO has been moved onto its location and its mooring anchors have been secured, the umbilicals and flowlines will be lifted and tied into the riser and manifold system aboard the FPSO. Commissioning of the FPSO will then occur, including energizing and testing of all of the vessel's systems. Commissioning and start-up are slated to occur from June 2010 to November 2010.

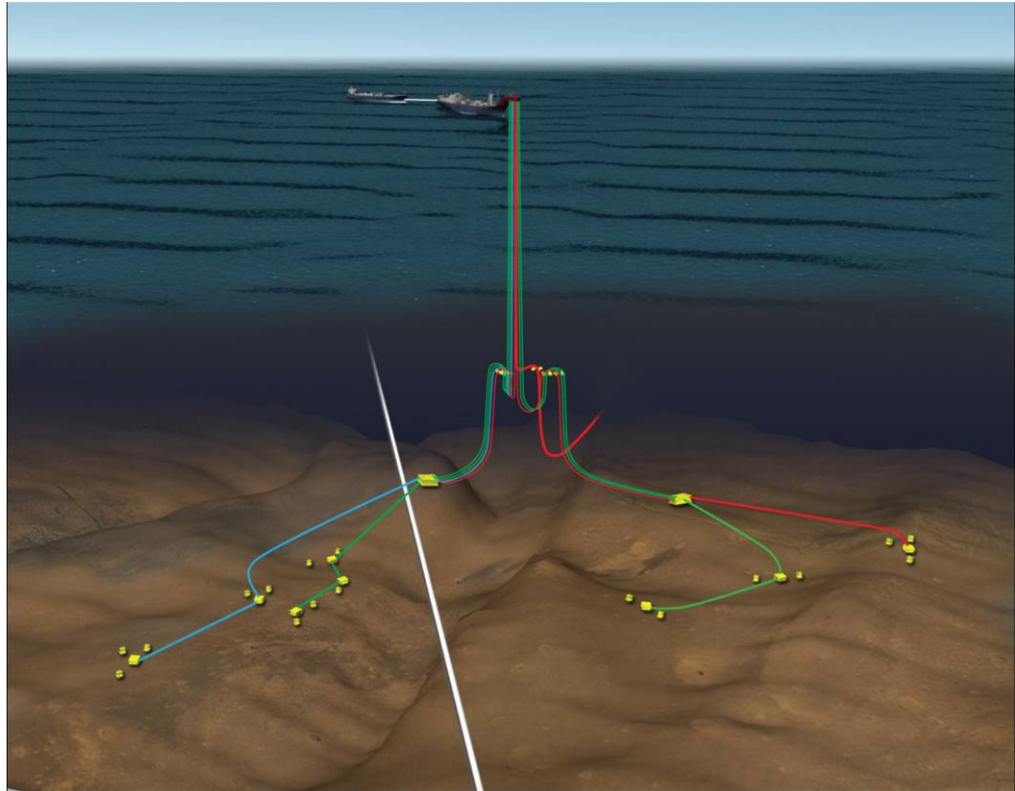


Figure ES.2. Schematic of FPSO and subsea equipment layout.



Figure ES.3. Schematic of possible FPSO configuration based on conversion of the very large crude oil carrier (VLCC) *Ohdoh*.

Routine Production Operations

Once the FPSO and subsea facilities have been commissioned, the project will begin opening wells to initiate production. At its maximum processing rate (120,000 bopd), the FPSO will fill to capacity in 13.3 days. Shuttle tankers will offload stored oil every 10 days in 1-million barrel loads, each of which will require approximately 24 hours to offload.

The mooring and offloading system will be a Single Point Mooring (SPM) system with tandem offloading. The SPM system will be designed to allow the FPSO to freely weathervane 360° around the SPM vertical axis, to align itself with the prevailing wind, wave, and current conditions. All crude oil transfers and vessel movements will be controlled via marine terminal rules and regulations being developed by Jubilee Joint Venture. Two tugs will assist the shuttle tanker in mooring to the FPSO and maintaining its position.

In the Phase 1 Development Plan, all gas (after fuel use on the FPSO) will be re-injected into the formation for future recovery and use. Three gas injection wells are included in the plan. The functional design of the FPSO is based on having sufficient on-board compression capacity to be able to re-inject 100% of associated gas volumes.

Decommissioning

Once the economic life of the Jubilee Field has been reached, the field will be abandoned. The field will be abandoned in accordance with widely accepted abandonment practices and procedures such as those used in the Gulf of Mexico. Following the abandonment of all wells, the subsea and surface facilities will either be removed or abandoned in place. A final environmental survey will be performed to ensure that all aspects of the abandonment have been carried out in accordance with the procedures.

Support Activities

Support vessels (e.g., crew and supply boats) and helicopters will be required to support Phase 1 drilling, installation, and production operations. The onshore support location will be Takoradi, Ghana, approximately 130 km inshore of the Jubilee Field. It is a major support base for Ghana's offshore oil industry. No new facilities or construction will be needed for support vessels or helicopter support for either installation or FPSO-shuttle tanker operations associated with Phase 1. Supplies that may be purchased locally include fresh water, fuel, and food.

During development drilling, approximately 140 jobs will be temporarily transferred to the country due to the operation of the two MODUs, with an expected local staffing complement of 10% for the *Eirik Raude*. Installation of the FPSO and subsea facilities will involve approximately 200 employment opportunities over the course of 3 months, with approximately 10% local staffing. Support operations during both development drilling and facility installation will provide approximately 260 employment opportunities with a local staff complement of between 30% and 80%. During routine production operations, the FPSO and onshore support base will result in approximately 156 employment opportunities with between 10% and 50% local staffing. Support operations during this time will provide approximately 60 employment opportunities with a local staff complement of between 30% and 80%.

Alternatives

In preparing the Phase 1 Development Plan, the Jubilee Joint Venture evaluated alternatives including the project location, development approach, drilling program, drilling fluid selection and cuttings disposal options, gas utilization, and onshore support base. The Development Plan as proposed is the alternative that meets the goal of developing and producing commercial hydrocarbon accumulations from the Jubilee Field rapidly and economically while ensuring protection of the environment.

DESCRIPTION OF THE ENVIRONMENT

The Jubilee Unit is located on the continental slope offshore Ghana in equatorial West Africa. The project area is approximately 132 km west-southwest of the port city of Takoradi, 63 km from the nearest shoreline of Ghana, and 75 km from the nearest shoreline of Côte d'Ivoire.

Water depths in the Jubilee Field range from 1,020 to 1,720 m. The seafloor in the project area is composed of soft to firm clays and silts that form a generally smooth seabed that slopes to the southwest. The most significant features are two broad seabed canyons occurring in the western portion of the West Cape Three Points block. Seabed dip is generally between 1° and 6° in the area outside the ancient seabed canyons. Otherwise, the seabed is benign and featureless.

Seasonal upwelling is an important oceanographic phenomenon in the region and a key influence on productivity and fishery resources. During upwelling periods, nutrients from deep, offshore waters are carried up into the photic zone, resulting in increased primary productivity. The major upwelling season occurs from July through September. The minor upwelling season normally lasts for only about 3 weeks and can occur any time from December through March.

Most marine fish landings in Ghana are from artisanal fishing in nearshore waters, and the most important resources are small pelagic fishes, especially the round sardinella, flat sardinella, European anchovy, chub mackerel, and bigeye grunt. Over time, Ghana's fishery resources have been subjected to increasing exploitation, resulting in a "boom and bust" pattern with huge variations in abundance of some targeted species.

At least 26 species of marine mammals and 5 species of sea turtles occur in the region, including several endangered, critically endangered, or vulnerable species. There are eight globally threatened bird species in Ghana, but none are seabirds or are specifically associated with marine habitats. Ghana's coastal wetlands provide feeding and roosting sites for thousands of resident and migratory birds including at least 11 species of tern. Thirty-six sites in Ghana have been designated as Important Bird Areas, of which five are along the coast. Two sites, the Anlo-Keta and Songor Lagoons, each support over 100,000 shore birds as well as internationally important numbers of several species of wading birds.

There is no critical habitat for marine mammals, sea turtles, or chemosynthetic communities at or near the Jubilee Field area. Critical habitat for sea turtles (nesting beaches) exists along the Ghana coastline but would not be affected by any routine project activities. Other protected areas that could be considered critical habitat (e.g., Ramsar sites, Important Bird Areas) exist along the coast, but there are none at or near the Jubilee Field.

The coast of western Ghana consists of predominantly rocky shores interspersed with pocket beaches. Along the coast of Ghana as a whole, there are more than 90 lagoons, which provide important habitats for fishes, shrimps, crabs, and molluscs and serve as nursery areas for juvenile fishes, overwintering sites for migratory birds, and roosting sites for local waterfowl.

Ghana's Western Administrative Region covers nearly 10% of Ghana and is home to approximately 2 million people. The Jomoro District (located closest to the Phase 1 development) and the Sekondi-Takoradi Metropolitan Area (location of the onshore support base) are both located in this Administrative Region. The four major occupations in the region are similar to the national trend: agriculture accounts for about 60% of the regional Gross Domestic Product (GDP) and employs about 57% of the total labour force. Production and transport work (14.5%), sales work (10.2%), and professional and technical work (5.0%) follow agriculture as prevalent occupations.

The Jubilee Field is located approximately 60 km from the closest coastal village of Effasu. Other villages on the coast inshore of the project include Mangyea, approximately 2 km to the east of Effasu; and Nzimtianu, approximately 4 km to the east of Effasu. Reconnaissance visits indicated that these coastal villages have inadequate service provision in terms of water, sanitation, and electricity.

IMPACTS AND MITIGATION

The potential environmental and socioeconomic impacts of the the Jubilee Field, Phase 1 development are evaluated in **ESER Chapter 5. Table ES.1** summarizes the impact analysis and includes mitigation measures to avoid, reduce, or minimise impacts.

For impacts on the physical, chemical, and biological environment, eight impact factors were identified for routine activities: (1) drilling discharges; (2) seafloor disturbance; (3) presence of structures; (4) operational effluent discharges; (5) marine debris; (6) air pollutant emissions; (7) support activities; and (8) structure removal.

For the socioeconomic environment, impact factors include the following: (1) creation or temporary transfer of employment opportunities; (2) opportunities for local enterprises; (3) economic impacts (e.g., from royalties, taxes, fees, etc.); (4) opportunities for community development; (5) population influx and increase in social pathologies; (6) housing demand; (7) increased strain on service provision; (8) increased traffic; (9) impacts on fishing; (10) onshore impacts of project infrastructure; and (11) health and safety impacts of normal operations.

Potential environmental and socioeconomic impacts of accidents were also considered, including those resulting from an oil spill (e.g., a crude oil spill resulting from a blowout, or a diesel fuel spill) and a hydrogen sulfide release.

Mitigation measures to avoid, reduce, or minimise impacts are indicated in the summary table. Many project activities are already subject to environmental, health, and safety (EHS) procedures and systems developed by the Jubilee Joint Venture. A detailed summary of mitigation and monitoring activities is presented in the ACMP.

CONCLUSION

In preparing the Phase 1 Development Plan, the Jubilee Joint Venture evaluated potential impacts and considered alternatives including the project location, development approach, drilling program, gas utilization, and onshore support base. The Phase 1 Development Plan as proposed is the alternative that meets the goal of developing and producing commercial hydrocarbon accumulations from the Jubilee Field rapidly and economically while ensuring protection of the environment. Based on the impact evaluation in the ESER, and taking into account the mitigation measures detailed in the ACMP, the project is expected to result in net economic benefits to the Republic of Ghana and no significant residual environmental or socioeconomic impacts. In addition, the Jubilee Joint Venture has prepared a PCDP outlining a comprehensive approach to public notification regarding the project and an SRP detailing the available mechanisms for filing of grievances.

Table ES.1. Summary of potential impacts and mitigation for the Jubilee Field, Phase 1 development.

Impact Factor	Impact Description	Significance without Mitigation	Mitigation	Residual Impact Significance
ENVIRONMENTAL IMPACTS OF ROUTINE ACTIVITIES				
Drilling discharges	• Water column turbidity, transient impacts on plankton and fishes • Burial, smothering, and anoxia effects on benthic communities, mainly within about 500 m of wellsites	Negligible to Low	• Compliance with project effluent guidelines including use of low-toxicity drilling fluids, no free oil, limits on mercury and cadmium concentrations in stock barite, and limits on drilling fluid retention on cuttings • Use of a cuttings dryer to minimise retention on cuttings	Negligible to Low
Seafloor disturbance	• Physical damage to benthic communities due to placement of structures and/or anchors	Low	• None recommended	Low
Presence of structures (including noise and lights)	• Platforms are likely to attract pelagic fish and plankton • Fouling community on offshore structures may result in localized benthic enrichment • Underwater noise may affect behaviour of marine mammals and turtles	Beneficial to Low	• None recommended	Beneficial to Low
Operational effluent discharges	• Minor impacts on water quality near offshore facilities, similar to existing ship traffic in region	Low	• Compliance with MARPOL • Compliance with project effluent guidelines including oil and grease content	Low
Marine debris	• Risk of death or injury to marine mammals, turtles, or birds due to ingestion of or entanglement with accidentally discarded debris • Water quality impacts; cluttering of seafloor and shorelines	Negligible to Low	• Compliance with MARPOL prohibitions on dumping trash and debris in the ocean • Development of Waste Management Plans to minimise the chance of accidentally losing items overboard • Site clearance survey to ensure that any debris from drilling activities is removed from the seafloor around the wellsites	Negligible

Table ES.1. (Continued).

Impact Factor	Impact Description	Significance without Mitigation	Mitigation	Residual Impact Significance
Air pollutant emissions	Minor impacts on air quality, similar to other vessel and aircraft traffic in region	Low	- Compliance with MARPOL Annex VI emissions limits for ships and IFC guidelines for emissions for small combustion sources - Routine inspection and maintenance of engines, generators, and other equipment to minimise excess noise and air emissions - Use of low-sulfur diesel fuel if available	Low
Support activities	- Helicopters flying over Important Bird Areas (IBAs) could disturb protected coastal bird populations - Potential for support vessel to strike a marine mammal or turtle - Minor disturbance of marine mammals, turtles, and birds	Low to Medium	Helicopter pilots advised to avoid flying over Amansuri wetland IBA. If avoidance is not feasible, a minimum altitude of 710 m should be maintained when flying over this area to minimise disturbance to wildlife	Low
Structure removal	Physical impacts to benthic communities, similar to those during installation	Low	Development of a decommissioning plan that includes appropriate environmental safeguards in accordance with international best practice	Low
SOCIOECONOMIC IMPACTS OF ROUTINE ACTIVITIES				
Creation/transfer of employment opportunities (development drilling, facility installation, and routine production operations) ¹	- Development drilling – 404 employment opportunities over approximately 2 years - Facility installation – 480 employment opportunities over approximately 2 years - Routine production operations – 216 employment opportunities over approximately 20 years 10% to 80% local staff.	Beneficial	- Establish “labour and employment desk” as contact point for local community members - Create skills register of local community members (qualifications, work experience) - Establish monitoring system to ensure Contractors honour specified employment policy - Use local staffing as far as possible	Beneficial
Loss of employment opportunities (decommissioning)	Upon decommissioning, employees will have to secure alternative employment	Medium	- Notify employees of pending retrenchments - Assist employees in securing alternative employment	Low
Opportunities for local enterprises and multiplier effects	- Numerous service companies will open in Sekondi-Takordi, which will allow other businesses to provide services - Although a large portion of the project’s expenditures will be allocated to ship conversions, this will have great spin-off benefits for the economy as a whole	Beneficial	- Develop register of local support and services companies - Establish linkages with other institutions involved in all skills development and business development - Investigate possibility to launch training/skills development initiative	Beneficial

Table ES.1. (Continued).

Impact Factor	Impact Description	Significance without Mitigation	Mitigation	Residual Impact Significance
Economic impacts – Production	GNPC estimates that more than 17.5% of income generated from selling oil will accrue to the Ghanaian Government	Beneficial	Ensure that contractual obligations are met in terms of royalties and taxes	Beneficial
–Decommissioning	- Reduced opportunities for local suppliers - Reduced financial benefits for the Government	Medium	- Give advance warning of decommissioning - Encourage suppliers to secure other contracts prior to decommissioning	Low
Opportunities for community development	Policy and program is presently being defined by the Jubilee Joint Venture	Beneficial	- Liaise with local communities regarding their needs and priorities - Liaise with other institutions and organisations (Metropolitan Authority, NGOs, etc.) to align CSR initiatives - Communicate community CSR initiatives clearly to relevant parties	Beneficial
Population influx and increase in social pathologies	Population influx into project area and increases in availability of cash may lead to increases in social pathologies (sexually transmitted diseases, alcoholism, substance abuse)	Low	- Measures to combat spread of sexually transmitted diseases: - Implement HIV/AIDS and alcohol abuse programmes for employees - Align awareness campaigns with those of other organisations in area - Measures to prevent conflict between employees and locals: - Recruitment policy must be fair and transparent - Communicate the policy to local communities - Measures to control access to onshore support base and movements of employees - Measures to address crime: - Consult with local police to establish standard operating procedure for control and/or removal of loiterers at support base	Negligible
Housing demand	- Employees will require housing in Sekondi-Takoradi - Offshore workers will be housed offshore on a rotational basis	Low	Liaise with Metropolitan Authorities to ensure adequate supply of housing	Negligible
Increased strain on service provision	Onshore support base will require electricity, water, and waste disposal services	Low	Inform Metropolitan Authorities well in advance of the anticipated timeframe and nature of services that will be required for service provision	Low

Table ES.1. (Continued).

Impact Factor	Impact Description	Significance without Mitigation	Mitigation	Residual Impact Significance
Increase in traffic	Port at Takoradi will experience increase in ship movements, and the military base will experience increase in helicopter movements	Negligible	Ensure efficient communication with port and airbase control officers to avoid unnecessary delays in shipping or airborne movements	Negligible
Impacts on fishing	- Exclusion zone for the MODUs and FPSO may disrupt fishing activities in the vicinity - Operational discharges may affect fishing activities, but the likelihood of this event is low	Low	- Establish clear communication channels to commercial deep-sea fishers and artisanal fishing villages - Inform port authorities and commercial fishing operations in advance of location and schedule of project activities - Treat human wastes according to MARPOL standards prior to discharge.	Negligible
Onshore impacts of project infrastructure	Offshore infrastructure not likely to be visible onshore; no pipelines, oil transport trucks, refineries, etc. are expected.	Negligible	None required	Negligible
Health and safety impacts of normal operations	- Exclusion zone may be breached by fishers in fishing activities - Increased risk for ship collisions due to more shipping movements - Construction risks to rig workers	Medium	- Liaise with harbour police authorities regarding patrolling of exclusion zone - Implement education and awareness programs in the coastal villages to inform villagers of potential dangers of fishing close to oil rigs - Liaise with harbour control officers to ensure adequate tracking and monitoring of shipping movements between the oil rigs and the harbour - Ensure that workers wear personal protective equipment	Low

Table ES.1. (Continued).

Impact Factor	Impact Description	Significance without Mitigation	Mitigation	Residual Impact Significance
ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS OF ACCIDENTS				
Oil spill (e.g., crude oil from a blowout, or a diesel fuel spill) – Environmental	- Depending on spill size and conditions, effects could include violation of water quality standards; contamination of sediments; death or injury of marine mammals, turtles, and birds; and contamination of coastal habitats - Physical effects on soft bottom benthos around wellsites in the event of a subsea blowout	Low to Medium	- Oil Spill Response Plan - MARPOL requires Shipboard Oil Pollution Emergency Plan and Oil Record Book	Low
– Socioeconomic	- Commercial and artisanal fishing including beach seining and lagoon fishing may be shut down temporarily during clean-up operations - Tourism sites may experience decline in visitors due to dissatisfaction of tourists - Possible temporary shutdown of cooling water intake at the Takoradi Thermal Power Plant, which may result in the loss of power to Sekondi-Takoradi and possibly other areas in Ghana - Vessels and gear in ports may be damaged and normal port operations may be influenced until clean-up completed	Negligible to High	- Establish Compensation Determination Committee that will manage all compensation claims - Establish effective communication channels with potentially affected groups including commercial deep-sea fishers, artisanal fishers, harbour control authorities, tourism sites, salt producers, and the Takoradi Thermal Plant to ensure rapid response to the event of an oil spill - Ensure that Oil Spill Response Plan provides the capability to combat oil spills in the harbour area and the Thermal Plant area	Low
H ₂ S release	Violation of air quality standards; potential death or injury of humans on offshore facilities	Low	- MODUs and FPSO equipped with H₂S detection equipment - Hydrogen Sulfide Program to protect employees in the event of an H₂S release	Low

CSR = Corporate Social Responsibility; GNPC = Ghana National Petroleum Corporation; IFC = International Finance Corporation; MARPOL 1973/1978 = International Convention for the Prevention of Pollution from Ships; and NGO = nongovernmental organization.

¹ Because some activities overlap among phases, the total number of jobs is likely to be less than the sum of the individual phases.

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List of Acronyms

Acronym	Definition
ACMP	Action, Contingency, and Mitigation Plan
AHTS	anchor handling tug supply
AHV	anchor handling vessel
AP	Action Plan
bbl/d	barrels per day
BCM	bow to centre manifold
bfpd	barrels of fluid per day
bhp	brake horsepower
BOP	blowout preventer
bopd	barrels of oil per day
BTEX	benzene, toluene, and xylene
bwpd	barrels of water per day
CBO	community-based organisation
CERD	Committee on the Elimination of Racial Discrimination
CIA	Central Intelligence Agency
CMS	Convention on the Conservation of Migratory Species of Wild Animals, 1979
CO	carbon monoxide
CPP	Convention Peoples Party
CSR	Corporate Social Responsibility
DP	dynamically positioned
dwt	dead weight ton
EHS	Environment, Health, and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMOBF	enhanced mineral oil-based fluid
ENSO	El Niño Southern Oscillation
EPA	Environmental Protection Agency
EPFI	Equator Principles Financial Institution
ERP	Emergency Response Plan
ESER	Environmental and Social Evaluation Report
FAO	Food and Agriculture Organization of the United Nations
FCCC	Framework Convention on Climate Change
FEED	front end engineering design
FPSO	floating production, storage, and offloading (vessel)
GDP	Gross Domestic Product
GHG	greenhouse gas
GNPC	Ghana National Petroleum Corporation
gpm	gallons per minute
HAZCOM	Hazard Communication Program
hp	horsepower
HOCNF	Harmonized Offshore Chemical Notification Format
IBA	Important Bird Area
ICERP	International Convention on the Elimination of all Forms of Racial Discrimination
ICT	information and computer technology

List of Acronyms (Continued)

Acronym	Definition
IFC	International Finance Corporation
ILO	International Labour Organisation
IMO	International Maritime Organization
ITCZ	Intertropical Convergence Zone
IUCN	International Union for the Conservation of Nature and Natural Resources
JSS	junior secondary school
Kosmos	Kosmos Energy Ghana HC
KPI	Key Performance Indicator
KTM	keel to masthead
lb	pound
LM2	Lower Mahogany 2
LOA	length over all
LWD	logging while drilling
MARPOL	International Convention for the Prevention of Pollution from Ships
MMbo	million barrels of oil
MMscfd	millions of standard cubic feet per day
MMS	Minerals Management Service
MODU	mobile offshore drilling
MSDS	material safety data sheet
NECC	North Equatorial Countercurrent
NGO	nongovernmental organization
NO _x	nitrogen oxide
o/w	oil in water
OECD	Organisation of Economic Co-operation and Development
OP	Operational Procedure
OSPAR Convention	Legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic
OSRL	Oil Spill Response Limited
OSRP	Oil Spill Response Plan
OWR	oil water ratio
OWS	oily water separator
PAH	polycyclic aromatic hydrocarbon
PAP	project affected person
PCDP	Public Consultation and Disclosure Plan
PPE	personal protective equipment
psia	pounds per square inch absolute
Ramsar	Ramsar Convention on Wetlands, 1971
ROV	remotely operated vehicle
rpm	revolutions per minute
RVP	Reid vapor pressure
SCSSV	surface-controlled subsurface safety valve
SDU	subsea distribution unit
SEC	South Equatorial Current
SHEP IV	Self Help Electrification Project
SOLAS	International Convention for Safety of Life at Sea, 1974

List of Acronyms (Continued)

Acronym	Definition
SOPEP	Shipboard Oil Pollution Emergency Plan
SO _x	sulfur
SPM	single position mooring
SRC	Social Reconciliation Committee
SRP	Social Reconciliation Plan
SRU	sulfate reduction unit
SSS	senior secondary school
STD	sexually transmitted disease
STMA	Sekondi-Takoradi Metropolitan Authority
TBA	traditional birth attendant
TD	true depth
TVD	true vertical depth
TVDS	true vertical depth subsea
TVP	true vapor pressure
UKOOA	United Kingdom Offshore Operators Association
UM2	Upper Mahogany 2
UNCLOS	United Nations Law of the Sea Convention
UNCRC	United National Convention on the Rights of the Child
UNEP	United Nations Environment Programme
UNEP-WCMC	United Nations Environment Programme-World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UPS	uninterruptable power supply
USEPA	U.S. Environmental Protection Agency
VLA	vertically loaded plate anchor
VLCC	very large crude oil carrier
VOC	volatile organic compound
WBF	water-based fluid

1.1 Overview

The Jubilee Joint Venture is proposing to develop petroleum resources in the Jubilee Field offshore Ghana, West Africa (**Figure 1.1**). Joint Venture participants include Kosmos Energy Ghana HC (Kosmos), Tullow Ghana Limited, Anadarko WCTP Company, Sabre Oil & Gas, the E.O. Group, and Ghana National Petroleum Corporation (GNPC). This document is an Environmental and Social Evaluation Report (ESER) for Lenders for Phase 1 of the proposed development.

The Jubilee Field includes portions of the Deepwater Tano Contract Area and West Cape Three Points Block. Successful exploration drilling in 2007 resulted in one discovery in each block. The discoveries identified a large accumulation of oil that underlies portions of both blocks. In consultation with GNPC, the accumulation was named the Jubilee Field.

A Phase 1 Development Plan has been prepared as the first of a multi-phase development of the Jubilee Field. The Phase 1 development will consist of nine production wells, five water injection wells, and three gas injection wells. Production will be gathered through subsea manifolds and conveyed by subsea flowlines to a floating production, storage, and offloading vessel (FPSO), which will be moored in the Jubilee Field area. Development drilling, well completions, subsea equipment installation, and FPSO installation will occur between late 2008 and early 2011. The development plan target for first production is 1 November 2010.

The scope of Phase 1 includes:

- Drilling of 15 new wells;
- Completion of 17 wells (the 15 new wells, plus the Mahogany 1 and Hyudea 1 exploratory wells as production and injection wells, respectively);
- Movement of two mobile offshore drilling rigs (MODUs) onto the Jubilee Field and associated drilling/completion;
- Installation of subsea equipment including flowlines, injection lines, and umbilicals; and risers, manifolds, and the FPSO in the Jubilee Field;
- Precommissioning, commissioning, and startup of the FPSO and subsequent FPSO operation, including mooring, offloading, and egress of shuttle tankers; and
- Decommissioning of the facilities after 20 years.

The Phase 1 Development Plan is based on oil production alone, with the future ability to export gas in subsequent phases. The plan assumes that all gas (after fuel use on the FPSO) will be re-injected into the formation for future recovery and use. The Jubilee Joint Venture is evaluating a number of options to bring the gas to market during subsequent phases. However, gas export activities are not part of this ESER and would be evaluated separately in the future if such activities are proposed.

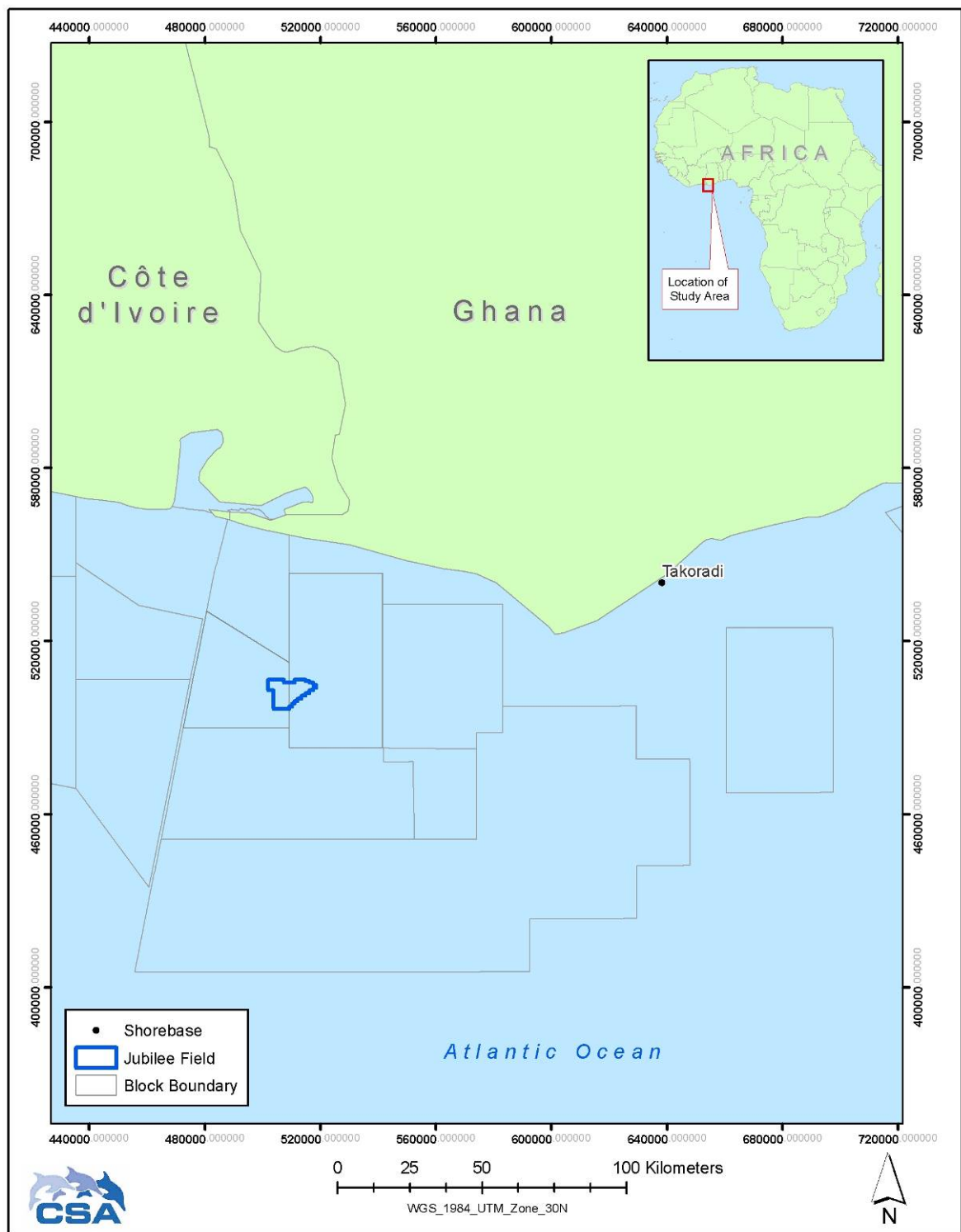


Figure 1.1. Location of the Jubilee Field relative to block boundaries and the coast of Ghana.

1.2 Report Objectives

The objectives of the ESER are to evaluate the potential environmental and socioeconomic impacts of the Phase 1 Development and to identify mitigation measures to ensure that the development is conducted in an environmentally sound and sustainable manner.

The ESER is intended for internal planning purposes by the Jubilee Joint Venture and for review by financial institutions rather than submission to the Republic of Ghana. A separate Environmental Impact Statement (EIS) will be prepared later for submission to the Republic of Ghana. The relevant laws and regulations of the Republic of Ghana are discussed in **Chapter 2.0**.

1.3 Report Organisation

The ESER is one of four environmental/socioeconomic documents prepared in conjunction with the Phase 1 Development Plan:

- **Environmental and Social Evaluation Report (ESER) for Lenders (this document)** – Evaluates the potential impacts of the Phase 1 development and identifies mitigation and monitoring measures.
- **Action, Contingency and Mitigation Plan (ACMP)** – Provides the details of contingency and mitigation measures cited in the ESER, including those that are required by laws or regulations, along with additional realistic, feasible, and cost-effective measures to prevent or reduce significant adverse impacts to acceptable levels.
- **Public Consultation and Disclosure Plan (PCDP)** – Outlines a comprehensive approach to public notification regarding the proposed project.
- **Social Reconciliation Plan (SRP)** – Details the available mechanisms for filing of grievance resulting from Jubilee Development operations.

The main chapters of the ESER are as follows:

- **Executive Summary** – Summarizes the project, significant impacts, mitigation measures, and any residual negative impacts that cannot be mitigated.
- **1.0 Introduction** (this chapter) – Provides an overview of the project and information about the scope and organisation of the ESER.
- **2.0 Legal and Regulatory Framework** – Reviews the legal framework for petroleum operations in Ghana as well as relevant international conventions and World Bank and International Finance Corporation (IFC) guidelines. The Joint Venture's Environment, Health, and Safety (EHS) policy also is described.
- **3.0 Project Description** – Explains project activities, including location and schedule, facilities and equipment, the sequence of activities to be conducted, effluent discharges, air pollutant emissions, and contingency and safety plans.

- **4.0 Description of the Existing Environment** – Summarizes the environmental and socioeconomic conditions within and near the project area potentially affected by development activities.
- **5.0 Impact Analysis** – Evaluates the potential environmental and socioeconomic impacts of the project, including those from routine operations and potential accidents.
- **6.0 Mitigation** – Outlines the mitigation measures to avoid or reduce adverse environmental impacts. These include existing management and control measures required by law or regulations, as well as measures recommended based on the impact analysis. Details for implementing these measures are presented in the ACMP.
- **7.0 Analysis of Alternatives** – Evaluates the “no project” alternative and describes technical and operational alternatives considered in devising the development plan.

Additional supporting information is provided in **Appendices A** through **E**. **Appendix A** provides the mobile offshore drilling unit specifications for the *Blackford Dolphin* and *Eirik Raude*. **Appendix B** includes the floating production, storage, and offloading vessel schematics. **Appendix C** presents the alternatives analysis of drilling fluid detection and cuttings disposal. Air emissions calculations are included in **Appendix D**, and a discussion of endangered or critically endangered marine mammals and turtles is presented in **Appendix E**.

2.0 Legal and Regulatory Framework

This chapter summarizes the legal and regulatory framework for the Jubilee Field, Phase 1 development. This information is provided for context only, as this ESER is intended for internal planning purposes and for review by financial institutions rather than submission to the government. A separate impact assessment will be conducted and a resulting report will be prepared for later submission to the Republic of Ghana (see **Section 2.1.4**).

2.1 Ghana Laws and Regulations

Key agencies and organisations relevant to offshore oil and gas activities in the Republic of Ghana are:

- The Ministry of Energy, which represents the state in its regulatory capacity;
- The Ghana National Petroleum Company (GNPC), which is the state oil company empowered to conduct petroleum operations and partner with foreign investors; and
- The Environmental Protection Agency (EPA), which is responsible for environmental protection in Ghana and supervises the impact assessment process.

Key laws and regulations relevant to offshore oil and gas activities include:

- The Ghana National Petroleum Act, 1983, which establishes the GNPC;
- The Petroleum (Exploration & Production) Law, 1984, which establishes the legal and fiscal framework for the conduct of petroleum exploration and production activities in Ghana;
- The Environmental Protection Act, 1994, which establishes the EPA and defines its regulatory authority; and
- The Environmental Assessment Regulations, 1999, which specify the types of activities that require an impact assessment report and explain the steps of the impact assessment process.

2.1.1 Ghana National Petroleum Corporation Act, 1983

This law establishes the GNPC as a corporation with the following objectives: (1) promote the exploration and the orderly and planned development of the petroleum resources of the Republic; (2) ensure that the Republic obtains the greatest possible benefits from the development of its petroleum resources; (3) obtain the effective transfer to the Republic of appropriate technology relating to petroleum operations; (4) ensure the training of citizens and the development of national capabilities in all aspects of petroleum operations; and (5) ensure that petroleum operations are conducted in such manner as to prevent adverse effects on the environment, resources and people of Ghana.

The law empowers the GNPC to (1) advise the Minister and the National Energy Board on matters relating to petroleum operations; (2) engage in petroleum operations,

alone or in association with others; (3) enter into petroleum exploration and production agreements and any other petroleum contracts providing for the assistance, participation or co-operation of contractors in connection with petroleum operations; (4) alone or in association with others, buy, sell, trade, store, exchange, import or export petroleum and for this purpose, acquire or operate any installations, facilities or means of transportation; (5) engage in research and development program related to petroleum; and (6) engage in any other activities, alone or in association with others, as may be necessary or desirable for the carrying out of petroleum operations. The GNPC started operations in 1985.

2.1.2 The Petroleum (Exploration & Production) Law, 1984

The Petroleum (Exploration & Production) Law, 1984 establishes the legal and fiscal framework for the conduct of petroleum exploration and production activities in Ghana. The law deals extensively with petroleum contracts, the rights, duties, and responsibilities of contractors and compensation payable to those affected by activities in the petroleum sector. Under the law, the Ministry of Energy represents the State in its regulatory capacity, with the GNPC operating as the state oil company. A Model Petroleum Agreement was developed as the basic contract between the state, the GNPC, and private companies.

The Petroleum Law requires adherence to international best oil industry practices during offshore operations. The Petroleum Agreement must also include a Development Plan (DP) that under which the development of fields must be conducted in a manner that has minimum negative impact on the environment. The DP must be approved by the GNPC, Ministry of Energy, and EPA. Furthermore, the law requires Environmental, Health, and Safety (EHS) audits of operations be conducted by EPA and GNPC. GNPC also requires a comprehensive EHS Manual, detailing the health, safety, and environmental issues, policies and procedures. The EHS Manual is to be submitted to GNPC for review and approval before commencing any operations. Emergency plans for handling accidents are to be discussed thoroughly among GNPC, EPA, and the operator before the commencement of operations.

2.1.3 The Environmental Protection Act, 1994

The Environmental Protection Agency Act, 1994 (Act 490) establishes and defines the responsibilities of the EPA. Key responsibilities include prescribing standards and guidelines, issuing environmental permits and enforcing compliance, and the authority to require an impact assessment.

The law is divided into four parts, of which the first two are most relevant. Part I (Establishment of the EPA) defines the functions of the Agency, including advising the Minister on the formulation of environmental policies; making recommendations for the protection of the environment; coordinating the activities of bodies concerned with the technical or practical aspects of the environment; issuing environmental permits and pollution abatement notices; prescribing standards and guidelines relating to the pollution of air, water, land and other forms of environmental pollution including the discharge of wastes; promoting studies, research, surveys and analyses for the improvement and protection of the environment and the maintenance of sound ecological systems in Ghana; initiating education programs for the creation of public awareness of the environment and its importance to the economic and social

life of the country; and developing a comprehensive database on the environment and environmental protection for the information of the public.

Part II of the Act (Enforcement and Control) defines the power of the EPA to request an impact assessment and to issue Enforcement Notices. It also delineates the requirements for, and responsibilities of, Environmental Protection Inspectors.

2.1.4 Environmental Assessment Regulations, 1999

The Environmental Assessment Regulations, 1999 (LI 1652) were promulgated to give legal status to Ghana's impact assessment procedures. The Regulations require that all development activities likely to adversely affect the environment must be subject to environmental assessment. The objective of the regulations is to ensure that such development activities are carried out in an environmentally sound and sustainable manner.

The Environmental Assessment Regulations provide a list of "undertakings" that require registration and Environmental Permits (Schedule 1) and those for which an impact assessment report is mandatory (Schedule 2). Schedule 1 includes crude oil and natural gas exploration; crude oil or petroleum production facilities; and natural gas production facilities. Schedule 2 includes oil and gas field development; construction of offshore and onshore pipelines; construction of oil and gas separation, processing, handling and storage facilities; and construction of oil refineries.

In accordance with these regulations, an impact assessment report will be required for the Jubilee Field, Phase 1 development. The Environmental Assessment Regulations specify the topics to be addressed in an impact assessment and the process for preparing one, including screening, scoping, review, and public involvement. A separate impact assessment will be prepared to address these Ghanaian legal requirements. As of September 2008, it has been noted by Ghanaian regulatory authorities that an Environmental Impact Statement (EIS) will be prepared for the Jubilee Field, Phase 1 development.

In 2002, Amendments to the Environmental Assessment Regulations were enacted, establishing a schedule of fees for environmental permits and certificates. The amendments also require the publication of a notice of every environmental permit within 3 months of its issuance.

2.2 International Conventions and Agreements

Ghana is party to several international conventions and agreements that address major environmental and social issues, including prevention of pollution to the marine environment, human rights, cultural heritage, workers' rights, and development principles intended to ensure socially responsible and sound environmental management.

2.2.1 Prevention of Marine Pollution and Relevant Environmental Conventions and Agreements

One of the most relevant and important international conventions is the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). MARPOL came into force in 1983 and initially comprised Annex I (Regulations for the Prevention

of Pollution by Oil Regulations) and Annex II (Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk). Four more annexes have been added; parties must accept Annexes I and II, but the other four are voluntary. Ghana has not yet ratified Annexes III, IV, V, or VI. **Table 2.1** summarizes MARPOL provisions that are relevant for oil and gas exploration. MARPOL Annex I also designates “special areas” where there are stricter controls on discharge of oily wastes. Waters offshore Ghana are not within a MARPOL special area. Other relevant international conventions and agreements are summarized in **Table 2.2**.

Table 2.1. MARPOL 1973/1978 provisions relevant to oil and gas development.

Environmental Aspect	Provisions of MARPOL 1973/1978	Annex
Drainage water	Ship must be proceeding en route, not within a 'special area' and oil must not exceed 15 ppm (without dilution). Vessel must be equipped with an oil filtering system, automatic cutoff and an oil retention system.	I
Accidental oil discharge	Shipboard oil pollution emergency plan (SOPEP) is required.	I
Bulked chemicals	Prohibits the discharge of noxious liquid substances, pollution hazard substances and associated tank washings. Vessels required to undergo periodic inspections to ensure compliance. All vessels must carry a Procedures and Arrangements Manual and Cargo Record Book.	II
Sewage discharge	Discharge of sewage is permitted only if the ship has approved sewage treatment facilities, the test result of the facilities are documented, and the effluent will not produce visible floating solids nor cause discoloration of the surrounding water.	IV
Garbage	Disposal of garbage from ships and fixed or floating platforms is prohibited. Ships must carry a garbage management plan and shall be provided with a Garbage Record Book.	V
Food waste	Discharge of food waste ground to pass through a 25-mm mesh is permitted for facilities more than 12 nautical miles from land.	V
Air pollutant emissions	Sets limits on sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances including halons and chlorofluorocarbons. Sets limits on emissions of nitrogen oxides from diesel engines. Prohibits the incineration of certain products on board such as contaminated packaging materials and polychlorinated biphenyls.	VI

¹ Ghana has ratified MARPOL Annexes I and II, but not Annex III, IV, V, or VI.
MARPOL = International Convention for the Prevention of Pollution from Ships.

Table 2.2. Relevant international conventions and agreements pertinent to environmental protection for which Ghana is a contracting party.

Protocol	Explanation
Ramsar Convention on Wetlands (1971)	Provides the framework for national action and international cooperation for conservation and wise use of wetlands. Parties agree to: (1) work towards the wise use of wetlands through national land-use planning, appropriate policies and legislation, management actions, and public education; (2) designate suitable wetlands for the List of Wetlands of International Importance and ensure their effective management; and (3) cooperate internationally concerning transboundary wetland systems and development projects affecting wetlands.
International Convention for the Prevention of Pollution from Ships (MARPOL) (1973/78)	Covers almost every aspect of marine environmental protection from the operation of ships, including design, construction, survey, inspection, discharges, reception facilities, operational standards, and reporting, and includes provisions for the reporting of violations (see text for details).
Convention on the Conservation of Migratory Species of Wild Animals (CMS) (1979)	The CMS aims to conserve terrestrial, marine and avian migratory species throughout their range. CMS Parties strive to protect migratory species threatened with extinction, conserve or restore places where they live, mitigate obstacles to migration, and control other factors that might endanger them. CMS also promotes concerted action among the states.
Convention on the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan Convention) (1981)	Covers the marine environment, coastal zones and related inland waters of the Western African Region, from Mauritania to South Africa. Parties agree to take appropriate measures to prevent, reduce, combat, and control pollution and to ensure sound environmental management of natural resources.
United Nations Law of the Sea Convention (UNCLOS) (1982)	Provides a universal legal framework for the management of marine natural resources, including efforts to prevent, reduce, and control marine pollution.
Vienna Convention for the Protection of the Ozone Layer (1985)	Commits governments to take measures to protect human health and the environment against adverse effects resulting from depletion of the ozone layer. Cooperative research and information exchange are encouraged to understand and assess effects of ozone layer modification on human health and the environment.
Montreal Protocol on Substances that Deplete the Ozone Layer (1987)	Supplements the Vienna Convention and is designed to regulate the production and consumption of ozone-depleting substances. Phase-out schedules are specified for controlled substances to allow for progressive tightening over time as scientific evidence for ozone depletion trend is strengthened and as substitutes are developed.
Framework Convention on Climate Change (FCCC) (1992)	Aims to stabilize greenhouse gas concentrations in the atmosphere at levels that would prevent dangerous human interference with the climate system and that are consistent with sustainable development. Governments should take precautionary measures to anticipate and prevent or minimise climate change and its adverse effects.

Table 2.2. (Continued).

Protocol	Explanation
Agenda 21 of the United Nations Conference on Environment and Development (1992)	Agenda 21, also known as the Rio Declaration, is a comprehensive plan of action to be taken globally, nationally, and locally by governments and organisations to reduce human impacts on the environment. Chapter 17 of Agenda 21 addresses protection of the oceans, and Section 17:30 calls for states to assess the need for additional measures to control degradation of the marine environment from sea-based activities, including activities associated with oil and gas platforms.
Convention on Biological Diversity (1992)	In support of conserving biological diversity, governments commit to integrating conservation and sustainable use of biological resources into national decisionmaking, establishing a system of protected areas and requiring environmental assessment of proposed projects that may adversely affect biological diversity.
Kyoto Protocol to the FCCC (1997)	The Kyoto Protocol has the same objectives, principles and institutions as the FCCC, but significantly reinforces the Convention by committing the parties to individual, legally binding objectives for the reduction or limiting of their greenhouse gas emissions.
Stockholm Convention (2001)	The Stockholm Convention is a global treaty to protect human health and the environment from persistent organic pollutants by prohibiting, phasing out as soon as possible, or restricting the production, placing on the market and use of these substances.
CMS Memorandum of Understanding Concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa (1999)	The agreement was concluded under CMS auspices and aims at safeguarding six marine turtle species that are estimated to have rapidly declined in numbers during recent years due to excessive exploitation (both direct and incidental) and the degradation of essential habitats. Parties agree to work closely together to improve the conservation status of the marine turtles and the habitats on which they depend.

2.2.2 Human Rights Conventions Ratified by Ghana

Human rights conventions serve to protect fundamental freedoms and enforce basic human rights. Ghana has ratified a number of such conventions, including those concerned with slavery, children's rights, the status of refugees and women's political rights, among others. These are discussed in more detail in the subsections below.

2.2.2.1 *Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery*

The United Nations 1956 Supplementary Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery (<http://www.yale.edu/lawweb/avalon/un/slave56.htm>, 1998), requires that:

- The parties commit to abolish and abandon debt bondage, serfdom, servile marriage, and child servitude;

- The parties commit to enacting minimum ages of marriage, encouraging registration of marriages, and encouraging the public declaration of consent to marriage;
- The parties commit to criminalise slave trafficking;
- Runaway slaves who take refuge on flag vessels of parties shall thereby attain their freedom;
- The parties commit to criminalise the marking (including mutilation and branding) of slaves and servile persons; and
- The parties commit to criminalise the enslavement and giving others into slavery.

Ghana signed the treaty in 1956.

2.2.2.2 International Covenant on Civil and Political Rights

Ghana signed the International Covenant on Civil and Political Rights treaty on 23 March 1976. This United Nations treaty is based on the Universal Declaration of Human Rights. The Covenant contains two Optional Protocols (www.unhchr.ch/html/menu3/b/a_ccpr.htm, 2008): the first creates an individual complaints mechanism whereby individuals in member States can submit complaints to be reviewed by the Human Rights Committee. The second optional protocol abolishes the death penalty.

Provisions made by the convention are divided into five broad categories:

- Protection of an individual's physical integrity, against things such as execution, torture, and arbitrary arrest;
- Procedural fairness in law, including rule of law, rights upon arrest, trial, basic conditions that must be met when imprisoned, rights to a lawyer, and an impartial process in trial;
- Protection based on gender, religious, racial, or other forms of discrimination;
- Individual freedom of belief, speech, association, freedom of press, and right to hold assembly; and
- Right to political participation, including organising a political party, voting, and voicing contempt for current political authority.

2.2.2.3 Convention on the Rights of the Child

Ghana signed the United Nations Convention on the Rights of the Child on 5 February 1990. This international convention is also referred to as the CRC or UNCRC, and sets out the civil, political, economic, social, and cultural rights of children (www.unhchr.ch/html/menu3/b/k2crc.htm, 2008).

Governments of countries that have ratified the Convention are required to report to, and appear before, the United Nations Committee on the Rights of the Child periodically to be examined on their progress with regards to the advancement of the implementation of the Convention and the status of child rights in their country. Their reports and the committee's written views and concerns are made available on the committee's website.

2.2.2.4 Convention Relating to the Status of Refugees

Ghana signed the United Nations Convention Relating to the Status of Refugees, which is an international convention that defines who is a refugee, and sets out the rights of individuals who are granted asylum and the responsibilities of nations that grant asylum (<http://www2.ohchr.org/english/law/refugees.htm>, 2008). The convention also sets out which people do not qualify as refugees, such as war criminals. The Convention also provides for some visa-free travel for holders of travel documents issued under the convention.

2.2.2.5 Convention on the Political Rights of Women

The Convention on the political rights for women was also signed by the Ghanaian Government (www.umn.edu/humanrts/instree/e2cprw.htm, 2008). This convention recognises that:

- Everyone has the right to take part in the government of his or her country, both directly and indirectly, through freely chosen representatives; and
- Everyone has the right to equal access to public service in his or her country.

Thus, the convention seeks to equalize the status of men and women in the enjoyment and exercise of political rights, in accordance with the provisions of the Charter of the United Nations and of the Universal Declaration of Human Rights.

2.2.2.6 International Convention on the Elimination of All Forms of Racial Discrimination

The International Convention on the Elimination of All Forms of Racial Discrimination (ICERD) is a United Nations convention entered into force on 4 January 1969. The Convention commits its members to the elimination of racial discrimination and the promotion of understanding among all races (<http://www2.ohchr.org/english/law/cerd.htm>, 2007). It is monitored by the Committee on the Elimination of Racial Discrimination (CERD).

The Convention consists of 25 articles, divided into three parts:

- Part 1 (Articles 1 to 7) commits parties to the elimination of all forms of racial discrimination and to promoting understanding among all races. Parties are obliged to not discriminate on the basis of race, not to sponsor or defend racism, and to prohibit racial discrimination within their jurisdictions. They must also review their laws and policies to ensure that they do not discriminate on the basis of race, and commit to amending or repealing those who do;
- Part 2 (Articles 8 to 16) governs reporting and monitoring of the Convention and the steps taken by the parties to implement it. It establishes the Committee on the Elimination of Racial Discrimination, and empowers it to make general recommendations to the UN General Assembly. It also establishes a dispute-resolution mechanism between parties, and allows parties to recognise the competence of the Committee to hear complaints from individuals about violations of the rights protected by the Convention; and

- Part 3 (Articles 17 to 25) governs ratification, entry into force, and amendment of the Convention.

2.2.2.7 African Charter on Human and Peoples' Rights

The African Charter on Human and Peoples' Rights (also known as the Banjul Charter) is an international human rights instrument that purports to promote and protect human rights and basic freedoms in the African continent (www.umn.edu/humanrts/instree/z1afchar.htm, 2008). The Charter recognises what most regard as universally accepted civil and political rights, including the right to:

- Equality, dignity, life, and personal integrity;
- Due process concerning arrest and detention;
- A fair trial;
- Freedom from discrimination; slavery; and cruel, inhuman, or degrading treatment or punishment;
- Freedom of religion, information, expression, movement, and association; and
- Freedom of assembly, political participation, and property.

2.2.3 Cultural Heritage

2.2.3.1 Convention Concerning the Protection of the World Cultural and Natural Heritage

The Convention concerning the Protection of the World Cultural and Natural Heritage came into being on 16 November 1972. This convention obliges countries to recognise that the sites located in their national territory, and those that have been inscribed on the World Heritage List, without prejudice to national sovereignty or ownership, constitute a world heritage to be protected by the international community. The Convention is thus an agreement, signed by 164 countries, to contribute the necessary financial and intellectual resources to protect World Heritage sites.

The following World Heritage sites are found in Ghana:

- Asante Traditional Buildings; and
- Forts and Castles – Volta, Greater Accra, and Central and Western Regions.

2.2.4 International Labour Organisation Conventions Ratified by Ghana

Ghana joined the International Labour Organisation (ILO) in 1957 and immediately the Convention Peoples Party (CPP) Government ratified many of the ILO Conventions, including the "core" Conventions that guarantee workers the right and freedom to form or join unions (Convention 87), the right to collective bargaining (Convention 98), abolition of forced labour (Conventions 29 and 105), and equal treatment (Conventions 100 and 111) (<http://www.ilo.org/ilolex/english/docs/declworld.htm>, 2006). Many other ILO Conventions that sought to promote industrial harmony and welfare of workers were also ratified. These included Conventions on hours of work in industry, weekly rest, minimum wage fixing, labour inspection, underground work by women, employment service, night work by women, social policy, working environment, child labour, labour administration, and many others. To date, Ghana has ratified 46 ILO Conventions.

2.2.4.1 ILO Convention 87 on Freedom of Association and Protection of the Right to Organize Convention

The central tenant of the ILO Convention 87, adopted on 9 July 1948, states that “workers and employers, without distinction whatsoever, shall have the right to establish and, subject only to the rules of the organisation concerned, to join organisations of their own choosing without previous authorisation” (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C087>, 2006).

2.2.4.2 ILO Convention 98 on the Right to Organize and Collective Bargaining

The central tenet of the ILO Convention 98, adopted on 1 July 1949, states that workers shall enjoy adequate protection against acts of anti-union discrimination in respect of their employment (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C098>, 2006). In addition, such protection will apply more particularly in respect of acts calculated to:

- Make the employment of a worker subject to the condition that he/she will not join a union or relinquish trade union membership; and
- Cause the dismissal of or otherwise prejudice a worker by reason of union membership, or because of participation in union activities outside working hours or, with the consent of the employer, within working hours.

2.2.4.3 Convention 29 on Forced Labour Convention, 1930

Convention 29, concerning Forced or Compulsory Labour, came into force on 1 May 1932. Primarily, it states that each member who ratifies this Convention undertakes to suppress the use of forced or compulsory labour in all its forms within the shortest possible period (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C029>, 2006). Forced or compulsory labour, according to the Convention, excludes, among others, work or service:

- Exacted in virtue of compulsory military service laws for work of a purely military character;
- Which forms part of the normal civic obligations of the citizens of a fully self-governing country;
- Exacted from any person as a consequence of a conviction in a court of law;
- Exacted in cases of emergency, including any circumstance that would endanger the existence or the well-being of the whole or part of the population; and
- Considered as normal civic obligations incumbent upon the members of the community.

2.2.4.4 Convention 105 Concerning the Abolition of Forced Labour

Convention 105, concerning the abolition of Forced Labour, came into force on 25 June 1957. Fundamentally, countries who have ratified this convention undertake to suppress and eradicate any form of forced labour (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C105>, 2006). Convention 105 prohibits:

- (Means of) political coercion, education or punishment for holding or expressing political views or views ideologically opposed to the established political, social, or economic system;

- (Method of) mobilising and using labour for purposes of economic development;
- (Means of) labour discipline;
- Punishment for having participated in strikes; and
- (Means of) racial, social, national, or religious discrimination.

2.2.4.5 Convention 100 on Equal Remuneration

Convention 100, concerning equal remuneration, came into force on 29 June 1951. Essentially this convention prescribes equal remuneration for male and female workers for work of equal value (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C100>, 2006). This can be applied by means of:

- National laws or regulations;
- Legally established or recognized machinery for wage determination;
- Collective agreements between employers and workers; or
- A combination of these various means.

2.2.4.6 Convention 111 on Discrimination (Employment and Occupation)

This convention concerning discrimination in relation to employment and occupation, was adopted on 25 June 1958. Countries who have ratified this convention undertake to declare and pursue a national policy designed to promote, by methods appropriate to national conditions and practice, equality of opportunity and treatment in respect of employment and occupation, with a view to eliminating any discrimination in respect thereof (<http://www.ilo.org/ilolex/cgi-lex/convde.pl?C111>, 2006).

2.2.5 The Equator Principles

A number of international financing institutions have adopted the Equator Principles – a set of principles that is intended to ensure that the projects financed by these institutions are developed in a manner that is socially responsible and reflect sound environmental management practices. These Principles are intended to serve as a common baseline and framework for the implementation by each Equator Principles Financial Institution (EPFI) of its own internal social and environmental policies, procedures and standards related to its project financing activities. EPFIs have undertaken not to provide loans to projects where the borrower will not or is unable to comply with the institutions' respective social and environmental policies and procedures that implement the Equator Principles.

The Principles apply to all new project financings globally with total project capital costs of US\$ 10 million or more, and across all industry sectors. In addition, while the Principles are not intended to be applied retroactively, they are applied to all project financings covering expansion or upgrade of an existing facility where changes in scale or scope may create significant environmental and/or social impacts, or significantly change the nature or degree of an existing impact.

The Principles also extend to project finance advisory activities. In these cases, EPFIs have committed to make the client aware of the content, application and benefits of applying the Principles to the anticipated project, and request that the client communicate to the EPFI its intention to adhere to the requirements of the Principles when subsequently seeking financing.

The ten Equator Principles are summarised below, and their implications from an environmental and socioeconomic perspective are discussed.

2.2.5.1 Principle 1: Review and Categorisation

When a project is proposed for financing, the EPFI will, as part of its internal social and environmental review and due diligence, categorise such project based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC).

2.2.5.2 Principle 2: Social and Environmental Assessment

For each project assessed as being either Category A or Category B (i.e., with significant or limited social or environmental impacts), the borrower must conduct a Social and Environmental Assessment (“Assessment”) process to address the relevant social and environmental impacts and risks of the proposed project. The Assessment should also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.

2.2.5.3 Principle 3: Applicable Social and Environmental Standards

For projects located in non-Organisation for Economic Co-operation and Development (OECD) countries, and those located in OECD countries not designated as High-Income, as defined by the World Bank Development Indicators Database, the Assessment will refer to the then applicable IFC Performance Standards and the then applicable Industry Specific EHS Guidelines (“EHS Guidelines”). The Assessment will establish to a participating EPFI’s satisfaction the project’s overall compliance with, or justified deviation from, the respective Performance Standards and EHS Guidelines.

The Assessment process should address compliance with relevant host country laws, regulations and permits that pertain to social and environmental matters.

2.2.5.4 Principle 4: Action Plan and Management System

For all Category A and Category B projects located in non-OECD countries, and those located in OECD countries not designated as High-Income, the borrower must prepare an Action Plan (AP) that addresses the relevant findings, and draws on the conclusions of the Assessment. The AP will describe and prioritise the actions needed to implement mitigation measures, corrective actions and monitoring measures necessary to manage the impacts and risks identified in the Assessment.

Aspects of an AP that are relevant from a socioeconomic point of view may include a resettlement action plan, and an indigenous peoples plan. The level of detail and complexity of the AP and the priority of the identified measures and actions will be commensurate with the project’s potential impacts and risks.

Borrowers will build on, maintain or establish a Social and Environmental Management System that addresses the management of these impacts, risks, and corrective actions required to comply with applicable host country social and environmental laws and regulations, and requirements of the applicable Performance Standards and EHS Guidelines, as defined in the AP.

2.2.5.5 Principle 5: Consultation and Disclosure

For all Category A and, as appropriate, Category B projects, the government, borrower, or third party expert must consult with project-affected communities in a structured and culturally appropriate manner. For projects with significant adverse impacts on affected communities, the process must ensure their free, prior, and informed consultation and facilitate their informed participation as a means to establish, to the satisfaction of the EPFI, whether a project has adequately incorporated affected communities' concerns.

In order to accomplish this, the Assessment documentation and AP, or nontechnical summaries thereof, will be made available to the public by the borrower for a reasonable minimum period in the relevant local language and in a culturally appropriate manner. The borrower will take account of and document the process and results of the consultation, including any actions agreed resulting from the consultation. For projects with adverse social or environmental impacts, disclosure should occur early in the Assessment process and in any event before the project construction commences, and on an ongoing basis.

2.2.5.6 Principle 6: Grievance Mechanism

For all Category A and, as appropriate, Category B projects, the borrower will, scaled to the risks and adverse impacts of the project, establish a grievance mechanism as part of the management system. The grievance mechanism is intended to ensure that consultation, disclosure and community engagement continues throughout construction and operation of the project. This will allow the borrower to receive and facilitate resolution of concerns and grievances about the project's social and environmental performance raised by individuals or groups from among project-affected communities. The borrower will inform the affected communities about the mechanism in the course of its community engagement process and ensure that the mechanism addresses concerns promptly and transparently, in a culturally appropriate manner, and is readily accessible to all segments of the affected communities.

2.2.5.7 Principle 7: Independent Review

For all Category A projects and, as appropriate, for Category B projects, an independent social or environmental expert not directly associated with the borrower will review the Assessment, APs and consultation process documentation in order to assist EPFI's due diligence, and assess Equator Principles compliance.

2.2.5.8 Principle 8: Covenants

An important strength of the Principles is the incorporation of covenants linked to compliance. For Category A and B projects, the borrower will covenant in financing documentation:

- To comply with all relevant host country social and environmental laws, regulations and permits in all material respects;
- To comply with the AP (where applicable) during the construction and operation of the project in all material respects;
- To provide periodic reports in a format agreed with EPFIs (with the frequency of these reports proportionate to the severity of impacts, or as required by law, but not less than annually), prepared by in-house staff or third party experts, that (1) document compliance with the AP (where applicable), and (2) provide representation of compliance with relevant local, state, and host country social and environmental laws, regulations and permits; and
- To decommission the facilities, where applicable and appropriate, in accordance with an agreed decommissioning plan.

2.2.4.9 Principle 9: Independent Monitoring and Reporting

To ensure ongoing monitoring and reporting over the life of the loan, EPFIs will, for all Category A projects, and as appropriate, for Category B projects, require appointment of an independent environmental and/or social expert, or require that the borrower retain qualified and experienced external experts to verify its monitoring information which would be shared with EPFIs.

2.2.4.10 Principle 10: EPFI Reporting

Each EPFI adopting the Equator Principles commits to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.

2.3 World Bank Policies and Guidelines

The World Bank is a specialized agency of the United Nations that provides financial and technical assistance to developing countries around the world. It is made up of two unique development institutions owned by 185 member countries – the International Bank for Reconstruction and Development and the International Development Association. Together these organisations provide low-interest loans, interest-free credit, and grants to developing countries.

The World Bank has issued widely used international guidelines for environmental management of industrial projects. The Pollution Prevention and Abatement Handbook (World Bank, 1998) includes sectoral guidelines for various industries, but does not include offshore oil and gas operations. However, the IFC, a member of the World Bank Group, has issued Performance Standards for offshore oil and gas development (IFC, 2007a). IFC applies the Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing in its member countries eligible for financing. The eight Performance Standards are listed below:

- Performance Standard 1: Social and Environmental Assessment and Management System;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Pollution Prevention and Abatement;

- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

Together, the eight Performance Standards establish standards that the client is to meet throughout the life of an investment by IFC or other relevant financial institution. Aspects of the Performance Standards are briefly discussed below.

2.3.1 Performance Standard 1: Social and Environmental Assessment and Management System

Performance Standard 1 underscores the importance of managing social and environmental performance throughout the life of a project (any business activity that is subject to assessment and management). An effective social and environmental management system is a dynamic, continuous process initiated by management involving communication between the client, its workers, and the local communities directly affected by the project (the affected communities). Drawing on the elements of the established business management process of “plan, implement, check, and act,” the system entails the thorough assessment of potential social and environmental impacts and risks from the early stages of project development, and provides order and consistency for mitigating and managing these on an ongoing basis. A good management system appropriate to the size and nature of a project promotes sound and sustainable social and environmental performance, and can lead to improved financial, social and environmental project outcomes. Its objectives are to:

- Identify and assess social and environment impacts, both adverse and beneficial, in the project’s area of influence;
- Avoid, or where avoidance is not possible, minimise, mitigate, or compensate for adverse impacts on workers, affected communities and the environment;
- Ensure that affected communities are appropriately engaged on issues that could potentially affect them; and
- Promote improved social and environment performance of companies through the effective use of management systems.

2.3.2 Performance Standard 2: Labour and Working Conditions

Performance Standard 2 recognises that the pursuit of economic growth through employment creation and income generation should be balanced with protection for basic rights of workers. The objectives of this Performance Standard are to:

- Establish, maintain and improve the worker-management relationship;
- Promote the fair treatment, nondiscrimination and equal opportunity of workers, and compliance with national labour and employment laws;
- Protect the workforce by addressing child labour and forced labour; and
- Promote safe and healthy working conditions, and protect and promote the health of workers.

To this end, the client is required to comply with the following:

- The client must adopt a human resources policy appropriate to its size and workforce that sets out its approach to managing employees consistent with the requirements of this Performance Standard. Under the policy, the client will provide employees with information regarding their rights under national labour and employment law. This policy will be clear and understandable to employees and will be explained or made accessible to each employee upon taking employment;
- All workers will have their working conditions and terms of employment, including their entitlement to wages and any benefits, communicated to them;
- The client will provide reasonable working conditions and terms of employment that, at a minimum, comply with national law;
- In countries where national law recognises workers' rights to form and to join workers' organisations of their choosing without interference and to bargain collectively, the client will comply with national law. Where national law substantially restricts workers' organisations, the client will enable alternative means for workers to express their grievances and protect their rights regarding working conditions and terms of employment;
- The client will not make employment decisions on the basis of personal characteristics unrelated to inherent job requirements;
- The client will develop a plan to mitigate the adverse impacts of retrenchment on employees, if it anticipates the elimination of a significant number of jobs or a layoff of a significant number of employees. The plan will be based on the principle of non-discrimination and will reflect the client's consultation with employees, their organisations and, where appropriate, the government;
- The client will provide a grievance mechanism for workers (and their organisations, where they exist) to raise reasonable workplace concerns;
- The client will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development;
- The client will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty;
- The client will provide the workers with a safe and healthy work environment, taking into account inherent risks in its particular sector and specific classes of hazards in the client's work areas, including physical, chemical, biological, and radiological hazards; and
- The adverse impacts associated with supply chains will be considered where low labour cost is a factor in the competitiveness of the item supplied.

2.3.3 Performance Standard 3: Pollution Prevention and Abatement

Performance Standard 3 recognises that increased industrial activity and urbanization may lead to increased pollution levels to air, water, and terrestrial resources, and that these increases may threaten people and the environment at the local, regional, and global level. The performance standard also recognizes the widespread availability and application of various pollution prevention and control technologies and practices. Performance Standard 3 promotes the private sector's ability to integrate pollution prevention and control technologies and practices, within technical and financial limits (i.e., where feasible and cost-effective). The basic tenets of Performance Standard 3 include the following:

- Avoid or minimise adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities; and
- Promote the reduction of emissions that contribute to climate change.

Table 2.3 shows the planned effluent limits for this project compared with the IFC (2007a) guidelines, as well as effluent limits used by the U.S. Environmental Protection Agency (2007) for oil and gas activities in the U.S. Gulf of Mexico. With minor exceptions, the planned effluent limits are consistent with both sets of guidelines.

Appendix C includes an analysis of feasible alternatives for drilling fluid and cuttings disposal as recommended by the IFC guidelines.

Tables 2.4 and **2.5** summarize the IFC (2007a) guidelines for air pollutant emissions and other aspects of offshore operations. The project expects to be consistent with these IFC guidelines.

2.3.4 Performance Standard 4: Community Health, Safety and Security

Performance Standard 4 recognises that project activities, equipment, and infrastructure can increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures, and releases of hazardous materials. The Performance Standard addresses the client's responsibility to avoid or minimise the risks and impacts to community health, safety and security that may arise from project activities.

Table 2.3. Effluent limits for this project compared with International Finance Corporation guidelines (IFC, 2007a) and U.S. Environmental Protection Agency permit requirements (USEPA, 2007) for the U.S. Gulf of Mexico.

Source	IFC (2007a)	USEPA (2007)	Jubilee Field, Phase 1
DRILLING FLUIDS AND CUTTINGS			
Free oil	Not specified	No free oil on discharged drilling fluids or cuttings	No free oil on discharged drilling fluids or cuttings
Toxicity	96-h LC-50 of suspended particulate phase not to exceed 30,000 ppm	96-h LC-50 of suspended particulate phase not to exceed 30,000 ppm	No toxicity testing; however, a low-toxicity enhanced mineral oil-based fluid to be used
Discharge rate	Not specified	1,000 bbl/h maximum	1,000 bbl/h maximum
Cadmium in stock barite	Not to exceed 3 mg/kg	Not to exceed 3 mg/kg	Not to exceed 3 mg/kg
Mercury in stock barite	Not to exceed 1 mg/kg	Not to exceed 1 mg/kg	Not to exceed 1 mg/kg
Discharge location	Discharge via a caisson at least 15 m below sea surface	Not specified	Not specified
Diesel fuel	No discharge of diesel-contaminated fluids or cuttings	No discharge of diesel-contaminated fluids or cuttings	No discharge of diesel-contaminated fluids or cuttings
Oil-based drilling fluids	No discharge of oil-based fluids. Cuttings may be discharged if residual oil concentration on dry cuttings is less than 1% by weight	No discharge of oil-based fluids or associated cuttings. This includes mineral oil, which may be used only as a carrier fluid, lubricity additive, or pill	Enhanced mineral oil-based fluid to be used. No discharge of drilling fluid; residual oil on cuttings expected to be 6% to 8%
Synthetic based drilling fluids	No discharge of fluids. Cuttings may be discharged if residual SBF concentration on dry cuttings is less than 1% by weight	No discharge of fluids. Cuttings may be discharged if residual synthetic-based fluids concentration on dry cuttings is less than 6.9% for internal olefins or 9.4% for esters	Not planned to be used. If used, no discharge of drilling fluid; residual synthetic-based fluids on cuttings expected to be 6% to 8%
OTHER EFFLUENTS			
Completion and workover fluids	Oil and grease not to exceed 42 mg/L daily maximum or 29 mg/L monthly average	No free oil; oil and grease not to exceed 42 mg/L daily max or 29 mg/L monthly average; no priority pollutants except in trace amounts	No free oil; oil and grease not to exceed 42 mg/L daily maximum or 29 mg/L monthly average; no priority pollutants except in trace amounts
Produced water	Oil and grease not to exceed 42 mg/L daily max or 29 mg/L monthly average	Oil and grease not to exceed 42 mg/L daily maximum or 29 mg/L monthly average; also subject to toxicity limits	Oil and grease not to exceed 42 mg/L daily maximum or 29 mg/L monthly average. Goal is 20 mg/L monthly average
Produced sand	No discharge unless residual oil less than 1% by weight on dry sand	No discharge	No discharge

Table 2.3. (Continued).

Source	IFC (2007a)	USEPA (2007)	Jubilee Field, Phase 1
Sewage	Treated in marine sanitation unit in compliance with MARPOL requirements	Treat with approved marine sanitation unit (achieves no floating solids and minimum residual chlorine of 1 mg/L)	Treat with approved marine sanitation unit (achieves no floating solids and minimum residual chlorine of 1 mg/L)
Food waste	Macerate to acceptable levels and discharged in compliance with MARPOL requirements	No floating solids or foam	Macerate to acceptable levels and discharge in compliance with MARPOL requirements (includes no floating solids or foam)
Bilge waters	Contaminated drainage waters should be treated before discharge to meet MARPOL requirements	No free oil	No free oil
Deck drainage	Contaminated drainage waters should be treated before discharge to meet MARPOL requirement.	No free oil	No free oil
Desalination brine	Mix with other discharge streams if feasible	No free oil	No free oil

MARPOL 1973/1978 = International Convention for the Prevention of Pollution Ships.

Table 2.4. Key provisions of the International Finance Corporation guidelines (IFC, 2007a) for air emissions.

Source	Guideline
General	All reasonable attempts should be made to maximise energy efficiency and design facilities for lowest energy use. The overall objective should be to reduce air emissions and evaluate cost effective options for reducing emissions that are technically feasible.
Exhaust gases	Guidance for the management of small combustion sources with a capacity of up to 50 megawatt hours thermal, including standards for exhaust emissions, is provided in the IFC's General EHS Guidelines (IFC, 2007b). For engines using liquid fuels: • Particulate matter: 50 mg/m³ (up to 100 if justified by project-specific conditions) • Sulfur dioxide: 1.5% (up to 3% if justified by project-specific conditions) • Nitrogen oxides: 1,460 mg/Nm³ if bore size diameter <400 mm (up to 1,600 mg/Nm³ if justified to maintain high energy efficiency) 1,850 mg/Nm³ if bore size diameter ≥400 mm • Dry gas, excess oxygen content: 15%
Greenhouse gases	Significant (>100,000 tons CO ₂ equivalent per year) greenhouse gas (GHG) emissions from all facilities and offshore support activities should be quantified annually as aggregate emissions in accordance with internationally recognized methodologies and reporting procedures.
Venting and flaring	Measures consistent with the Global Gas Flaring and Venting Reduction Voluntary Standard (part of the World Bank Group's Global Gas Flaring Reduction Public-Private Partnership should be adopted when considering venting and flaring options for offshore activities). The standard provides guidance on how to eliminate or achieve reductions in the flaring and venting of natural gas. Continuous venting of associated gas is not considered current good practice and should be avoided.
Well testing	During well testing, flaring of produced hydrocarbons should be avoided, especially in environmentally sensitive areas. Feasible alternatives should be evaluated for the recovery of these test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of alternatives for produced hydrocarbons should be adequately documented and recorded.
Fugitive emissions	Methods for controlling and reducing fugitive emissions should be considered and implemented in the design, operation, and maintenance of offshore facilities. The selection of appropriate valves, flanges, fittings, seals, and packings should consider safety and suitability requirements as well as their capacity to reduce gas leaks and fugitive emissions.

Table 2.5. Other relevant environmental provisions of the International Finance Corporation guidelines (IFC, 2007a).

Source	Guideline
Spills	• Develop a Spill Response Plan that addresses potential oil, chemical, and fuel spills from offshore facilities and support vessels including tankers. • Conduct a spill risk assessment for offshore facilities and support vessels; • Design process, utility, and drilling systems to reduce the risk of major uncontained spills; • Install valves, including subsea shutdown valves, to allow early shutdown or isolation in the event of an emergency; • Ensure adequate corrosion allowance for the lifetime of the facilities and/or installation of corrosion control and prevention systems in all flowlines, process equipment, and tanks; • Develop maintenance and monitoring programs to ensure the integrity of well field equipment; • For facilities with potentially significant releases, install an Emergency Shutdown System that initiates automatic shutdown actions to bring the offshore facility to a safe condition; • Provide adequate personnel training in oil spill prevention, containment and response; and • Ensure spill response and containment equipment is deployed or available as necessary for response.
Waste Management	• Segregate offshore wastes into nonhazardous and hazardous wastes at a minimum, and ship to shore for re-use, recycling, or disposal; • Develop a waste management plan that contains a clear waste tracking mechanism to track waste consignments from the originating location offshore to the final waste treatment and disposal location onshore; and • Endeavor to eliminate, reduce, or recycle wastes at all times.
Hazardous Materials	General guidance for the management of hazardous materials is provided in the General EHS Guidelines (IFC, 2007b). The following additional principles should be followed for offshore chemicals: • Use chemical hazard assessment and risk management techniques to evaluate chemicals and their effects; • Select offshore drilling and production chemicals based on the OSPAR Harmonized Offshore Chemical Notification Format (HOCNF) or similar internationally recognized system; • Select chemicals with least hazard and lowest potential environmental impact, and lowest potential health impact, whenever possible; • Avoid using chemicals suspected to cause taint or known endocrine disruptors; • Avoid using Ozone Depleting Substances; and • Avoid using chemicals known to contain heavy metals, other than in trace quantities.
Decommissioning	• Follow guidelines and standards issued by the International Maritime Organization (IMO) and OSPAR for the decommissioning of offshore facilities; and • Develop a preliminary decommissioning plan that considers well abandonment, removal of oil from flowlines, facility removal, and subsea pipeline decommissioning along with disposal options for all equipment and materials. This plan can be further developed during field operations and fully defined in advance of the end of field life.

In order to address such risks, the client is required to comply with the following:

- The client will evaluate the risks and impacts to the health and safety of the affected community during the design, construction, operation, and decommissioning of the project and will establish preventive measures to address them in a manner commensurate with the identified risks and impacts;
- The client will design, construct, and operate and decommission the structural elements or components of the project in accordance with good international industry practice;
- The client will prevent or minimise the potential for community exposure to hazardous materials that may be released by the project;
- The client will prevent or minimise the potential for community exposure to water-borne, water-based, water-related, vector-borne disease, and other communicable diseases that could result from project activities;
- The client will assist and collaborate with the community and the local government agencies in their preparations to respond effectively to emergency situations, especially when their participation and collaboration are necessary to respond to such emergency situations; and
- When the client directly retains employees or contractors to provide security to safeguard its personnel and property, it will assess risks to those within and outside the project site posed by its security arrangements. The client will not sanction any use of force except when used for preventive and defensive purposes in proportion to the nature and extent of the threat.

2.3.5 Performance Standard 5: Land Acquisition and Involuntary Resettlement

Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or means of livelihood) as a result of project-related land acquisition. Resettlement is considered involuntary when affected individuals or communities do not have the right to refuse land acquisition that results in displacement. The objectives of this Performance Standard are:

- To avoid or at least minimise involuntary resettlement wherever feasible by exploring alternative project designs;
- To mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by: (1) providing compensation for loss of assets at replacement cost; and (2) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected;
- To improve or at least restore the livelihoods and standards of living of displaced persons; and
- To improve living conditions among displaced persons through provision of adequate housing with security of tenure⁴ at resettlement sites.

To this end, the client is required to comply with the following:

- The client will consider feasible alternative project designs to avoid or at least minimise physical or economic displacement, while balancing environmental, social, and financial costs and benefits;
- When displacement cannot be avoided, the client will offer displaced persons and communities compensation for loss of assets at full replacement cost and other assistance to help them improve or at least restore their standards of living or livelihoods;
- Following disclosure of all relevant information, the client will consult with and facilitate the informed participation of affected persons and communities, including host communities, in decision-making processes related to resettlement;
- The client will establish a grievance mechanism consistent with Performance Standard 1 to receive and address specific concerns about compensation and relocation;
- Where involuntary resettlement is unavoidable, the client will carry out a census with appropriate socioeconomic baseline data to identify the persons who will be displaced by the project, to determine who will be eligible for compensation and assistance, and to discourage inflow of people who are ineligible for these benefits;
- If people living in the project area must move to another location, the client will:
(1) offer displaced persons choices among feasible resettlement options, including adequate replacement housing or cash compensation where appropriate; and
(2) provide relocation assistance suited to the needs of each group of displaced persons, with particular attention paid to the needs of the poor and the vulnerable;
- If land acquisition for the project causes loss of income or livelihood, regardless of whether or not the affected people are physically displaced, the client will promptly compensate economically displaced persons for loss of assets, access to assets or income at full replacement cost; and
- Where land acquisition and resettlement are the responsibility of the host government, the client will collaborate with the responsible government agency, to the extent permitted by the agency, to achieve outcomes that are consistent with the objectives of this Performance Standard.

2.3.6 Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management

Performance Standard 6 recognizes the importance of protecting and conserving biodiversity, including genetic, species, and ecosystem diversity. The performance standard also recognizes the ability of natural systems to change and evolve, and that this capability is fundamental to sustainable development. The components of biodiversity, as defined in the Convention on Biological Diversity, include ecosystems and habitats, species and communities, and genes and genomes, all of which have social, economic, cultural, and scientific importance. This Performance Standard reflects the objectives of the Convention on Biological Diversity to conserve biological diversity and promote use of renewable natural resources in a sustainable manner. This Performance Standard addresses how clients can avoid or mitigate threats to

biodiversity arising from their operations as well as sustainably manage renewable natural resources.

The objectives of this Performance Standard are:

- To protect and conserve biodiversity; and
- To promote the sustainable management and use of natural resources through the adoption of practices that integrate conservation needs and development priorities.

2.3.7 Performance Standard 7: Indigenous Peoples

Performance Standard 7 recognises that Indigenous Peoples, as social groups with identities that are distinct from dominant groups in national societies, are often among the most marginalized and vulnerable segments of the population. These characteristics expose Indigenous Peoples to different types of risks and severity of impacts, including loss of identity, culture, and natural resource-based livelihoods, as well as exposure to impoverishment and disease.

In order to address such potential impacts, the client is required to comply with the following:

- The client will identify all communities of Indigenous Peoples who may be affected by the project within the project's area of influence, as well as the nature and degree of the expected impacts on them, and avoid adverse impacts whenever feasible;
- When avoidance is not feasible, the client will minimise, mitigate or compensate for these impacts in a culturally appropriate manner;
- The client will establish an ongoing relationship with the affected communities of Indigenous Peoples from as early as possible in the project planning and throughout the life of the project;
- The client will seek to identify opportunities for culturally appropriate development benefits. Such opportunities should be commensurate with the degree of project impacts, with the aim of improving their standard of living and livelihoods in a culturally appropriate manner, and to fostering the long-term sustainability of the natural resource on which they depend;
- Indigenous Peoples are often closely tied to their traditional or customary lands and natural resources on these lands, even though these lands may not be under their legal ownership. If the client proposes to locate the project on, or commercially develop natural resources located within, traditional or customary lands under use, the client is required to undertake the following:
 - o The client will document its efforts to avoid or at least minimise the size of land proposed for the project;
 - o The Indigenous Peoples' land use will be documented by experts in collaboration with the affected communities of Indigenous Peoples without prejudicing any Indigenous Peoples' land claim;
 - o The affected communities of Indigenous People will be informed of their rights with respect to these lands under national laws, including any national law recognising customary rights or use;

- o The client will offer affected communities of Indigenous Peoples at least compensation and due process available to those with full legal title to land in the case of commercial development of their land under national laws, together with culturally appropriate development opportunities; land-based compensation or compensation-in-kind will be offered in lieu of cash compensation where feasible; and
 - o The client will enter into good faith negotiation with the affected communities of Indigenous Peoples, and document their informed participation and the successful outcome of the negotiation.
- The client will consider feasible alternative project designs to avoid the relocation of Indigenous Peoples; and
- Where a project proposes to use the cultural resources, knowledge, innovations, or practices of Indigenous Peoples for commercial purposes, the client will not proceed with such commercialisation unless it: (1) enters into a good faith negotiation with the affected communities of Indigenous People; (2) documents their informed participation and the successful outcome of the negotiation; and (3) provides for fair and equitable sharing of benefits from commercialization of such knowledge, innovation, or practice, consistent with their customs and traditions.

2.3.8 Performance Standard 8: Cultural Heritage

Performance Standard 8 recognises the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to protect irreplaceable cultural heritage and to guide clients on protecting cultural heritage in the course of their business operations. To this end, the client is required to comply with the following:

- In addition to complying with relevant national law on the protection of cultural heritage, including national law implementing the host country's obligations under the Convention Concerning the Protection of the World Cultural and Natural Heritage and other relevant international law, the client will protect and support cultural heritage by undertaking internationally recognized practices for the protection, field-based study, and documentation of cultural heritage;
- The client is responsible for siting and designing a project to avoid significant damage to cultural heritage;
- Where a project may affect cultural heritage, the client will consult with affected communities within the host country who use, or have used within living memory, the cultural heritage for longstanding cultural purposes to identify cultural heritage of importance, and to incorporate into the client's decision-making process the views of the affected communities on such cultural heritage;
- The client will not remove any cultural heritage, unless there are no technically or financially feasible alternatives to removal, the overall benefits of the project outweigh the anticipated cultural heritage loss from removal, and any removal of cultural heritage is conducted by the best available technique; and
- Critical cultural heritage consists of (i) the internationally recognized heritage of communities who use, or have used within living memory the cultural heritage for

long-standing cultural purposes; and (ii) legally protected cultural heritage areas, including those proposed by host governments for such designation. The client will not significantly alter, damage, or remove any critical cultural heritage. The client will also comply with defined national or local cultural heritage regulations or the protected area management plans.

2.4 Jubilee Joint Venture Policies

2.4.1 Environment, Health and Safety (EHS) Policies

The Jubilee Joint Venture has adopted the following EHS policy. The expectations and philosophy of this policy will govern all aspects of the Jubilee Development. Meeting this commitment is a responsibility shared by all employees, business partners, and contractors.

2.4.1.1 Mission

The Jubilee Development will ensure EHS is a high priority during design, construction, and operation. We will conduct our business with respect and care for our employees, contractors, communities, and the environments in which we operate. We will accomplish this by creating enduring value, practicing stewardship through corporate social responsibility, and operating in an environmentally sustainable manner.

2.4.1.2 EHS Management System

The execution of the Jubilee Development will be governed by the following expectations and operating philosophy of the EHS Management System. Appropriate procedures, plans and programs will be implemented during the course of the project to ensure that these management expectations are met. The 12 key elements and expectations are:

- 1. Policy and Leadership** – The leadership will establish policy, provide perspective, set expectations and provide the resources for responsible EHS management of the Jubilee Development.
- 2. Risk Management** – Appropriate risk management techniques will be used at all project phases to protect employees, contractors, communities and the environment, and to preserve assets, investor value and the reputation of the Jubilee Operators.
- 3. Facilities Design and Construction** – Sound standards, procedures, and management systems will be utilised for facility design, construction, commissioning and startup activities to ensure safety and minimise risk to health and the environment.
- 4. Information and Documentation** – Information on the design, configuration and capabilities of processes and facilities and infrastructure, potential environment, health, and safety hazards and all legal and regulatory requirements will be documented and maintained, and made readily accessible for review to acceptably manage the risks associated with the development.

5. **Personnel and Competence** – The success of development operations depends on competent people. Effective selection, placement, ongoing assessment and competence of employees and contractors executing the development will be ensured.
6. **Operations and Maintenance** – The development will deliver facilities that have effective operating and maintenance procedures and practices in place with reliable safety and control facilities, and competent personnel who consistently execute these procedures and practices.
7. **Health and Safety** – The development activities will be conducted in accordance with health and safety standards and practices that are adopted in the international E&P industry. Key Performance Indicators (KPIs) will be established to monitor performance and where possible to benchmark against the rest of the industry.
8. **Environmental Protection** – The development will operate in accordance with sound environmental practices and will respect the customary rights, cultural heritage, social values, and resource utilization patterns of the countries where development activities occur.
9. **Incident Reporting and Investigation** – An incident reporting system will be established to ensure management is notified and that incidents are properly investigated with the goal of preventing recurrence.
10. **Emergency Response** – The development will prepare Emergency Response plans that reflect the reasonably foreseeable scenarios associated with development activities.
11. **Community Relations and Outreach** – Open and honest communications will be established with the communities affected by the development to build trust and confidence in the integrity of our parent companies and their operations. A strong Corporate Social Responsibility (CSR) program will be developed and implemented.
12. **Continuous Improvement** – The development will establish a process to measure the performance relative to the expectations established in this management system and to ensure that any lessons are learned and communicated to sustain or improve performance as appropriate.

2.4.2 Community Development and Corporate Social Responsibility Policies

The Jubilee Joint Venture's Corporate Social Responsibility (CSR) policy is to conduct all activities to best industry standards and to behave in a socially responsible manner.

2.4.2.1 Corporate Social Responsibility Values

The Joint Venture's goal is to behave ethically and with integrity in the communities where it works, and to respect cultural, national and religious diversity. Key CSR values include:

- Awareness of and respect for the Republic of Ghana;
- Contribution to and support of local communities;

- Balanced environmental and business risks;
- Empowerment and support of the individual;
- Valued and fostered long-term relationships; and
- Transparency in project activities and reporting.

2.4.2.2 Corporate Social Responsibility Strategy

The Jubilee Joint Venture, employees and contractors are responsible for ensuring compliance with this policy. The core elements of the CSR strategy are to:

- Respect the rights of all employees, treating them fairly and without discrimination;
- Commit to providing opportunities for staff development;
- Provide equal employment opportunities;
- Recognize individual and team contributions;
- Ensure compliance with all EHS policies by all personnel involved in our activities;
- Provide clear direction on key CSR initiatives, policies, performance data and targets;
- Actively engage in and support community development, namely in the areas of health and education, surrounding the Jubilee Development's area of operations;
- Support selected social and community development projects through directly managed projects, NGO partnerships, and/or local authorities;
- Maintain high ethical standards and support transparency in our activities;
- Encourage our partners and stakeholders to observe similar standards wherever possible; and
- Support local content if priced competitively and of quality and quantity comparable to industry standards.

To support the above policy, values, and strategy, the Jubilee Joint Venture will implement a strategic plan for Community and Social Responsibility projects and initiatives. The identified projects will aim to benefit both the community and the Jubilee Field, Phase 1 development. Each project identified will have reviewable objectives to ensure project success.

3.0 Project Description

3.1 Location

At its closest point to shore, the Jubilee Field lies approximately 60 km south of the Ghana coastline. Jubilee Field, Phase 1 facilities, including the proposed floating production, storage, and offloading (FPSO) mooring location and subsea wells, lie approximately 130 km west-southwest of Takoradi and 65 km southeast of the Ghana/Côte D'Ivoire boundary (**Figure 3.1**).

Water depths within the Jubilee Field (i.e., the Jubilee Unit Area) range from 1,000 to 1,700 m. Reservoir objectives in the Jubilee Field range in depth from 3,150 to 3,755 m true vertical depth subsea (TVDSS). Coordinates for Phase 1 facilities, including well centres and individual wells, are provided in **Table 3.1**. Well centres are the locations where the mobile offshore drilling units (MODUs) will be placed; templates below each MODU will serve as guides for drilling of individual wells. The FPSO and single point mooring anchor locations are provided in **Table 3.2**.

3.2 Schedule

3.2.1 Drilling and Development Activities

The schedule for both drilling and development-related project elements leading up to first oil production can be divided into several stages, including 1) well drilling and completion, to be completed by the MODUs within the Jubilee Field; 2) fabrication and conversion of subsea systems and the FPSO, respectively, to be completed at specialized facilities (i.e., subsea system fabrication at various fabrication facilities in the U.S. and Europe and FPSO conversion at a shipyard in China); 3) delivery and installation, to be completed within the Jubilee Field; and 4) FPSO commissioning and start-up. The projected schedule for these stages is depicted in **Figure 3.2** and includes:

Well Drilling and Completion:

- September 2008 to August 2011; further details are provided in **Section 3.2.2**.

Fabrication and Conversion:

- Subsea fabrication: September 2008 to April 2010; to occur off-site, with fabricated components to be shipped to Ghana for in-field installation; and
- FPSO conversion: September 2008 to November 2009; to be conducted by MODEC in China, with subsequent transport to Ghana.

Delivery and Installation:

- Tree delivery: March 2009 to October 2010;
- Subsea installation: September 2009 to September 2010; and
- FPSO installation: January to May 2010.

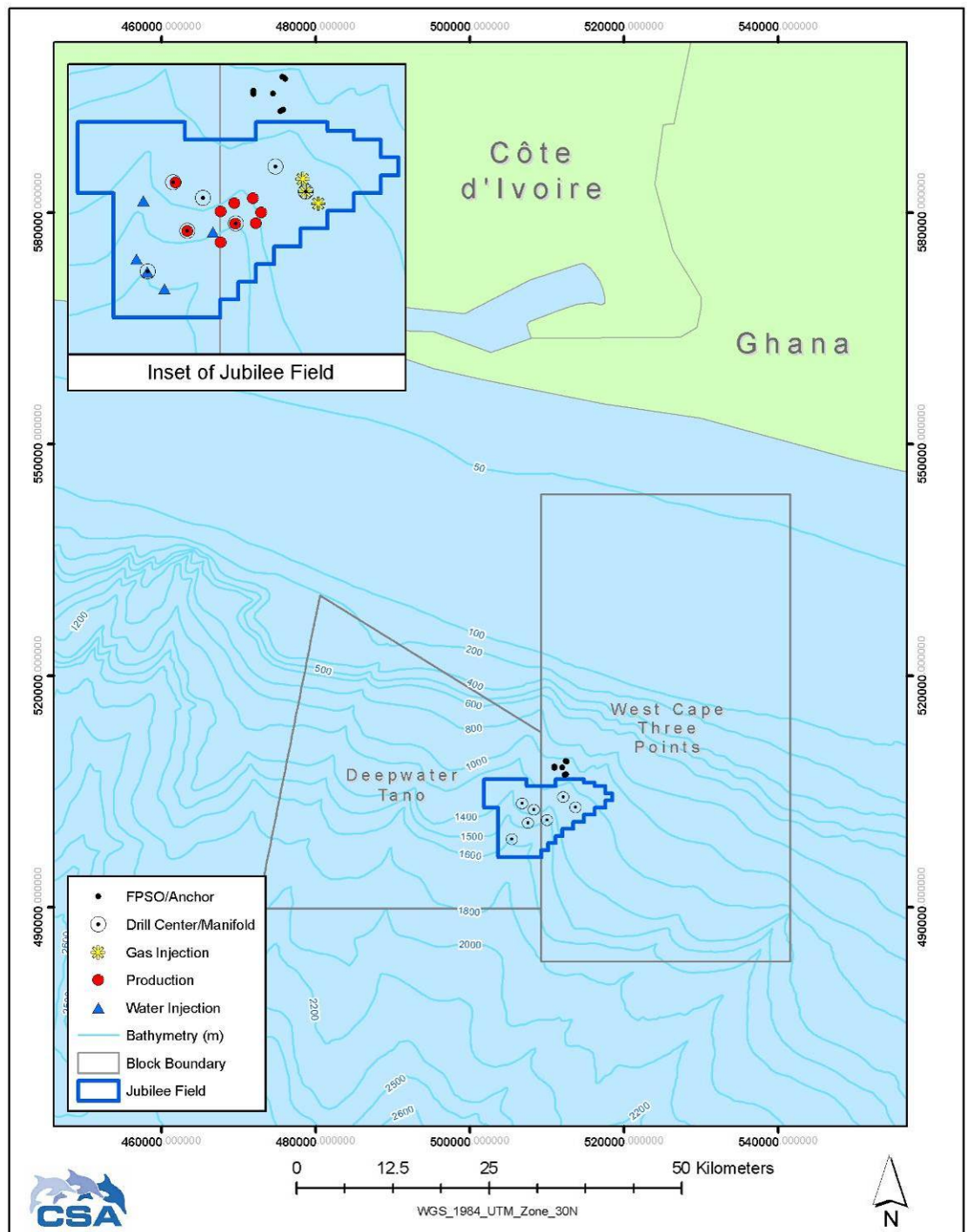


Figure 3.1. Overview of the Jubilee Field showing drill centres and floating production, storage, and offloading (FPSO) locations relative to block boundaries and the coast of Ghana.

Table 3.1. Geographic coordinates of drill centres/manifolds and associated wells, Jubilee Field, Phase 1. Water depths for each well are also noted.

Type	Drill Centre/ Manifold	Manifold Centre		Well Slot	Well Name	Water Depth (m)	Surface Location		UM3 Take Point			LM2 Take Point		
		(X) Easting	(Y) Northing				(X) Easting	(Y) Northing	TVDSS (m)	(X) Easting	(Y) Northing	TVDSS (m)	(X) Easting	(Y) Northing
Production	P1	506808	503474	A	Unused	---	---	---	---	---	---	---	---	---
				B	Unused	---	---	---	---	---	---	---	---	---
				C	J8 (Hyedua 2)	1,245	506808	503474	-3400	506911	503480	---	---	---
				D	Unused	---	---	---	---	---	---	---	---	---
	P2	508350	502665	A	Unused	---	---	---	---	---	---	---	---	---
				B	J7 (D109)	1,280	508350	502665	-3605	509967	502407	---	---	---
				C	J6 (D103)	1,280	508350	502665	---	---	---	-3630	509251	501981
				D	Unused	---	---	---	---	---	---	---	---	---
	P3	507539	500951	A	J2 (D104)	1,355	507539	500951	---	---	---	-3660	509261	500388
				B	Unused	---	---	---	---	---	---	---	---	---
				C	Unused	---	---	---	---	---	---	---	---	---
				D	J1 (D102)	1,355	507539	500951	---	---	---	-3690	507539	500951
	P4	512112	504279	A	Unused	---	---	---	---	---	---	---	---	---
				B	Unused	---	---	---	---	---	---	---	---	---
				C	Unused	---	---	---	---	---	---	---	---	---
				D	Unused	---	---	---	---	---	---	---	---	---
	P5	510045	501340	A	J3 (D107)	1,317	510014	501351	-3400	511359	501933	---	---	---
				B	J4 (D106)	1,317	510014	501351	---	---	---	-3590	511100	501371
				C	J9 (Mahogany 1)	1,322	510014	501351	---	---	---	-3562	510014	501351
				D	J5 (D108)	1,317	510014	501351	-3380	510930	502668	---	---	---
Water Injection	WI1	507539	500951	A	W5 (WIW006)	1,521	507539	500951	-3530	508889	500914	---	---	---
				B	Unused	---	---	---	---	---	---	---	---	---
				C	Unused	---	---	---	---	---	---	---	---	---
				D	W4 (WIW003)	1,355	507539	500951	-3480	505272	502539	---	---	---
	WI2	505480	498864	A	Unused	---	---	---	---	---	---	---	---	---
				B	W2 (WIW102)	1,521	505480	498864	---	---	---	-3770	506374	497967
				C	W3 (H1)	1,521	505480	498864	---	---	---	-3709	505480	498864
				D	W1 (WIW 102)	1,521	---	---	---	---	---	-3780	504916	499528
Gas Injection	GI1	513691	502991	A	G2 (GIW102)	1,200	513691	502991	---	---	---	-3470	513691	502991
				B	G3 (GIW103)	1,200	513691	502991	---	---	---	-3470	514332	502380
				C	Unused	---	---	---	---	---	---	---	---	---
				D	G1 (GIW101)	1,200	513691	502991	-	---	---	-3485	513521	503648

LM2 = Lower Mahogany 2.

TVDSS = true vertical depth subsea.

UM2 = Upper Mahogany 2.

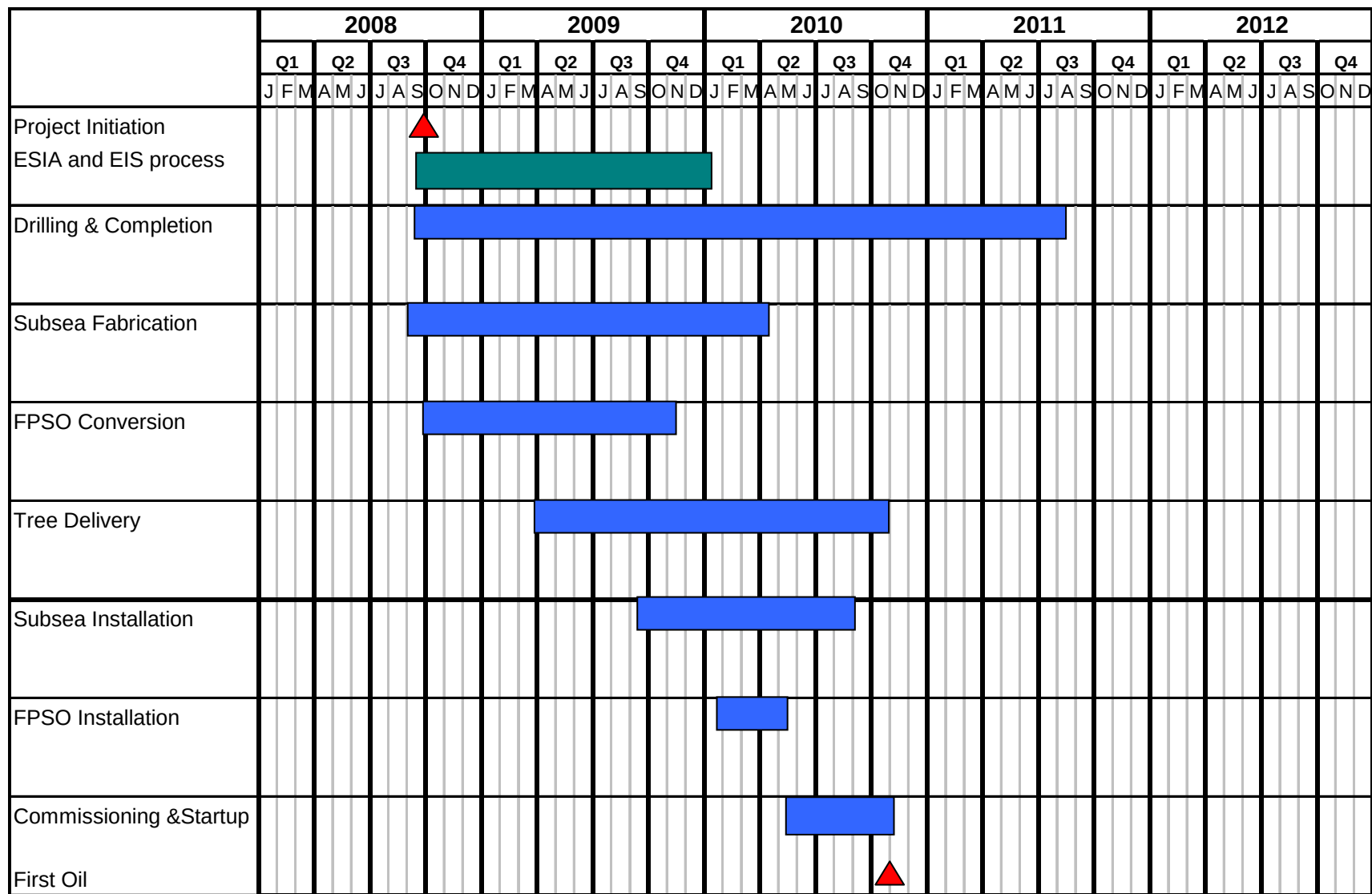


Figure 3.2. Jubilee Field, Phase 1 development project schedule.

Table 3.2. Floating production, storage, and offloading (FPSO) and mooring anchor locations and anchor layout.

Facility or Component	(X) Easting	(Y) Northing	Water Depth (m)	Slope (degrees)		
FPSO					Leg Designation	
	512800	508000	~1,100	4.0	Anchor Leg Side	Position
Anchors						
1	512767	509477	974	3.0	North	East
2	512692	509516	974	3.5		Middle
3	512617	509550	972	3.5		West
4	510288	508053	1,054	4.0	West	North
5	510291	507965	1,060	4.0		Middle
6	510300	507877	1,067	4.0		South
7	512911	506534	947	5.5	South	West
8	512990	506585	937	5.5		Middle
9	513066	506639	929	5.0		East

Commissioning and Start-up:

Once the FPSO has been moved onto its location and mooring anchors secured, the umbilicals and flowlines will be lifted and tied into the riser and manifold system aboard the FPSO. Commissioning of the FPSO occurs following FPSO installation and encompasses energizing and testing of all of the vessel's systems, including (but not limited to) processing equipment, control systems, power generation systems, fire and emergency control systems, and seawater conditioning and injection systems. Commissioning of the subsea flowlines typically includes gauging, cleaning, pigging and hydrostatic testing, and drying/nitrogen purge. Commissioning and start-up are slated to occur from June 2010 to November 2010.

Jubilee Joint Venture will then begin opening wells in an approved sequence to initiate production. The Jubilee Field, Phase 1 development schedule projects oil production to begin (i.e., achieve First Oil) by November 1, 2010. Shuttle tanker operations will begin shortly after initial oil production. As the production rate builds, Jubilee Joint Venture will commence gas compression and injection operations. Water injection operations will commence after gas injection rates are established. Operation of the FPSO, including oil production, processing, storage, and offloading, will occur over the 20-year life of the Phase 1 development – from late 2010 to 2030.

3.2.2 Detailed Drilling Schedule

The drilling schedule, including the drilling and completion of production and injection wells, is depicted in **Figure 3.3**. A total of 17 wells is encompassed under Phase 1, including two wells already drilled under the exploratory drilling program (Mahogany 1 and Hyedua 1) and 15 new wells. Mahogany 1 and Hyedua 1 will need to undergo only well completion.

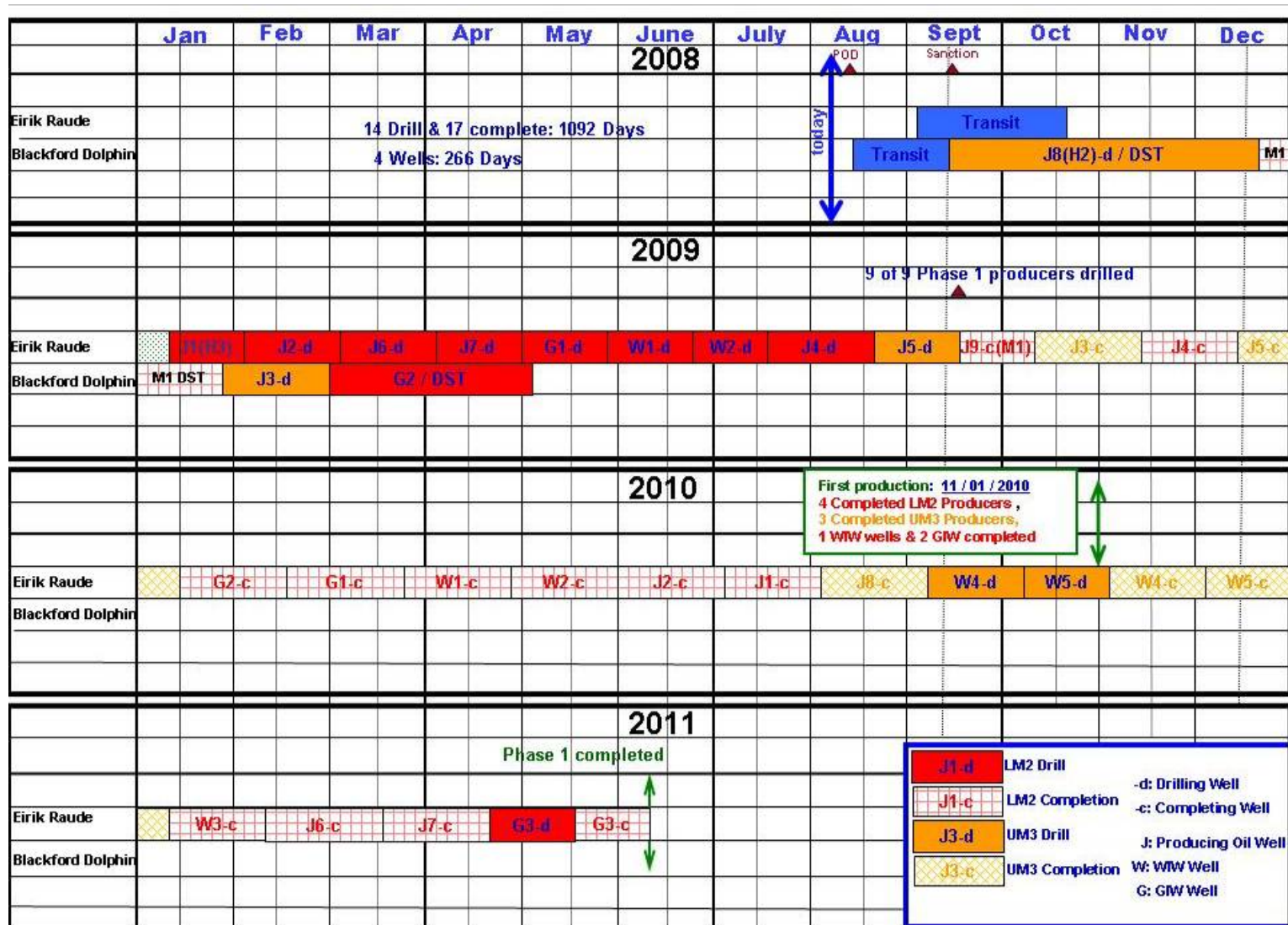


Figure 3.3. Detailed drilling and completion schedule of Jubilee Field, Phase 1.

Two MODUs will be employed for well drilling and completion. The *Blackford Dolphin* will drill or conduct drill stem testing on four wells in the Jubilee Field between the 4th quarter 2008 and 2nd quarter 2009. Jubilee Joint Venture estimates *Blackford Dolphin* activities on the four wells will require 266 days.

The *Eirik Raude* will drill 12 wells and conduct 16 well completions on the remaining wells (i.e., those drilled by the *Blackford Dolphin* and *Eirik Raude*) between the 1st quarter 2009 and 2nd quarter 2011. Jubilee Joint Venture estimates *Eirik Raude* drilling and completion activities will require 1,092 days. The operational schedule for the *Eirik Raude* will include 1) drilling nine new wells for approximately nine months (between January and September 2009), 2) conducting 11 well completions for one year (between September 2009 and September 2010), 3) drilling two new wells for three months (between September and November 2010), 4) conducting five well completions for six months (between November 2010 and April 2011), and 5) alternating once between drilling a single well and completing that well for one month each (between April and June 2011). The *Eirik Raude* is expected to depart the Jubilee Field in June 2011.

Only during the period December 2008 until May 2009 will both MODUs be operating in the Jubilee Field. During this period, *Blackford Dolphin* will be drilling on wells J3 and G2, while the *Eirik Raude* will be drilling on wells J1, J2, J6, J7, and G1.

3.3 Facilities and Equipment

3.3.1 Mobile Offshore Drilling Units

Two MODUs – *Eirik Raude* and *Blackford Dolphin* – will be utilised for the development drilling program (**Figure 3.4**). *Eirik Raude* is a fifth generation harsh environment, dynamically positioned semisubmersible drilling rig, capable of operating in water depths up to 3,000 m. Its dynamic positioning capability is rated to Class 3. It has been outfitted with a low-emission power generation system.

Blackford Dolphin is an Aker H-3 propulsion-assisted semisubmersible drilling rig (i.e., 1A1 column-stabilized drilling unit), capable of operating in water depths up to 2,134 m and drilling to a maximum depth of approximately 9,000 m. The *Blackford Dolphin* recently completed an extensive overhaul, with modifications as a deepwater drilling unit. *Blackford Dolphin* completed commissioning and testing in Rotterdam in 2008 and is currently being mobilised under drilling contract with Tullow offshore Ghana. Summary vessel characteristics are provided in **Table 3.3**.

Full specifications for the *Eirik Raude* and *Blackford Dolphin* are provided in **Appendix A**.

Consistent with industry practice, an “exclusion zone” will be established around the MODUs while drilling or relocating within the Jubilee Field. The exclusion zone will be kept clear of all vessels not associated with Jubilee Field operations. Jubilee Joint Venture currently estimates that the exclusion zone will encompass surface waters within a 500-m radius of a MODU to address safety concerns and to avoid any potential for anchor line fouling or allision.

(a)



(b)



Figure 3.4. Semisubmersibles Eirik Raude (a) and Blackford Dolphin (b).

Table 3.3. Summary specifications for proposed mobile offshore drilling units to be used during the Jubilee Field, Phase 1 development offshore Ghana, West Africa (Adapted from: RigZone, 2008).

Rig Name	Owner	Rig Type	Drillship Type	Rated Water Depth (ft)	Drilling Depth (ft)	Derrick	Drawworks	Mud Pumps	Top Drive and Rotary Table
<i>Eirik Raude</i>	Ocean Rig	Semisubmersible	5 th generation; Trosvik Bingo 9000	10,000	30,000	Hydralift 170 x 40 x 40 ft; 2,000,000 lb; hook + setback 1,300,000 lb	Continental Emsco Electrohoist IV, 4,000 hp	3 x Continental Emsco FC-2200 triplex 7500 psi, 2,200 hp	Hydralift HPS-1,000 2E 2,000,000; Varco 60.5-in. diameter Model BJ RST 1,000 tons
<i>Blackford Dolphin</i>	Fred Olsen ASA	Semisubmersible	2 nd generation; Aker H-3 propulsion assisted	7,000	30,000	Lee C Moore 185 x 40 x 40 ft; Capacity: 1,000,000 lb	National 1625 DE, 3,000 hp	2 x National 12-P-160 triplex, 1,600 hp	Varco TDS-4S P85; Oilwell 37.5-in. diameter Model T-375 opening with independent electric drive

3.3.2 FPSO and Toppers Processing

3.3.2.1 FPSO Overview

Phase 1 development of the Jubilee Field will employ a permanently moored FPSO vessel that will serve as the main production and storage facility. Jubilee Joint Venture has selected the very large crude oil carrier (VLCC) *Ohdoh* (formerly *Tohdoh*; **Figure 3.5**) as the vessel for modification to meet the processing capacity and schedule requirements of the Jubilee Field. The *Tohdoh* is a single hull, 261,212 dead weight ton (dwt) VLCC built in 1991. Salient specifications for the *Tohdoh* include:

- LOA (length over all): 330 m;
- Beam: 59 m;
- KTM (keel to masthead): 64.8 m; and
- BCM (bow to centre manifold): 156 m.

Retrofitting of the FPSO will allow for storage of at least 1.6 million barrels of oil, excluding slop tanks, off-spec tank, and methanol storage. Offloading capabilities will include a one million barrel parcel in 20 hours. The FPSO will carry the Flag of a reputable Flag state. The FPSO will be designed in accordance with the most recent revisions of all applicable national and international maritime conventions, acts, codes, rules and regulations. Schematics of the FPSO *Ohdoh* are provided in **Appendix B**.

The FPSO will have an initial capacity to process up to 120,000 barrels of oil per day (bopd), 80,000 barrels of water per day (bwpd), and handle up to 160,000 barrels of total fluids. It will also have the capability to provide 232,000 bwpd of water injection and 160 millions of standard cubic feet per day (MMscfd) of gas injection to the field. Gas required for riser gas-lift will be siphoned off of the gas injection pipeline subsea. The 160 MMscfd gas handling capacity considers both produced associated gas and any recycled gas from gas lift. The storage capacity of the FPSO will be approximately 1.6 million barrels of oil (MMbo) minimum.

The FPSO facility topsides will be designed to achieve a minimum of 95% availability or uptime for service on the Jubilee Field at a 90% confidence level. Availability includes planned maintenance at 100% available production. The FPSO facility water injection system will be designed to achieve 95% availability based on annual volumes of injected water.

3.3.2.2 Mooring and Offloading

The mooring and offloading system will be a Single Point Mooring (SPM) system with tandem offloading. The SPM system will be designed to allow the FPSO to freely weathervane 360° around the SPM vertical axis, to align itself with the prevailing wind, wave, and current conditions.



Figure 3.5. Very large crude oil carrier (VLCC) *Tohdoh* prior to conversion to the floating production, storage, and offloading (FPSO) vessel *Ohdoh* and schematic of possible FPSO configuration.

The SPM will consist of a turret that functions as the mechanism for connecting the mooring lines to the FPSO and allowing the ship to rotate about the mooring centre. The risers that bring the subsea production to the FPSO will be supported in the ship by the turret. A schematic of the FPSO and subsea architecture are shown in **Appendix B** and **Figure 3.6**, respectively. It should be noted that **Figure 3.6** is a conceptual depiction of the Jubilee Field Phase 1 layout and has not been drawn to scale. The FPSO will be designed to remain on station and maintain full operability for a 20-year service life.

At maximum processing capacity (120,000 BOPD), the FPSO will fill to capacity in 13.3 days; Jubilee Joint Venture plans to offload oil in 1-million barrel loads, each of which will require approximately 20 hours to offload. The shuttle tanker will offload stored oil every 10 days. Dual-carcass transfer hoses and securing hawser will be approximately 150 m in length.

3.3.2.3 Station Keeping System

The SPM station-keeping system comprises a turret mooring system where the mooring lines and risers reach up from the sea floor and connect to the FPSO. The SPM system is an external bow-mounted turret designed to allow the FPSO to weathervane about the mooring. In the offloading condition, the mooring system will be capable of withstanding loads from the FPSO, as well as withstanding loads imposed by the shuttle tanker while tandem-moored. The design life of the turret and major structural components is 20 years.

The turret will be designed to accommodate 14 flexible risers and three umbilicals. There will be six production line risers, two gas injection risers, two gas export risers, and two water injection risers. The umbilicals will provide electrical power cabling and hydraulic control lines. Two risers are designated for future expansion as production or water injection risers. The risers are connected to two riser bases at the seabed. Installation of the anchor legs and risers and re-tensioning of anchor legs will be accomplished with the pull-in winch.

3.3.2.4 FPSO Location

The proposed FPSO location is approximately 7 km north-northeast of the Mahogany 1 wellsite, along the northern edge of the Jubilee Field, Phase 1 development. At this site, the FPSO will sit directly atop one of the primary seabed channels that cut through the development area. The water depth at this location is approximately 1,100 m.

3.3.2.5 Mooring System

The proposed taut-leg mooring system is designed to keep the FPSO vessel on station while permanently moored. The design life of the mooring system is 20 years. The mooring system will consist of a total of nine anchor legs in a 3 by 3 arrangement, where the groups are 120° apart. Each anchor leg is composed of a combination of studless chain and polyester rope with a total length of about 1,900 m for each leg.

FPSO and Subsea Architecture

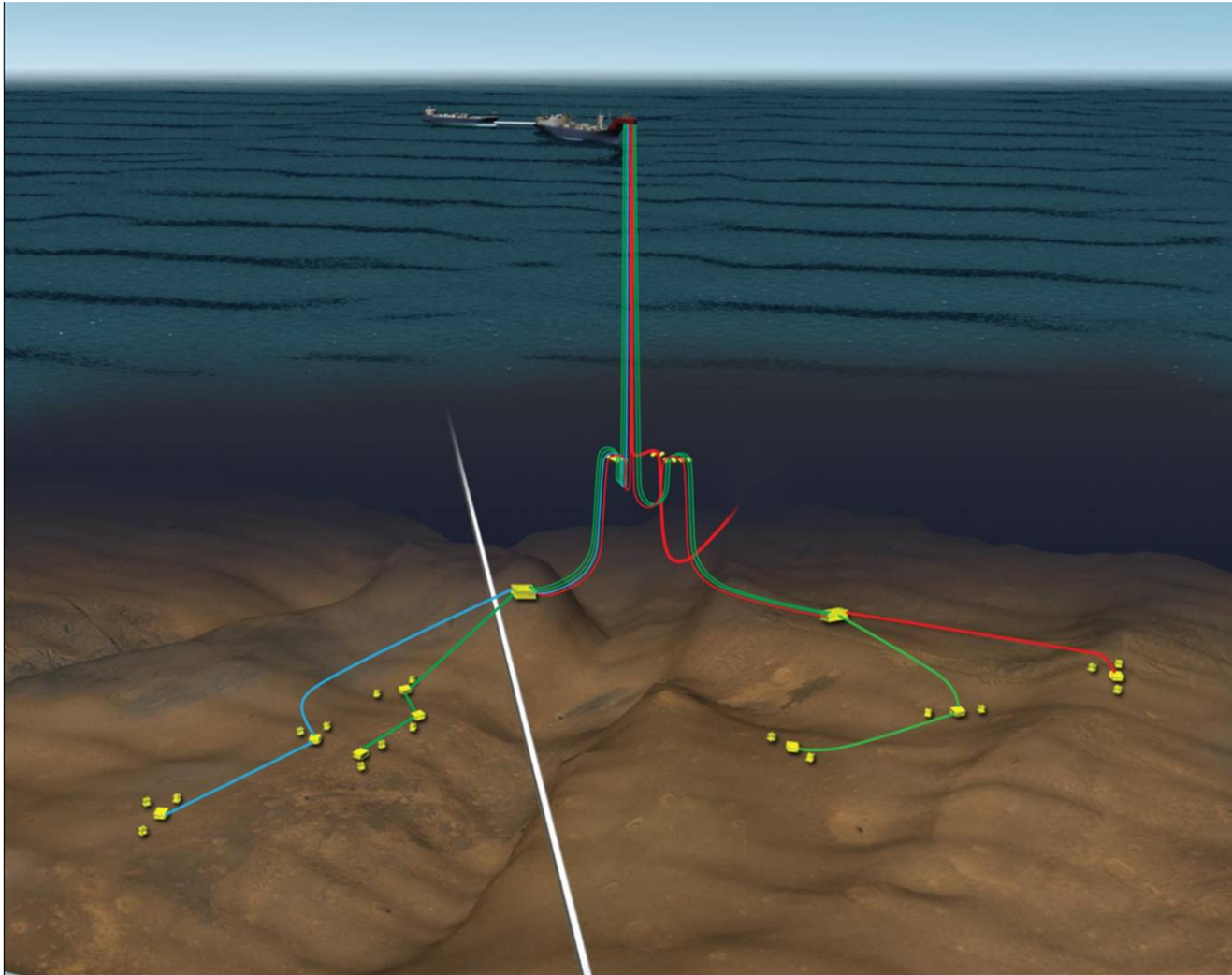


Figure 3.6. Schematic of proposed Jubilee Field, Phase 1 offshore Ghana, West Africa.

Vertically loaded plate anchors (VLA) or suction piles will be used at the termination of each anchor chain leg, with the final determination being made during the detailed design phase depending on the final geotechnical data for the site and the optimisation of the installation program. The anchor leg system has been designed to require minimal maintenance over the life of the installation once it has been installed and tensioned to the design pre-tension. The anchor legs are designed to have adequate wear and corrosion allowance and fatigue life for 20 years. The mooring system is designed to ensure that the maximum vessel offset is 5% of water depth with all mooring components intact and 6% of water depth with one mooring line failed. Individually, VLA or suction piles measure 4 m in diameter. Chain or mooring line may drag across the seafloor (e.g., during installation) and may extend several tens of meters from the anchor location; estimates of seafloor potentially affected are 100 to 200 m² per line.

3.3.2.6 Riser Connections

The FPSO turret or riser porch will accommodate the following riser requirements:

- Six 10-in. internal diameter (ID) production risers;
- Two 10-in. ID gas injection risers;
- Two 10-in. ID gas export risers;
- Two 10-in. ID water injection risers;
- Two 10-in. ID future production or water injection risers; and
- Three 8-in. ID umbilicals.

The risers may have a one-time pull in weight during installation of up to 350 metric tons and the FPSO will have a fixed facility able to pull in and land the risers. The dimensions of the riser porch are 10 by 10 m.

3.3.2.7 Hull Structure and Accommodation

The VLCC *Tohdoh* has been designated as the candidate vessel for conversion to the FPSO, to be renamed FPSO *Ohdoh*. Hull repair and life extension will be carried out in compliance with Classification Society (CS) requirements on the following basis noted below.

- Single hull tanker *Ohdoh* (formerly *Tohdoh*) converted to an FPSO for the Ghana environment;
- Adequate scantling for permanent mooring and continuous operation in the Jubilee Field;
- Adequate scantling for transit voyage to *in-situ* at specific seasonal environment; and
- FPSO service fatigue life of 20 years considering prior service.

A maximum crewing level of 120 personnel is proposed during normal operations, including 100 permanent and 20 temporary personnel. Existing facilities will be refurbished and extended to accommodate the expected level of people. All materials and equipment used will, as a minimum, be in accordance with the International Convention for the Safety of Life at Sea (SOLAS) requirements and will be similar to existing items in appearance and quality. All cabins and offices will be furnished in a manner consistent with modern, offshore operating practice and suitable for a future

20 year field life. All furniture will be built of fire resistant material and all textiles will be of flame retardant type in accordance with authority requirements.

3.3.2.8 Exclusion Zone and Limits on Bottom-founded Activity

Consistent with industry practice or regulatory requirements (e.g., see Minerals Management Service [MMS], 2008), an “exclusion zone” will be established around the Jubilee Field FPSO equivalent to double the length of the FPSO, hawser, shuttle vessel, tug line, tug, and the safety buffer, including a “far condition” assuming a damaged mooring line. The exclusion zone will be kept clear of all vessels not associated with Jubilee Field operations. Jubilee Joint Venture will also maintain on site a dedicated field vessel that can assist in case of a possible allision. While final exclusion zone boundaries will be determined during front end engineering design (FEED), Jubilee Joint Venture currently estimates that the exclusion zone will encompass surface waters within a 1,000-m radius of the SPM.

Exclusion zones were developed by Kosmos based on international best practices designed to mitigate risk. The 500-m radius has been adopted by the United Kingdom Offshore Operators Association (UKOOA) for all vessels approaching an offshore oil and gas facility (UKOOA Guidelines, Offshore Safety Division of the UK Health and Safety Executive, Section 22 of the Petroleum Act 1987, as cited by International Association of Geophysical Contractors, 2004). The 1,000-m radius considered the total length of both the FPSO and shuttle tanker (plus a reasonable buffer zone) to preclude interference from non-project vessels which may be in the area. It should be noted that during those periods where the shuttle tanker is not moored to the FPSO, the exclusion zone radius drops back down to 500 m. The specified exclusion zones for the Project will be discussed and corroborated with the Ghanaian governmental authorities (GNPC and EPA).

Bottom-founded activity should be precluded from the Jubilee Field due to installation and operation of wellheads, injectors, production and injection manifolds, risers, and associated unburied flowlines, injector lines, and umbilicals. While final restrictions on bottom-founded activity will be determined during FEED, Jubilee Joint Venture currently estimates that the entire Jubilee Field will be precluded from bottom-founded activities (e.g., trawling).

3.3.3 Subsea Systems

The Phase 1 development subsea layout includes eight, four-well manifolds associated with either production or injection. Production and injection will occur in both blocks and on both sides of the canyon. Three production drill centres (P1, P2, and P3) located on the west side of the seabed canyon will accommodate up to 12 production wells. Phase 1 development (Kosmos Energy, LLC, 2008) includes five production wells on the west side, allowing for future addition of seven production wells (**Figure 3.7**).

Two production drill centres (P4 and P5) will be located on the east side of the seabed canyon, each equipped with four-well manifolds, able to accommodate up to eight production wells. One east side drill centre (P5) will be located adjacent to the Mahogany 1 wellsite and will accommodate the four east side Phase 1 production wells. The other drill centre (P4), located at an intermediate point between the FPSO and P5, will accommodate up to four additional production wells in the future. No drilling at drill centre P4 is proposed under Phase 1.

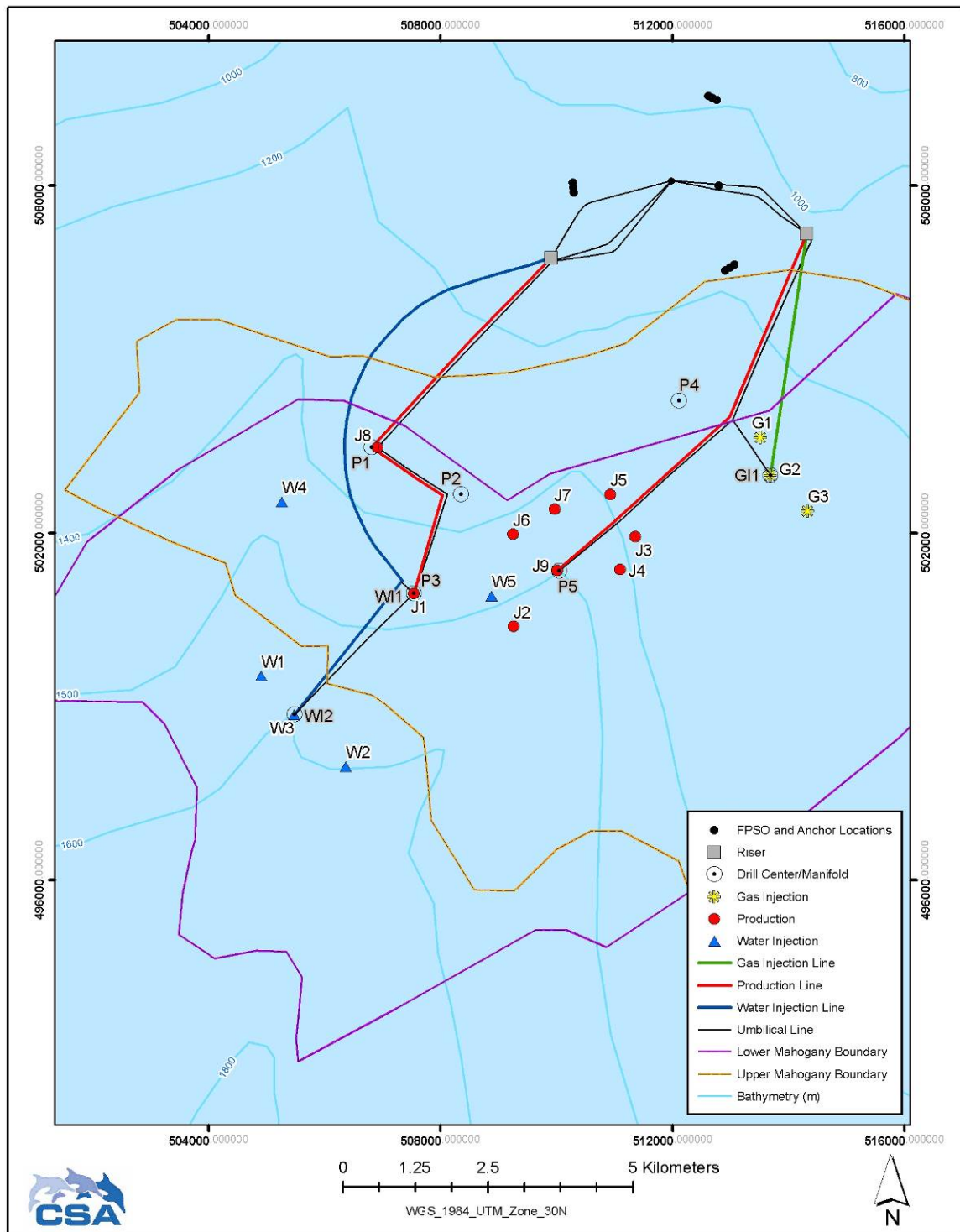


Figure 3.7. Drill centre locations and associated flowlines, injector lines, and umbilicals for Jubilee Field, Phase 1 offshore Ghana, West Africa (From: Kosmos Energy, LLC, 2008).

Two water injection drill centres are located on the west side and can accommodate up to eight water injection wells. Under Phase 1, WI1 will target the UM3 reservoir with two injection wells and WI2 will target the LM2 reservoir with three injection wells. Gas injection will occur at the remaining east side drill centre (GI1), slated to accommodate three Phase 1 gas injection wells and capable of accommodating one additional gas injection well in the future. All subsea wells will be accessible for future interventions with floating drilling rigs.

3.3.3.1 Production Wells

All production wells in Phase 1 will be drilled from five drill centres using the *Eirik Raude* or *Blackford Dolphin* via seafloor moorings or dynamic positioning. Each production drill centre will have a production manifold with connection hubs for up to four wells. A total of nine production wells are proposed under Phase 1, with all to be tied back to the subsea manifolds with rigid, insulated jumpers. Dual insulated flowlines will carry production to intermediate production manifolds and then to riser bases located in proximity to the FPSO, and finally through flexible risers to the FPSO.

Production Manifolds

Production manifolds will be installed on the seafloor as a gathering point for produced oil, gas, and water from individual production wells. Manifolds will be mounted on suction piles measuring 4.6 to 5.2 m in diameter. The dimensions of each manifold are 6.1 by 9.1 m, with a weight of 100 tons. Production manifolds and suction piles, exclusive of production lines, will occupy an area of 56 m².

Production Trees

Production from individual wells will be controlled by subsea Christmas trees connected to the 18-3/4-in. DrilQuip wellhead, using a hydraulically operated connection system. All production well trees will be 5- by 2-in., 10,000 psi, 121 °C, FMC Technologies enhanced horizontal subsea trees (**Figure 3.8**). With an estimated weight of 83,000 lb, the seafloor footprint dimensions for each production tree are approximately 4.4 by 4.4 m, or approximately 20 m².

3.3.3.2 Injection Wells

All injection wells in the Phase 1 development will be drilled from three drill centres with a moored or dynamically positioned MODU. Each water injection drill centre will have a water injection manifold with connection hubs for up to four wells. The injection wells will be tied-back to the injection manifolds with rigid jumpers. Single flexible risers will be installed from the FPSO turret to each riser base. A single 10-inch flowline will carry water to an intermediate water injection manifold and then to the outlying, water injection manifold. Water injection is planned for the west side of the Jubilee Field.

Gas injection will leave the FPSO through a single 8-in. flexible riser to a riser base. An 8-in. single steel flowline will then transport the gas to a four-well, gas injection manifold. Gas injection is planned for the east side of the Jubilee Field. Although no gas injection is planned for the west side of the Jubilee Field within the Phase 1 development, the riser base will be equipped for future gas injection expansion.

FMC 5"x 2"-10K EHXT for Jubilee – Production Trees

Jubilee

- FF Prod, EE Annulus, PSL 3G
- 5"-10K vertical Torus III hub
- 18 ¾"-15K Torus IV connector for H4 wellhead profile (DQ)
- 2 CID, 2 SV's, 1 DHPT
- 1 CIT between PMV & PWV, 1 between Choke and PIV, and 1 between PIV and Hub
- 3 sensors:
 - 1 Annulus PT
 - 1 Production upstream PT
 - 1 Production downstream PT with intrusive sand detector
- Silicon based Novolastic™ insulation
- Qty 2 dual core chemical metering valves

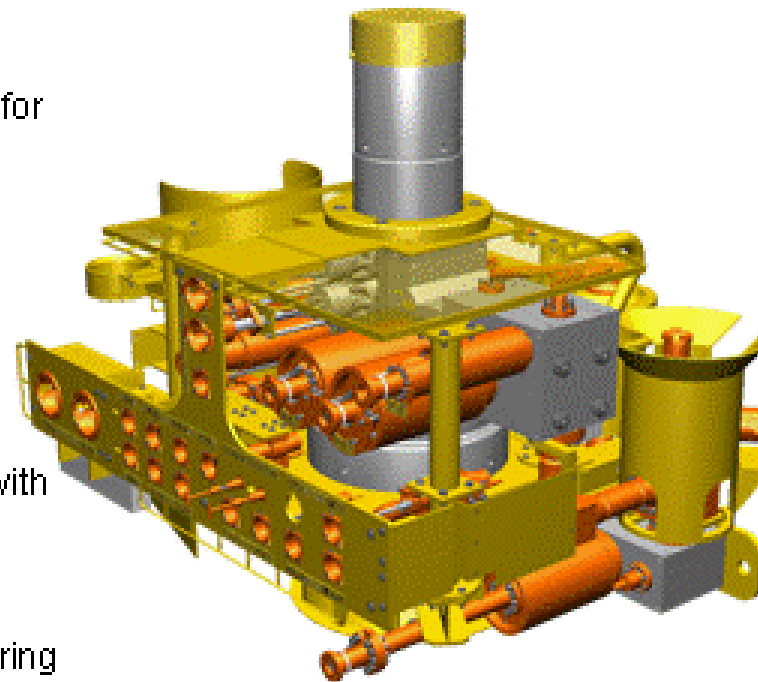


Figure 101

Figure 3.8. Production tree schematic for Jubilee Field, Phase I (From: Kosmos Energy, LLC, 2008).

Injection Manifolds

Gas and water injection manifolds will be installed on the seafloor as a distribution point for injected gas and water to the individual injection wells. The manifolds will be supported by suction piles to provide additional support. A vertical connection system with integral connection tooling will be used on the 5-in. rigid jumpers to connect injection wells to the manifold. Hydraulically operated, 5-in. isolation valves (one per well, four per manifold) will be installed on the manifold immediately downstream of the 10-in. main injection line. Each injection manifold will measure 6.1 by 6.1 m, with a weight of 80 tons. Injection manifolds and suction piles, exclusive of injection lines, will occupy an area of 37 m².

Injection Trees

All injection well trees will be 5- by 2-in., 10,000 psi WP, FMC Technologies enhanced horizontal subsea trees, mounted atop subsea wellheads in a similar manner to that employed for the production trees (**Figure 3.9**). Gas injection trees will be similar to the production trees equipped with a modified choke design. With an estimated weight of 83,000 lb, the seafloor footprint dimensions for each injection tree are approximately 4.4 by 4.4 m, or approximately 20 m².

3.3.3.3 Injection Flowlines, Risers, and Umbilicals

Phase 1 development injection lines will carry conditioned seawater from the water injection skid on the FPSO and wet gas from the production separators to the individual water and gas injection manifolds. Water injection will be through single 10-in., uninsulated steel flowlines from the FPSO to an intermediate water injection manifold and then to the outlying manifold. Single 8-in., uninsulated steel flowlines will carry gas to the gas injection manifold.

Flexible risers will connect the individual lines at the riser base (riser porch) to the FPSO connection through the turret. Risers will have buoyancy modules installed to develop the optimum catenary in a lazy “S” configuration. Risers will be installed in the field after FPSO installation. Umbilicals will be used to convey chemical, pressure, and temperature data and allow hydraulic manipulation of chokes and tree valves.

A total of 10,724 m of 10-inch water injection lines and 3,024 m of 8-in. gas injection lines are to be installed in the Jubilee Field under Phase 1. Additionally, a total of 19,843 m of 8-in. umbilicals are to be installed under Phase 1 to control production and injection wells.

Due to the high gas-oil ratio in Jubilee Field reservoirs, artificial lift will not be required at field start-up. Later in field life, water production rates will increase and lift will be necessary. Production rates will be enhanced by reducing the hydrostatic pressure of the producing column through the injection of gas-lift gas. This reduction in hydrostatic pressure will allow wells to be produced at higher water cut limits, increasing the ultimate recovery. Riser gas-lift will be employed during latter stages of Phase 1 production.

FMC 5" x 2"-10K EHXT for Jubilee – Injection Trees

Jubilee

- GI: FF Prod, EE Annulus, PSL 3G
- WI: HH Prod, EE Annulus, PSL 3G
- 5"-10K vertical Torus III hub
- 18 ¾"-15K Torus IV connector for H4 wellhead profile (DQ)
- 2 SV's, 1 DHPT
- 1 CIT between PMV & PWV
- 3 sensors:
 - 1 Annulus PT
 - 1 Production upstream PT
 - 1 Production downstream PT
- No PIV, metering valves, or insulation

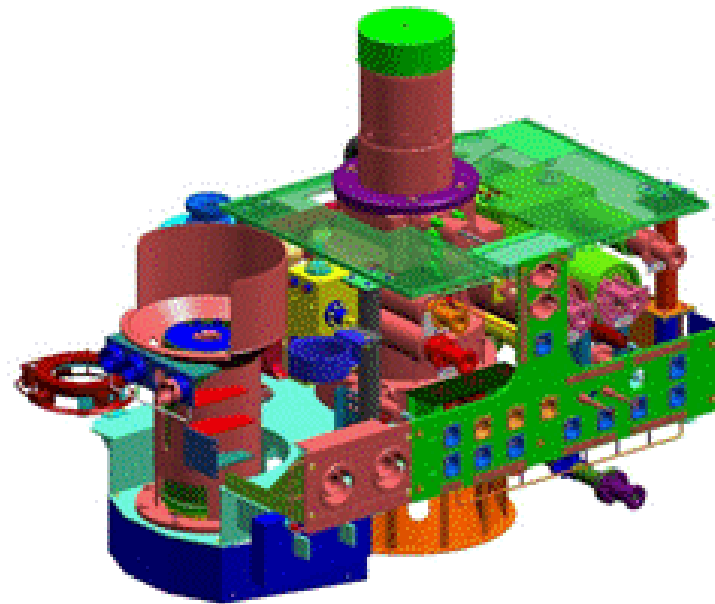


Figure 102

Figure 3.9. Injection tree schematic of Jubilee Field, Phase 1 (From: Kosmos Energy, LLC, 2008).

3.3.3.4 Production Flowlines and Risers

Phase 1 development flowlines will carry multi-phase and commingled well streams from individual wells and manifolds. Dual, insulated 10-in. steel production flowlines will extend to all production manifolds in series and convey the well streams to riser bases located in proximity to the FPSO. A total of 29,669 m of 10-in. production line will be installed in the Jubilee Field under Phase 1, comprising five paired (i.e., east and west) lines running from the drill centres (manifolds) to the risers and FPSO.

Single uninsulated steel flowlines will carry gas and water for injection to injection manifolds and the individual injection wells; gas and water injection lines will be 8 and 10 inches in diameter, respectively. Riser gas-lift gas will be taken at the riser base through control valves.

Flexible risers will connect the individual lines at the riser base to the FPSO connection through the turret. Risers will have buoyancy modules installed to develop the optimum catenary in a lazy “S” or lazy wave configuration. Risers will be installed in the field after FPSO installation.

3.3.3.5 Subsea Control System

All subsea hydraulically operated valves will be actuated using an FMC Technologies electro-hydraulic subsea control system. Hydraulic power, electrical power, communication signals, and production chemicals will be supplied and distributed from the FPSO Subsea Control System through intermediate Subsea Distribution Units (SDUs). The SDUs will be mounted on mud mats placed on the seabed in proximity to the manifolds. Electric and hydraulic flying leads will connect the SDUs to the subsea trees and manifolds. Each SDU measures 4.6 by 9.1 m; mud mats will measure 7.6 by 12.2 m, occupying an area of 93 m².

Umbilicals will be used to convey multiple chemical supply lines, low and high pressure hydraulic supply and pressure, temperature and communication data, and subsea electronics electrical power. Dynamic umbilical sections will connect at the FPSO turret and riser bases, and static umbilical sections will connect the riser bases to the SDUs.

3.4 Activities

3.4.1 Drilling and Well Completion

3.4.1.1 Drilling

The drilling campaign will utilise the *Blackford Dolphin* and *Eirik Raude* for drilling and testing operations. The Phase 1 development plan includes 17 wells; however, Mahogany 1 and Hyedua 1 will be completed for production and injection, respectively. The Hyedua 1 will be renamed W3, and the Mahogany 1 will be renamed J9 for the Phase 1 development. Since these two appraisal wells will be completed for Phase 1 development, the drilling plan includes 15 new wells. Replacement wells could be required in the event of wellbore failure during drilling or completion operations, or in the event insufficient pay thickness or quality is realised.

The *Eirik Raude* will perform all completions. The current schedule assumes that wells will be drilled and completed in batch mode to improve efficiency and minimise the time required to run and retrieve the riser and blowout preventor (BOP) stack. Typical wellbore diagrams for production and injection wells are shown in **Figure 3.10**.

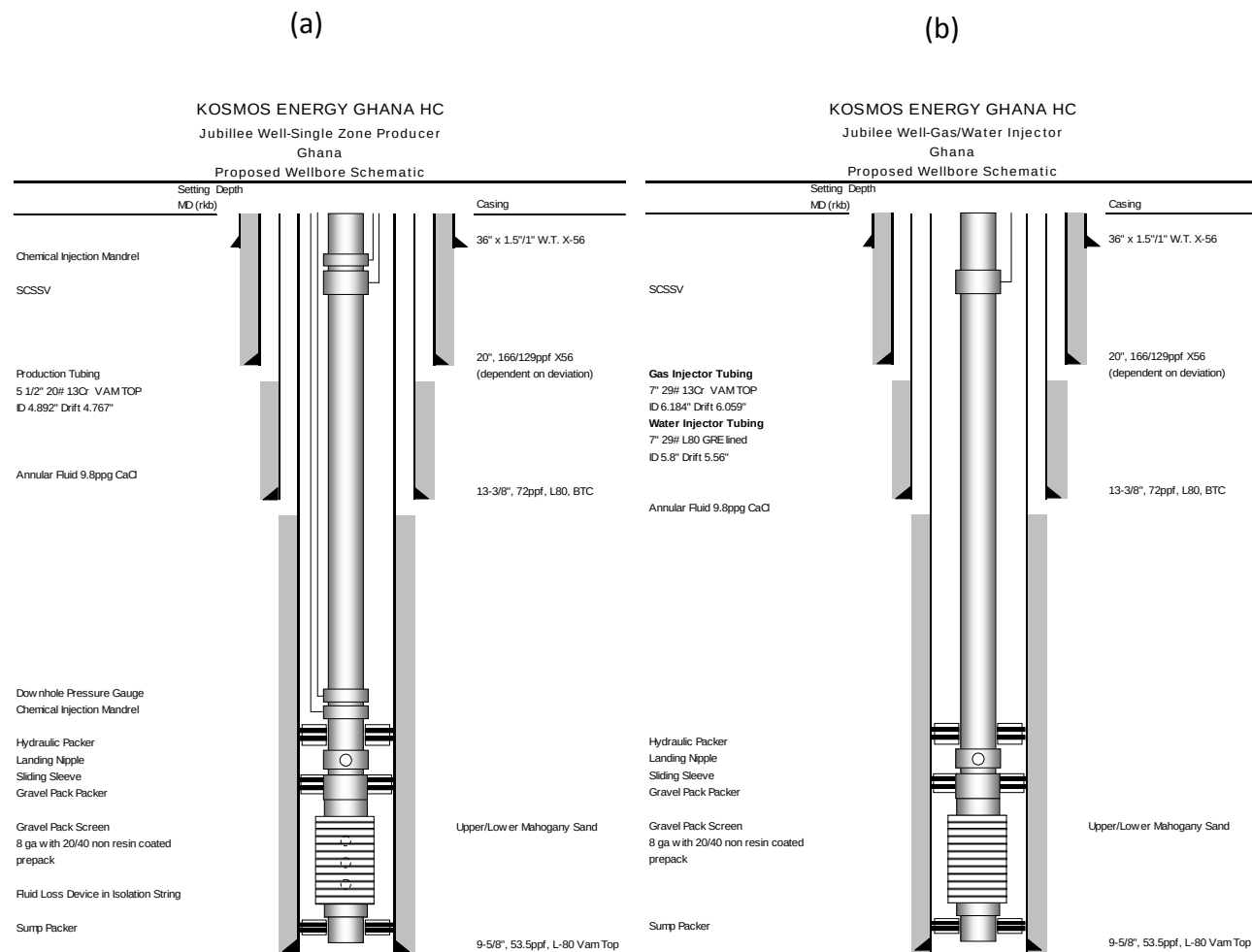


Figure 3.10. Typical wellbore diagrams for production (a) and injection (b) wells for Jubilee Field, Phase 1 (From: Kosmos Energy, LLC, 2008).

A typical well design (**Figure 3.11**) will include the following:

- 36-in. conductor/structural casing jetted to approximately 70 m below the mudline;
- 26-in. hole drilled with seawater and gel sweeps to approximately 500 m below the mudline;
- 20-in. casing set to section true depth (TD) and cemented to the mudline;
- 17-1/2-in. hole section directionally drilled with enhanced mineral oil-based fluid (EMOBF) to approximately 1,400 m true vertical depth (TVD) below the mudline;
- 13-3/8-in. casing string will be set and cemented;
- 12-1/4-in. hole section directionally drilled to TD; and
- 9-5/8-in. production casing string, with gas-tight connections, set and cemented at TD.

Cuttings being discharged while using the EMOBF system will have an oil retention range of 6% to 8%, with a maximum of 8%. Both MODUs will use a cuttings dryer to minimise retention on cuttings.

Following drill stem testing, the wells will be suspended and the *Eirik Raude* will complete the wells for production at a later date. Although the Phase 1 wells are planned with hole angles of generally less than 55°, the potential application of horizontal and high angle wells during the Phase 1 development will continue to be considered. However, the most likely application would be implemented during future phases of development (Kosmos Energy, LLC, 2008).

The average time required to drill and suspend Phase 1 wells will be 26 days, based on the existing penetrations and projected efficiency improvements (**Figure 3.12**).

3.4.1.2 Well Completion

Data acquired from cores and electric logs (Kosmos Energy, LLC, 2008) have indicated the potential for production of reservoir sand in the Jubilee Field. The wells in the Jubilee Field will be gravel packed completions to prevent sand production, extend well life, and maximise recovery.

Although smart completions were evaluated for application in the Phase 1 development, single zone completions are planned due to the significant production life anticipated from Jubilee Field wells. The application of smart completions will continue to be evaluated during the Phase 1 development. The completion fluid to be used will be a 9.9 ppg calcium chloride (CaCl₂). The average time required to complete Phase 1 wells will be 34 days.

Sub-surface safety valves will be installed in each wellbore to provide pressure isolation and prevent pollution in the event of damage to the tree, wellhead, or subsea system. Profile nipples will be installed in the tubing strings for pressure isolation during routine well maintenance operations.

Permanent downhole pressure and temperature gauges will be installed in each well above the perforated interval to provide continuous data recording during the life of the wells. The data will be transmitted back to the FPSO via umbilicals, with the data distributed for analysis. In addition, pressure and temperature will be recorded at the subsea tree. The pressure and temperature data will be vital in the ongoing reservoir management of the Jubilee Field.

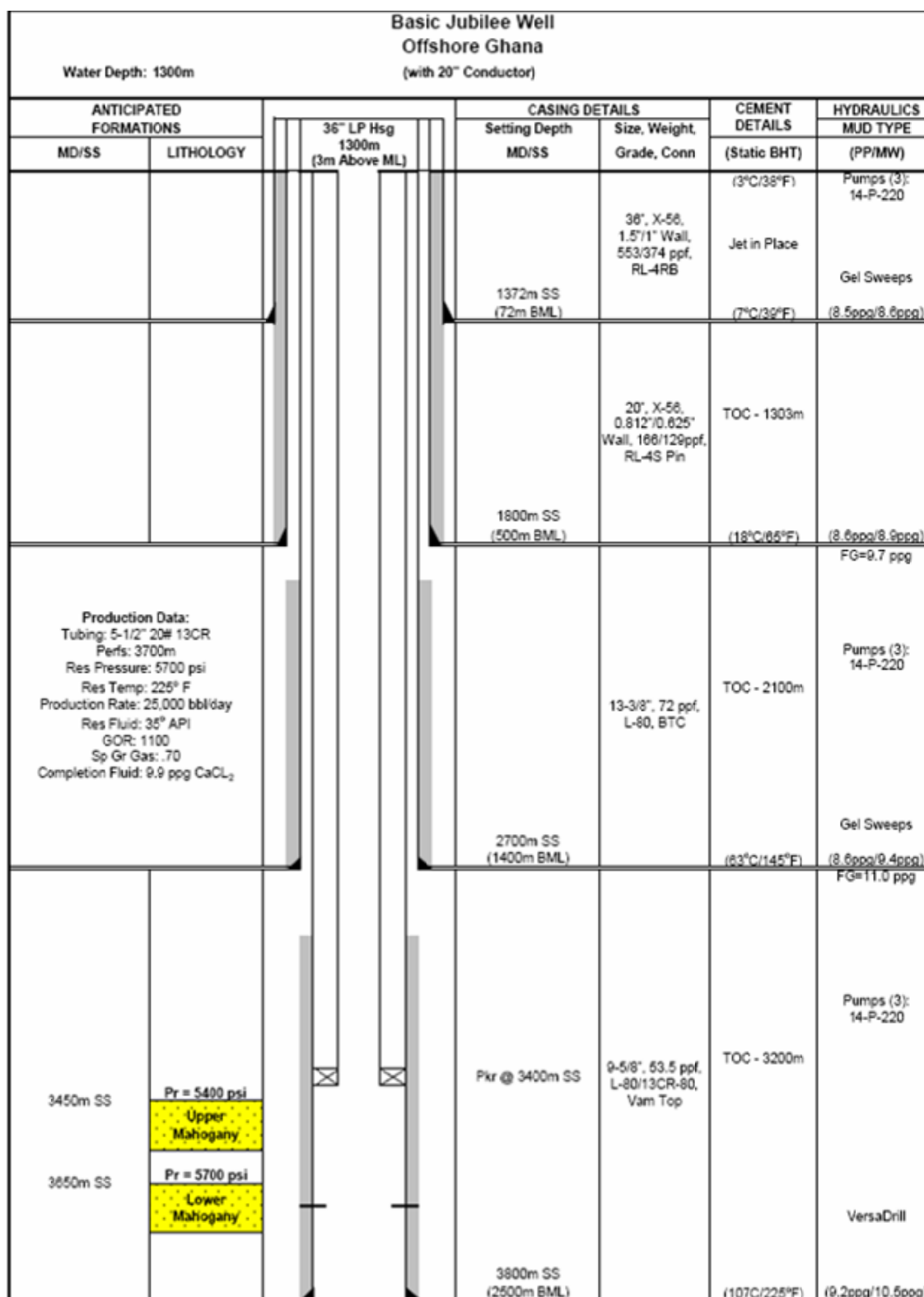


Figure 3.11. Typical well diagram for Jubilee Field, Phase 1 (From: Kosmos Energy, LLC, 2008).

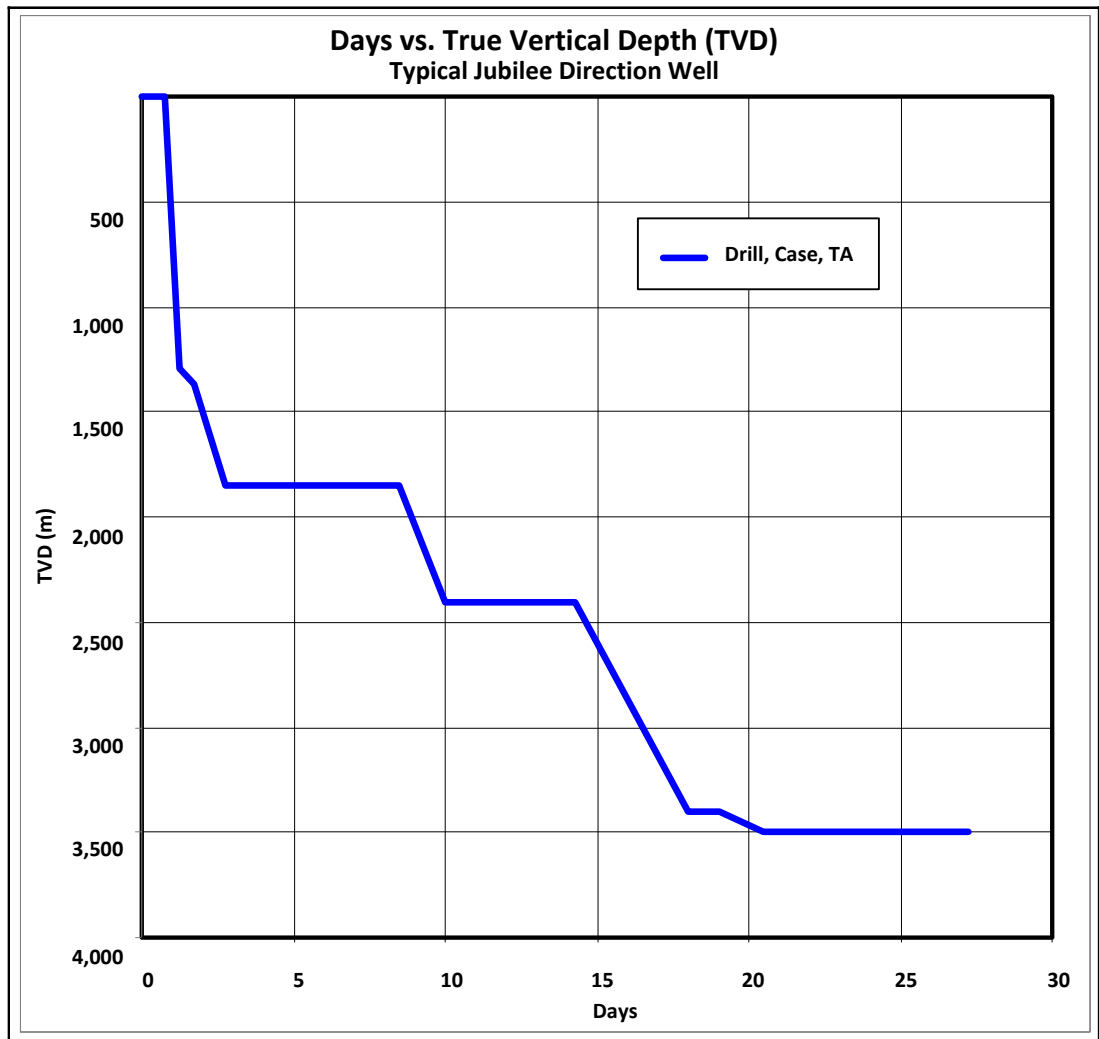


Figure 3.12. Drilling days versus depth of a typical well for Jubilee Field, Phase 1 (From: Kosmos Energy, LLC, 2008). (TVD = true vertical depth.)

3.4.2 Facility Installation

3.4.2.1 FPSO

Installation of the FPSO will require several sequential steps. Anchors and lower chain and wire segments of mooring lines will be installed initially, with work completed either by a pair of large anchor handling vessels (AHVs, or anchor handling tug supply [AHTS] vessels; requires approximately four weeks) or by a dynamically positioned construction vessel (requires approximately two weeks). AHV/AHTS vessels to be used for the Phase 1 development are expected to be in the 60- to 75-m size class with a 20,000-hp rating.

Prior to the beginning of installation work at the site, a long baseline acoustic-positioning array will be established on the seafloor, providing accurate navigational control for positioning objects on the seafloor. Each of the three anchor clusters will be positioned 1,000 m from the final FPSO location using the positioning array. The positioning array may be made up of several smaller arrays; one with four or five transponders at each major worksite, including three anchor clusters, three subsea well/manifold clusters, etc. Each battery-powered transponder is mounted on a small support frame that sits on the seafloor and can be remotely released for recovery. The small support frames are left on the seafloor, but they affect only a few square feet of ocean bottom and do not penetrate significantly below the sediment surface. Transponders send and receive low-level acoustic signals.

Each of the preinstalled mooring segments will consist of a fabricated steel drag anchor (weighing several hundred-thousand pounds), approximately 305 m of 13.7-cm (5-in.) chain, a length of spiral wire strand (approximately 14 cm in diameter), and a temporary support buoy. Two AHV/AHTS would position themselves over each anchor location; one lowering the anchor while the other pays out the attached chain, wire, and buoy. Each anchor will be partially set by one or both AHV/AHTS pulling towards the eventual FPSO location.

Proofloading of the anchors will be completed as part of the process of hooking up the FPSO on location. Final setting of each anchor is expected to disturb a volume of sediment approximately 3 to 6 m wide, as much as 61 m long and to a depth of 15 to 30 m, depending on the strength of the seafloor sediments. The chain and wire segment of each mooring line is expected to disturb a narrow zone of sediments from the anchor toward the centre of the array for a distance of 305 to 610 m, essentially laying on the seafloor intermittently over most of this distance. At completion of the preinstallation, a buoy will support each segment. The buoy may be fabricated steel or syntactic foam, but will be lighted and designed to minimise damage to either the buoy or a vessel in the event of a collision during the brief period leading up to FPSO hookup.

Installation of each preinstalled mooring segment will take approximately one day. Because the components are very large, it is assumed that the AHV/AHTS will make two round trips to the shorebase for resupply. AHV/AHTS will spend approximately half of this time working in the vicinity of the FPSO site and half in transit or at the shorebase.

Since the FPSO is not self propelled, it will be towed from the conversion and precommissioning site (China) to the installation site by three to five tugs. That portion of the FPSO tow occurring within Ghana waters will last one to two days.

Hookup of the FPSO to the mooring spread will be performed by a DP construction vessel. The vessel will pick up the upper end of one of the preinstalled mooring segments, remove the buoy, connect another segment of wire, and move toward the FPSO, while also paying out wire. During this operation, the FPSO will be held on location by tugs.

The construction vessel will pass the end termination of the mooring segment directly to the FPSO, where it is lowered underwater and brought up through fairleads, or guide tubes, in the turret, terminating on the turret deck. The construction vessel then proceeds to repeat the process with another segment of the mooring spread. Once

enough segments are hooked up to keep the FPSO on station, the attending tugs can depart. Once all segments are hooked up, the FPSO can fully set and proofload each anchor by pulling with several opposing lines. This work can proceed while the construction vessel begins the riser hookup process.

3.4.2.2 Subsea Manifolds

Each of the eight subsea manifolds will be installed on the seafloor at various locations in the Jubilee Field. Subsea wells will have surface locations within a short distance (estimated at approximately 30 m) from each manifold. Manifolds can be installed on the seafloor by a DP construction vessel, an AHV/AHTS outfitted with an A-frame or a MODU. If manifold installation is the first onsite activity for the construction vessel, the manifolds might be transported offshore as deck cargo. Otherwise, the manifolds would be transported on a cargo barge with an attendant tug. Manifold configurations are expected to comprise a fabricated steel framework with integral piping, valving, and controls. Manifolds will be mounted on suction piles and may be equipped with short steel extensions that will penetrate the sediments and provide horizontal resistance to movement. Suction piles will support the weight of the manifold and provide for leveling.

Installation will be a matter of attaching lifting slings, lifting the manifold from the deck of the cargo barge and lowering it to set on the seafloor, using the acoustic positioning system to control location and orientation. Once on the seafloor, each manifold will disturb the surface sediments over an area roughly coincident with its plan dimensions. The seafloor extensions will penetrate 3 m or so below the seafloor at each “corner,” depending on the strength of the sediments.

3.4.2.3 Flowlines and Umbilicals

Flowlines can be installed by several different methods including S-lay, J-lay, reel barge, and tow-in lay methods. Due to water depths of the Phase 1 development, it is expected that a J-lay approach will be used. Installation of the flowlines will be performed by a DP lay vessel and will likely begin by lowering flowlines from individual production wells to the production manifolds, then in the direction of the FPSO. Ends of each flowline will be terminated, lowered, and temporarily abandoned on the seafloor in the vicinity of the planned location of the lower end of the production riser, which will be connected to the flowline and installed after the FPSO is moored in place. The lay vessel will be resupplied (with pipe, material, fuel, etc.) either by supply vessel or cargo barges towed by tugs. Disturbance of seafloor sediments by flowlines will be limited to narrow areal corridors.

Installation of the control umbilicals, one to each subsea manifold, will proceed in a manner similar to installation of flowlines and may be performed by a special DP cable/umbilical vessel or by the same lay vessel that installs the flowlines. Installation will likely begin by lowering the umbilical on the seafloor within 15 to 30 m of the subsea manifold and laying in the direction of the FPSO location. If timing is such that the FPSO is in place at the start of umbilical installation, the preferred approach could proceed by laying the umbilical in one piece, installing buoyancy to achieve the desired lazy wave riser configuration and passing the end termination directly to the FPSO, where it is lowered underwater and brought up through guide tubes in the turret, terminating on the turret deck. If this is not possible, the umbilical will be terminated in a sled and lowered to the seafloor, to be connected later to a riser termination sled

by jumpers. As in the case of the subsea flowlines, disturbance of seafloor sediments by the deepwater portion of the control umbilicals will be limited to narrow areal corridors.

3.4.2.4 Risers

Installation of umbilical risers, production risers, and the gas and water injection risers are required to complete the FPSO installation. This work can proceed in the order that is most convenient. All risers will be suspended underneath the turret of the FPSO in a lazy wave configuration, passing up through guide tubes within the turret cylinder, and connecting at the riser termination deck on the turret.

Assuming that the injector lines will be handled initially, a DP construction vessel will locate the temporarily abandoned terminus of each injector line on the seafloor and raise it to the surface. The bottom end of the riser will be welded or connected to the terminus of the injection line. The vessel will move toward the FPSO, paying out riser and attaching buoyancy elements to provide the lazy wave configuration, and will pass the top termination of the riser to the FPSO, where it will be lowered underwater and brought up through a guide tube in the turret, pulled in and terminated on the turret deck.

Installation of production flowline risers will likely proceed in a similar manner. Final connection between each umbilical and its riser sled is made by jumpers. Jumper installation is accomplished by first positioning the construction vessel above the termination sleds and accurately measuring the distance between connection points using the acoustic positioning array. Each jumper is then cut to fit on the deck of the construction vessel, then lowered and stabbed to make the needed connections.

3.4.3 Commissioning and Start-up

Dynamic commissioning of all systems will occur to ensure compliance with engineering completions, testing, and commissioning of fire and gas, safety and process control systems. Commissioning and start-up will take approximately five months, with first oil scheduled for November 2010. At that time, Jubilee Joint Venture estimates that seven wells will be producing (i.e., four LM2 and three UM3 producers), and three injection wells will be available (i.e., two gas and one water injector). Initial oil production will be determined by the number of wells producing; each well is estimated to produce 25,000 BOPD. Similarly, initial gas production will be dictated by the number of wells online. Gas reinjected will be equal to the volume produced, less 10% for fuel usage and shrinkage after processing aboard the FPSO. Water injection volumes will be established to maintain reservoir pressure. Initially, Jubilee Joint Venture estimates start-up production at 120,000 bopd, 130 MMcfd to be reinjected, and up to 125,000 barrels of fluid per day (bfpd).

3.4.4 Production

Oil Processing and Production

The well stream fluid will be stabilized and separated on board the FPSO and the produced crude oil stored on board for subsequent export via shuttle tanker. Produced gas will be processed and used for fuel, with surplus sent into an injection flowline. Produced water will be treated and discharged overboard if overboard

specifications are met. Seawater will be lifted, filtered, deoxygenated, desulfated, and injected into the reservoirs.

The FPSO topsides facilities consist of 1) one crude separation/stabilization train, four total stages of stabilization provide enhanced oil recovery, with 2 x 100% hp separators for increased flexibility/availability; 2) two 50% two-stage LP gas compression trains and associated equipment; 3) three 50% gas turbine generators; 4) two 100% single-stage MP gas compression trains upstream of dehydration; 5) one 100% gas dehydration and TEG regeneration system; 6) two 100% single-stage hp gas compression trains downstream of dehydration; 7) two 100% single-stage gas injection compression trains downstream of hp gas compression; 8) one 100% fuel gas conditioning system with 2 x 100% filters; 9) one 100% produced water treating system with rotating equipment spared at two 100%; 10) chemical injection system with four spare pumps and two spare tanks; 11) sulfate reduction unit (SRU) seawater treatment system including lift pumps, suction caissons and hoses, coarse strainers, multi-media and cartridge filters, vacuum deaerator with associated vacuum pumps, SRU feed pumps, and seawater injection pumps; 12) flare/vent system with HP (high pressure) and LP (low pressure) flare knockout drums; 13) one closed-loop process cooling medium system, with three 50% circulation pumps and one expansion tank; 14) one closed-loop heating medium system, with two 100% circulation pumps and one expansion tank; 15) waste heat recovery units provided on each main generator; 16) instrument, utility, and nitrogen air system including four 33% service/instrument air and one 100% nitrogen generation units with one receiver for each system; 17) fresh water system including two 100% reverse osmosis units; 18) closed drain system includes piping headers for each pressure classification to the LP flare knockout drum and two 100% pumps; and 19) a flowline circulation system including two pumps and a flowline circulation fluid heater.

Water Injection

With maturity of the field, water injection will be required to maintain reservoir pressure as oil and gas is produced from the reservoir. Seawater will be used as injection water. The water injection facility located on the FPSO will pump seawater from the FPSO sea chest, which contains minimal solids, and filter the injection water through coarse and fine filters. The injection water will be treated to remove any bacterial content and oxygen that would cause the formation of hydrogen sulfide-producing bacteria in the reservoir, souring the reservoir. In addition, the sulfate content in the seawater will be reduced to a minimal level to eliminate the possibility of barium sulfate formation in the wells. The injection water will be pumped at high pressure to the water injection wells in the field. Injection volumes into each well are calculated based on upstream and downstream choke pressures at each well.

Gas Injection, Compression, and Riser Gas-lift

Primary gas injection equipment (compression, filtration, and dehydration equipment) will be located on the FPSO in support of gas injection and riser gas-lift. Jubilee Field will utilise high-pressure gas from the FPSO as injection gas to enhance ultimate recovery. Pipelines will carry the high-pressure gas from the FPSO to the gas injection manifold, where it will be distributed to the gas injection wells. Gas for riser gas-lift will be accommodated either by using a separate, low pressure gas-lift riser that feeds lift gas into the riser base, or by taking a side-stream off of the high pressure gas injection riser in the riser base.

Phase 1 will consist of a modification to the FPSO involving the installation of a JT-LTS (Joule Thomson-low temperature separator) processing scheme and will produce approximately 600 to 2,000 bbl/d (barrels per day) of hydrocarbon liquids, depending on the gas quality requirement, which can be spiked into the crude oil stream while remaining within an RVP (Reid vapor pressure) of 9 psia (pounds per square inch absolute) and a true vapor pressure (TVP) of 14 psia. Maximum gas production is estimated at 25 to 30 mmscf/d (million standard cubic feet per day). Jubilee Joint Venture estimates that 90 to 95 mmscf/d of dense phase gas will be used for fuel gas on the FPSO and for re-injection into the Jubilee Field reservoir.

Shuttle Tanker Operations

Crude oil stored on the FPSO will be transferred to a shuttle (i.e., export) tanker every 10 days, with offloading volumes typically being approximately one million barrels of oil. Offloading will require 24 hours. All crude oil transfers and vessel movements in the Jubilee Field will be controlled via marine terminal rules and regulations being developed by Jubilee Joint Venture. Upon arrival at the Jubilee Field, the shuttle tanker will be boarded by a Jubilee Joint Venture-appointed Mooring Master before proceeding to the loading position with the FPSO *Ohdoh*. Two tugs will assist the shuttle tanker in mooring to the FPSO and maintaining its position (i.e., one tug attached to the tanker stern, another attached to the bow). The shuttle tanker will be moved into a bow-to-stern position with the FPSO at which time a 183 m-long mooring hawser will secure the two vessels in a tandem mooring configuration. The hawser is equipped with an emergency release system that will be manned during mooring and transfer. During cargo transfer operations, the bow tug will move off while the stern tug will remain attached to hold the tanker back from the FPSO (**Figure 3.13**). The FPSO and moored shuttle tanker will weathervane around the SPM turret.

Cargo transfer will occur via a 16-in. diameter, 183-m long transfer hose. The transfer hose terminates at the shuttle tanker end with butterfly valves and locking flanges. When not in use, the cargo transfer hose will be stored aboard the FPSO.

Once attached, export crude is pumped to the shuttle tanker by a combination of the FPSO's four steam turbine-driven cargo pumps. The FPSO is capable of completing the transfer of 1 million barrels of crude oil in 24 hours and production operations are able to continue during transfer.

The FPSO *Ohdoh* will not be equipped to receive dirty ballast water from incoming tankers. Shuttle tankers in the Jubilee Field for cargo transfers may only discharge clean ballast water meeting international guidelines. The FPSO has permanent, separate ballast tanks and there will be routine discharge of clean ballast water from the FPSO to maintain the proper draft during production and cargo loading cycles.

All cargo tanks are maintained in an inerted, pressurized state and the vapor space created in the storage tanks of the FPSO is filled with inert gas. The purpose of maintaining the inert condition of the void spaces in the storage tanks is to avoid the potential for a fire or explosion. Inert gas is supplied by the flue gas exhaust from the main uptake. The main gas-fired steam boiler is operated during cargo transfer to provide sufficient steam to the cargo pumps and also to provide inert gas to the storage tanks to fill the void of the offloaded crude. The export tankers also use inert gas to fill the void space that is displaced by incoming oil. All excess inert gas is vented during offloading operations. The inert gas emissions from the FPSO are dispersed via a cold vent line located on the gas flare tower.



Figure 3.13. Example of tandem offloading between a floating production, storage, and offloading (FPSO) vessel and shuttle tanker (From: Minerals Management Service, 2008).

Electrical Power Generation

The electrical power generation system aboard the FPSO will consist of three dual fuel turbine generator sets at a minimum as well as refurbished existing shipside essential diesel generators and one emergency diesel generator. The gas turbine generators will be located topsides and will typically have electrical specifications of 11.0 kV, 3-phase, 60 Hz. Precise specifications will be determined later during detailed engineering. Produced gas will supply fuel for turbine generators. Genset quantities and ratings will be determined based on equipment loading calculated from various loading conditions.

The low-voltage power distribution system located in the topsides electrical building(s) will supply power to topsides process consumers through power transformers. The shipside low-voltage power system will derive power from a dedicated shipside step-down power transformer. An emergency diesel engine power generator with output of 450 Vac, 3 phases, 60 Hz will be installed in a dedicated room located in a safe area above the uppermost continuous deck. Upon total blackout, the emergency loads will be automatically supplied with power from the emergency generator in a specified time required by class. Uninterruptable power supply (UPS) and battery back-up systems will supply power to critical loads during the transition and other periods when no AC generation is available.

The topside power generation system will comprise dual fuel turbine generators that can provide sufficient electrical power to serve the entire facility. The FPSO will also provide accommodations, safety systems, and all other systems necessary for safe, efficient operations.

3.4.5 Support Operations

Support vessels (e.g., crew and supply boats) will be required to support Phase 1 installation, drilling, and production operations. Helicopter support will also be necessary during installation, development drilling, and production operations. Vessel and helicopter requirements are detailed in **Table 3.4**.

The onshore support location will be Takoradi, Ghana, approximately 130 km inshore of the Jubilee Field. It is a major support base for Ghana's offshore oil industry. No new facilities or construction will be needed for support vessels or aircraft (helicopter) support for either installation or FPSO-shuttle tanker operational activities associated with Phase 1. However, with the anticipated and rapid expansion of Sekondi-Takoradi resulting from Ghana's offshore oil and gas activities, there appear to be numerous opportunities for local enterprises to provide support services to the oil and gas sector, including Jubilee Joint Venture. Further, MI Drilling Fluids is expected to construct a support base at Sekondi-Takoradi to support Phase 1 operations. Jubilee Joint Venture estimates that an additional 10 to 12 major service companies will be opening offices in Sekondi-Takoradi to support broader oil and gas operations offshore Ghana, including the Phase 1 development. Jubilee Joint Venture currently projects that half of these service companies rent existing space, while the other half will build facilities to support development. Supplies that may be purchased locally include fresh water, fuel, and food. Otherwise, little or no use of local resources is expected during the project.

Table 3.4. Summary of vessel and helicopter support requirements for Jubilee Field, Phase 1 development.

Phase	Number Required	Candidate Vessel or Aircraft Characteristics	Frequency (Round Trip Per Day)
Drilling			
MODU	2	17 wellsites; MODU set on five well centres plus four individual wells; 26 d to drill, 34 d to complete each well	NA
AHV/AHTS	2	60 to 75 m in length; 10,000 hp	NA
Support vessel	4	185-ft workboat; 8,500 hp; two per MODU; 266 d supporting <i>Blackford Dolphin</i> ; 1,092 d supporting <i>Eirik Raude</i> DP	1
Helicopter	1	Sikorsky S-76, S-61, or S-92; Eurocopter AS332, EC 155, AS365; Bell 212, 412	4
FPSO and Infrastructure Installation			
AHV/AHTS	1	60 to 75 m length; 10,000 hp	NA
Tow-in vessel	3-5	Length variable; 4,200 to 7,000 hp	NA
Support vessel	2	185-ft workboat; 8,500 hp	1
Pipelay vessel	1	20,000 hp	NA
Umbilical vessel	1	16,000 hp	NA
Helicopter	1	Sikorsky S-76, S-61, or S-92; Eurocopter AS332, EC 155, AS365; Bell 212, 412	1
Production			
FPSO	1	Single hull, 261,212 dwt (prior to FPSO conversion) VLCC; 330-m length; 59-m beam	NA; moored
Support vessel	1	185-ft workboat; 8,500 hp	1
Shuttle tanker	1	1 Mbbl	NA
Tug assist	2	4,200 hp; used as needed during mooring	NA
Helicopter	1	Sikorsky S-76, S-61, or S-92; Eurocopter AS332, EC 155, AS365; Bell 212, 412	2

AHV/AHTS = anchor handling vessel/anchor handling tug supply; bbl = barrel; DP = dynamically positioned; dwt = dead weight ton; FPSO = floating production, storage, and offloading vessel; Mbbl = thousand barrels; MODU = mobile offshore drilling unit; VLCC = very large crude oil carrier.

Initial MODU anchoring and subsequent relocations will be supported by two AHV/AHTS until dynamic positioning is required (i.e., as field infrastructure is installed). To date, Gulf Offshore UT 722L anchor handlers *Highland Courage* and *Highland Valour* have been contracted by Tullow Oil for five wells plus three option wells offshore Ghana. The vessels will work supporting the semisubmersible *Blackford Dolphin*.

Once anchored or positioned on site, a total of two work boats will support each MODU for logistics, making at least one round trip per day between the shorebase and the drilling rig. One helicopter also will be dedicated to the project for personnel movement and other trips as needed to transport critical equipment to the MODUs. The helicopter is assumed to make four round trips per day during drilling. Support vessels and helicopters will normally follow the most direct route between the wellsites and the onshore base, weather and traffic permitting.

Once the FPSO has been installed and begins operations, a single work boat will visit the FPSO on a daily basis. In addition, two helicopter trips to the FPSO will be required daily.

3.4.6 Decommissioning

Decommissioning is the process of dismantling production and transportation facilities and restoration of depleted producing areas in accordance with license requirements and/or regulations. Various methodologies have been developed to remove offshore production facilities structures during decommissioning (Kaiser et al., 2005). These methods are generally grouped and classified as either explosive or nonexplosive, and they can be deployed and operated by divers, remotely-operated vehicles (ROVs), or

from the surface. Factors considered by operators in selecting a method include the target size and type, water depth, economics, environmental concerns, and weather conditions.

Once the economic life of the Jubilee Field has been reached, the field will be abandoned. The field will be abandoned in accordance with widely accepted abandonment practices and procedures such as those used in the Gulf of Mexico. Following the abandonment of all wells, the subsea and surface facilities a final environmental survey will be performed to insure that all aspects of the abandonment have been carried out in accordance with the procedures.

For offshore pipelines, the most common international practice is to abandon the pipeline in place (Scandpower Risk Management Inc., 2004). Prior to abandonment, pipelines are purged until hydrocarbon levels are undetectable. In some cases, after the pipeline is purged, the pipe may be recovered as scrap.

The wells will be individually abandoned using a drilling rig or well service vessel depending on the requirements. In each well, cement and mechanical plugs will be installed to ensure that no hydrocarbons will be released into the environment. All subsea flow lines and manifolds will be flushed of hydrocarbons and abandoned in place. Where required, equipment that could possibly interfere with marine or fishing activities will be removed. The surface facilities (FPSO) will be removed along with associated mooring equipment, as required.

The abandonment of each well will require approximately 16 days to complete. Two of the 16 days will be allocated to flush any residual hydrocarbons back to the FPSO for proper disposal.

3.5 Impact Producing Factors

Impact producing factors associated with Phase 1 activities will include emissions, discharges, noise, solid waste, seafloor disturbance and areal exclusion, and personnel requirements and local employment. These factors are detailed in the following text.

3.5.1 Emissions

Phase 1 activities, including MODU installation, operation, and relocation; FPSO facility installation and operation; shuttle tanker operation, flowline and umbilical installation; and support vessel and helicopter operations will emit significant quantities of greenhouse gases (GHGs) and varying amounts of other pollutants such as carbon monoxide (CO), oxides of nitrogen (NO_x) and sulfur (SO_x), volatile organic compounds (VOCs), and particulate matter.

Table 3.5 outlines projected emissions of criteria pollutants (PM, SO_x, NO_x, VOCs, and CO) from MODU installation, operation (drilling and completion), and relocation; FPSO facility installation, commissioning and start-up, and operation; flowline and umbilical installation and testing; and support vessel and helicopter operations for all phases of Phase 1 activities. Estimated GHG emissions are provided in **Table 3.6**. Emission factors for CO₂ and CH₄ for diesel fuel and natural gas were taken from Wilson et al. (2007); to calculate CO₂ equivalence, CH₄ emissions were multiplied by a factor of 21 (MMS, 2007a). Detailed spreadsheets are provided in **Appendix D**.

Table 3.5. Estimated air pollutant emissions for the Jubilee Field, Phase 1 development.

	Duration	Estimated Emissions (tons)				
		PM	SO _x	NO _x	VOC	CO
Drilling/completion (<i>Eirik Raude</i>)	1,092 d	626.22	2872.79	21526.35	645.79	4696.66
Drilling/completion (<i>Blackford Dolphin</i>)	266 d	106.61	489.06	3664.64	109.94	799.56
Flowline/injector/umbilical installation	90 d	33.87	155.40	1164.45	34.93	254.06
FPSO installation	92 d	14.58	66.89	501.19	15.04	109.35
Production	Annual	92.07	406.01	3160.22	917.46	732.86

CO = carbon monoxide; FPSO = floating production, storage, and offloading; NO_x = oxides of nitrogen; PM = particulate matter; SO_x = sulfur; VOC = volatile organic compound.

Table 3.6. Estimated greenhouse gas emissions for the Jubilee Field, Phase 1 development.

	Duration	Estimated Emissions (tons)		
		CO ₂	CH ₄	CO ₂ equivalent*
Drilling/completion (<i>Eirik Raude</i>)	1,092 d	1,029,742.34	58.71	1,030,975.21
Drilling/completion (<i>Blackford Dolphin</i>)	266 d	175,303.10	9.99	175,512.98
Flowline/injector/umbilical installation	90 d	55,703.02	3.18	55,769.71
FPSO installation	92 d	23,975.25	1.37	24,003.95
Production	Annual	160,679.09	9.16	160,871.47

* CH₄ was assumed to have a CO₂ equivalence of 21 (MMS, 2007a).

CH₄ = methane; CO₂ = carbon dioxide; FPSO = floating production, storage, and offloading.

3.5.2 Discharges

Discharges associated with installation, drilling, and production activities will include:

- MODU: drilling fluids and cuttings from production well drilling, gray and black water, bilge water, deck drainage, ballast water, cooling water, produced water, garbage, and miscellaneous waste discharges (such as BOP fluid and cement slurry);
- FPSO: gray and black water, bilge water, deck drainage, ballast water, storage displacement water, cooling water, produced water, garbage, and miscellaneous waste discharges;
- Installation vessels: gray and black water, bilge water, deck drainage, ballast water, cooling water, garbage, and miscellaneous waste discharges; and
- Shuttle tankers: gray and black water, bilge water, deck drainage, ballast water, cooling water, garbage, and miscellaneous waste discharges.

The following text separately characterizes drilling discharges and other routine discharges.

3.5.2.1 Drilling Discharges

Drilling fluids are a complex mixture of clays, chemical additives, freshwater, and/or seawater that are used to lubricate and cool the drill bit, flush out cuttings, control formation pressures, seal permeable formations, and maintain well bore stability. Drilling fluids will be required to drill production and injection wells.

Jubilee Joint Venture proposes the use of both water-based fluids (WBFs) and an EMOBF. WBFs, consisting of fresh or salt water, barite, clay, caustic soda, lignite, lignosulfonates, and/or water-soluble polymers, will be used in the upper sections of the well bore (i.e., during initial spudding and upper section drilling, down to approximately 500 m below the mudline). Mineral oil based fluids typically contain barite, clays, emulsifiers, water, calcium chloride, lignite, and lime.

Jubilee Joint Venture has selected Versaclean, an EMOBF, for its drilling program and intends to use this fluid for mid- and lower sections of each well, from approximately 500 m below the mudline to the bottom of each hole (approximately 2,500 m). Versaclean employs Escaid 120 as its base oil at a 75:25 OWR (oil:water ratio). The base oil is a highly refined mineral oil that has low aromatic content and low toxicity. The EMOBF will be recovered and returned to the vendor for recycling; it will not be discharged except for small amounts adhering to cuttings.

Appendix C presents an alternatives analysis explaining the drilling fluid selection process and the options considered for drilling fluid and cuttings disposal.

A typical well plan for Phase 1 wells was described in **Section 3.4.1**. Jubilee Joint Venture indicates that a typical Phase 1 well will have a TVD of approximately 3,500 m, or approximately 2,500 m below the mudline (i.e., 2,450 m for Upper Mahogany; 2,650 m for Lower Mahogany). Each well will require 26 days to drill. Formation evaluation will be conducted for each well, will consist of logging-while-drilling (LWD) in the 12-1/4-in. hole section, and will include gamma-ray, neutron-density, resistivity, and annular pressure measurements while drilling with the option to run formation pressure while drilling.

Cuttings will be discharged continuously during drilling. Cuttings being discharged while using this drilling fluid system will have an oil retention range of 6% to 8%, with a maximum of 8%. Both MODUs will use a cuttings dryer to minimise retention on cuttings. As noted in **Appendix C**, a cuttings dryer can, in some cases, reduce drilling fluid retention to below 5%. Discharge to the ocean will be at a rate of 0.2 to 2.0 m³/h (53 to 530 gal/h). Solids to be discharged from each well are expected to comprise 1,014 bbl (161.1 m³) of water-based drilling fluids, 1,497 bbl (237.8 m³) of cuttings drilled with WBF, and 1,478 bbl (235 m³) of cuttings and residual EMOBF. Cuttings will account for 2,975 bbl, or about 400 metric tonnes per well (**Table 3.7**).

Table 3.7. Estimated drilling fluid and cuttings discharge volumes for a Phase 1 well
(From: Kosmos Energy, LLC, 2008).

Interval (bit size, inches)	Depth Below Mud Line (m)	Fluid Type	Estimated Discharges			Discharge Location
			Drilling Fluids	WBF Cuttings	EMOBF Cuttings	
36	0 – 72	Seawater with viscous sweeps	39 bbl (6.1 m ³)	302 bbl (48 m ³)	0	Seafloor
26	72 – 500	Seawater with viscous sweeps	975 bbl (155 m ³)	1,195 bbl (190 m ³)	0	MODU
17.5	500 – 1,400	EMOBF	0	0	925 bbl (147 m ³)	MODU
12.25	1,400 – 2,500	EMOBF	0	0	553 bbl (88 m ³)	MODU
Total:			1,014 bbl (161.1 m³)	1,497 bbl (237.8 m³)	1,478 bbl (235 m³)	

MODU = mobile offshore drilling unit; EMOBF = enhanced mineral oil-based fluid; WBF = water-based fluid.

3.5.2.2 Routine Discharges

The MODU, FPSO facility, and associated support vessels will produce a series of discharges including black water, gray water, produced water, and miscellaneous discharges (i.e., bilge water, deck drainage, and cooling water). MODU and associated support vessel discharges will cease following completion of well drilling operations. FPSO discharges will continue for the life of the Phase 1 development.

Black and Gray Water

Black water (i.e., sewage or sanitary waste), consisting of human body wastes from toilets and urinals, will be treated using a marine sanitation device that produces an effluent with a minimum residual chlorine concentration of 1.0 mg/L and no visible floating solids or oil and grease. Wastewater treatment sludge will be transported to shore for disposal at an approved facility.

Gray water (i.e., domestic waste) includes water from showers, sinks, laundries, galleys, safety showers, and eye-wash stations. Gray water does not require treatment before discharge.

All Phase 1 vessels – MODUs, FPSO, installation and support vessels – will be equipped with an approved marine sanitation device. Food waste, a type of domestic waste, will be ground prior to discharge, in accordance with MARPOL requirements.

It is assumed that one person generates 100 L/d of sanitary waste and 220 L/d of domestic waste. It is predicted that sanitary wastes have an associated biological oxygen demand (BOD) of 240 mg/L. BOD estimates for domestic waste are extremely variable and significantly lower than that measured for sanitary waste. Assuming a maximum crew complement of 120 persons (i.e., maximum manning levels), Phase 1 facilities may be expected to generate about 12,000 L of sanitary wastewater (resulting in 2.9 kg of BOD) and 26,400 L of domestic waste on a daily basis.

Produced Water

Produced water includes formation water, injection water, and process water that are extracted along with oil and gas during oil and gas production. Produced water includes water that accompanies the hydrocarbon being produced (formation water)

and water created through the injection of seawater into the formation to provide necessary pressure to access oil as the reservoir is drawn down during the life of a project (injection water). Produced water is usually discharged back into the marine environment or it may be reinjected. Produced water is normally warmer than the receiving environment and typically contains residual oil from the formation. Organics contained within produced water may include benzene, toluene, and xylenes (BTEX); naphthalenes (naphthalene, C1- through C3-naphthalenes); phenanthrenes (phenanthrene, C1- through C3-phenanthrenes); dibenzothiophenes (dibenzothiophene, C1- through C3-dibenzothiophenes); acenaphthylene; acenaphthene; fluorine; fluoranthene; pyrene; chrysene; benz(a)anthracene; benzo(a)pyrene; benzo(ghi)perylene; benzo(k)fluoranthene; and phenols (phenol, C1- through C7-phenols). Produced water may also contain a range of organic acids (e.g., formic, acetic, propionic, butyric, valeric, and caproic acids), methanol, trace metals (barium, cadmium, copper, iron, mercury, and zinc), and radionuclides.

Toxicity of produced water is related to its chemical composition, both of which vary widely, ranging from nontoxic to toxic. Causative agents of observed toxicity in produced water are not well known. It has been theorized that toxic responses may be related to extremely high dissolved solids (salinity) concentrations, altered ratios of seawater ions, elevated ammonia (Moffitt et al., 1992), hydrocarbons, hydrogen sulfide, and volatile compounds (Sauer et al., 1992).

Volumes of discharged produced water can be extremely variable, depending upon the maturity of the producing formation, the type of hydrocarbon being produced, the volume of water required for injection, and the rate of hydrocarbon production realised at the offshore facility. Jubilee Joint Venture projects very low produced water generation rates during the early stages of Jubilee Field production.

Deck Drainage

Deck drainage consists of all waste resulting from rainfall, rig washing, deck washings, tank cleaning operations, and runoff from curbs and gutters, including drip pans and work areas. MODUs and the FPSO have been designed to contain runoff and prevent oily drainage from being discharged. Deck drainage that may contain oil is diverted to separation systems depending on the area collected. There will be no discharge of free oil in deck drainage that would cause a film, sheen, or discoloration of the surface of the water, or a sludge or emulsion to be deposited beneath the surface of the water. Only nonoily water (42 mg/L maximum, 29 mg/L, monthly average) will be discharged overboard. If the deck becomes contaminated, oily deck drainage will be contained by absorbents or collected by a pollution pan for recycling and/or disposal.

The volume of deck drainage varies with the amount of rainfall and differences in deck surface area (e.g., between MODUs and FPSO). Assuming a typical surface area of about 10,000 m² for either MODU and a maximum monthly rainfall of about 170 mm, the monthly average deck drainage from a single MODU would be 1,700 m³ (1.7 x 10⁶ L). During the period when both MODUs are on site within the Jubilee Field, total average deck drainage would be 3,400 m³. When only the *Eirik Raude* or *Blackford Dolphin* is on site, deck drainage would be 1,700 m³. Assuming a surface area of 20,000 m² for the FPSO and a similar maximum monthly rainfall amount, the monthly average deck drainage would be 3,400 m³ (3.4 x 10⁶ L). Rig washes may account for an additional 200 L (approximately) per month.

Miscellaneous Discharges

Additional miscellaneous discharges typically occur from numerous sources on a MODU or FPSO. Examples include uncontaminated freshwater and seawater used for cooling water and ballast, desalination unit discharges, blowout preventer fluids, and boiler blowdown discharges (U.S. Environmental Protection Agency [USEPA] 1993). These discharges must meet MARPOL requirements and are expected to be diluted rapidly in the open ocean.

Cooling Water

Most modern diesel propulsion and auxiliary engines installed on support vessels are fresh water cooled – water coolant is circulated in a closed-loop piping system around the engine block and cylinder heads, and then cooled by a heat exchanger. Typical heat exchangers include keel coolers or grid coolers built into the vessel hull. Heat exchange is accomplished by indirect contact with ambient seawater that is exterior to the hull and cooler in temperature. There is no thermal discharge into the marine environment.

Older vessels may operate with a “once-through” cooling water arrangement, typical on larger deep-draft vessels. Once-through cooling utilises the intake of raw seawater through a sea chest. Water is then circulated around the engine before it is discharged back into the environment. Vessels outfitted with once-through water cooling arrangements would have varying rates of discharge depending on the engine make/size and cooling water piping arrangement. ENSR Corporation (2007) characterizes a typical marine diesel propulsion engine – Caterpillar 3516B (3,384 brake horsepower [bhp] [2,525 kW] at 1,800 revolutions per minute – as using 0.264 gallons per minute (gpm) of cooling water per engine. Using the heat transfer/cooling water requirements for this engine as the basis for extrapolation to other diesel engines, the approximate discharge rates of once-through engine-cooling water for diesel engines would be:

- Idle: 0.0615 gpm per bhp
- 50% load: 0.0936 gpm per bhp
- 90% load: 0.1311 gpm per bhp

For example, a 3,000 hp vessel idling would discharge approximately 185 gpm of engine-cooling seawater; at 50% load and at 90% load, this volume would increase to 281 and 393 gpm (1,064 and 1,488 L/min), respectively.

Bilge Water

Support vessels will occasionally discharge treated bilge water. These vessels must comply with the applicable sections of MARPOL. Under these regulations, water must be retained onboard until it could be discharged to an approved reception facility, unless it is treated by approved oily water separators (OWS) and monitoring equipment before being discharged to the sea. Vessels must employ approved equipment, examined and tested in accordance with the specifications and requirements contained in Part I of the annex to IMO Resolution MEPC.60 (33), *Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships*.

OWS discharge rates vary depending on vessel size. Regarding throughput capacity, standard bilge OWS units are sized at 5, 10, 25, and 45 gpm, or larger. Models are

available to fit almost any bilge arrangement, and combinations of these sizes, could be used to closely match the needs of a particular vessel.

Storage Displacement Water

Storage displacement water is seawater that is pumped into and out of oil storage chambers (either through mechanical or natural [gravity] means) on certain types of production installations during oil production and offloading operations. Storage displacement water that is discharged should be treated to reduce its oil concentration to an acceptable level (e.g., 15 mg/L or less).

Brine Discharge

Brine generated from reverse osmosis during freshwater generation will be discharged overboard. Brine discharges are estimated at 30 to 100 bbl/d.

Summary of Discharges

A summary of project-related discharges, exclusive of drilling discharges, is presented in **Table 3.8**. Most discharges will occur overboard either while on site (e.g., MODU, FPSO, or shuttle tanker) or while the vessel is in transit (shuttle tanker and support vessels). All discharges will be treated and/or monitored according to applicable standards, protocols, or regulations.

3.5.2.3 Seawater Usage

Seawater usage, as detailed previously for cooling water, freshwater generation, and storage displacement as part of miscellaneous discharges, also includes ambient seawater uptake for water injection and fire system testing. Seawater will be drawn from below the FPSO and processed via desulfination prior to injection (**Table 3.9**). Injection water will not be discharged. Water injection will be minimal at start-up, increasing over time. Maximum injection rate of conditioned seawater is estimated at 1,534 m³/h, or 232,000 bbl/d. Other seawater uses will include cooling water and storage displacement water, as detailed previously. Seawater will also be used to generate freshwater.

Table 3.8. Summary of mobile offshore drilling unit (MODU); floating production, storage, and offloading (FPSO) facility; and associated support vessel discharges associated with Phase 1 operations, exclusive of drilling fluids.

Discharge and Source	Treatment	Discharge Point(s) and Location	Discharge Volume and Comments
Black water	Maceration and chlorination	Single; holding tank storage; discharge overboard	Total volumes variable, depending upon number of personnel; no visible floating solids or discoloration of surrounding water allowed, per Annex IV MARPOL; black water discharges estimated at 100 L per person per day (26 gal or 0.1 m ³ per person per day) <u>Drilling</u> : MODU: 100 personnel, 11,400 L/d; Support Vessels (AHTS and work boat): 52 personnel, 5,928 L/d <u>FPSO Installation</u> : FPSO and support vessels: 200 personnel, 22,800 L/d <u>Flowline/Umbilical/Injection Line Installation</u> : 3 vessels, est. 60 personnel, 6,840 L/d <u>FPSO Operations</u> : 120 personnel (maximum), 12,000 L/d; Support Vessels, installation: 26 personnel, 2,964 L/d; <u>Shuttle Tanker</u> : est. 50 personnel, 5,700 L/d
Gray water	Remove floating solids	Single; holding tank storage; discharge overboard	Total volumes variable, depending upon number of personnel; no visible floating solids or discoloration of surrounding water allowed, per Annex IV MARPOL; gray water discharges estimated at 220 L per person per day (58 gal or 0.22 m ³ per person per day) <u>Drilling</u> : MODU: 100 personnel, 18,900 L/d; Support Vessels (AHTS and work boat): 52 personnel, 9,828 L/d <u>FPSO Installation</u> : FPSO and support vessels: 200 personnel, 37,800 L/d <u>Flowline/Umbilical/Injection Line Installation</u> : 3 vessels, est. 60 personnel, 11,340 L/d <u>FPSO Operations</u> : 120 personnel (maximum), 26,400 L/d; Support Vessels, installation: 26 personnel, 4,914 L/d; <u>Shuttle Tanker</u> : est. 50 personnel, 9,450 L/d
Produced water	Oil-water separation	Single; holding tank storage; discharge overboard	FPSO: Low levels during initial production; maximum of 160,000 bbl/d MODU, Shuttle Tanker, Support Vessels: None
Deck drainage	Oil-water separation	Single, discharge overboard	Deck drainage water generation variable, depending upon facility and vessel characteristics, rainfall amounts; discharge volumes variable; 42 mg/L (maximum) or 29 mg/L (monthly average) o/w threshold. MODU, FPSO, shuttle tanker: 100 bbl/d (est.)
Bilge water	Oil-water separation	Single, discharge overboard	Bilge water generation variable, depending upon facility and vessel characteristics; discharge volumes variable; 42 mg/L (maximum) or 29 mg/L (monthly average) o/w threshold. MODU: 240 bbl/d (est.); FPSO: 110 bbl/d (est.); Support Vessels: 110 bbl/d (est.); Shuttle Tanker: 100 bbl/d (est.)
Cooling water	None	Single, discharge overboard	Pass-through cooling water for internal combustion engines; volumes variable.
Brine	None	Single, discharge overboard	Brine generated during freshwater generation; volumes variable. MODU: 30-100 bbl/d; FPSO: 30-100 bbl/d; Support Vessels: NA; Shuttle Tanker: 30-100 bbl/d

Notes: Discharge overboard while on site (MODU, FPSO, shuttle tanker, support vessels) or in transit (shuttle tanker, support vessels). Estimates (est.) derived from Cascade-Chinook project ocean discharge estimates (Minerals Management Service, 2008).

AHTS = anchor handling tug supply; MARPOL 1973/1978 = International Convention for the Prevention of Pollution from Ships; o/w = oil in water.

Table 3.9. Seawater injection water characteristics (From: Kosmos Energy, LLC, 2008).

Parameter	Rate/Limit
Maximum injection rate	1,534 m ³ /h; 232,000 bbl/d
Oxygen removal	10 ppb, maximum
Desulfination system	Yes
Sulfate content	50 mg/L
Maximum particle size	≤40 µm

3.5.3 Noise

The FPSO, MODU, installation vessels, shuttle tankers, and support vessels will introduce sound into the marine environment during their operation. Vessel noise is primarily attributed to propeller cavitation, propeller singing, and propulsion engines (i.e., noise transmitted through the vessel hull).

Cavitation is usually the dominant noise source according to Ross (1976, as cited in Richardson et al., 1995). The frequency spectrum of cavitation noise has been characterized as broadband noise consisting of sharp pulses that correspond with the propeller rotation frequency times the number of blades (Erbe and Farmer, 2000). Generally, as the size of the vessel increases, the sound level increases and the frequency of the sound decreases.

Vessel duty cycle will also influence noise levels. Support vessels operating in a standby mode, or at idle while loading or offloading equipment, personnel, and supplies, will generate lower sound levels than while operating at or near full power (e.g., during transit). Supply boat noise ranges from 170 to 180 dB re 1 µPa at 1 m, with predominant frequencies at 100 Hz.

Well drilling creates a maximum broadband noise (i.e., in the 10- to 10-kHz frequency range) level of 190 dB re 1µPa at 1 m. The level of drilling noise from any platform will, on occasion, increase temporarily when operations such as tripping (removing the drill string to remove and replace the drillbit) are performed; no references to quantitative measurements of these variations have been found. Measurements of noise from fixed production platforms showed strongest levels at low frequencies, between 4.5 and 38 Hz, as measured at ranges 9 to 61 m. Peak sound spectrum levels were at 50 to 200 Hz. Whitford (2007) noted that production machinery is generally located above the sea surface, with noise transferred to the water column not as prominent.

Additional noise is generated during oil production activities, including drilling and production operations support (e.g., supply vessels and helicopters), cementing, installation of borehole casing, perforating, and pumping. Supply boat noise ranges from 170 to 180 dB re 1 µPa at 1 m, with predominant frequencies at 100 Hz. Other production activities can generate source levels as high as 135 dB re 1µPa at 1 km from the source (Greene and Moore, 1995); Whitford (2007) calculated corresponding source levels as high as 195 dB re 1 µPa at 1 m, with peak levels in the 40 to 100 Hz range.

3.5.4 Solid Waste

Offshore oil and gas operations generate trash including paper, plastic, wood, glass, and metal. Most miscellaneous wastes are associated with galley and food service operations and with operational supplies such as shipping pallets, containers used for drilling fluids and chemical additives (sacks, drums, and buckets), and protective coverings used on mud sacks and drilling pipes (MMS, 2007b). Some personal items, such as hardhats and personal flotation devices, are occasionally and accidentally lost overboard. Generally, galley, operational, and household trash is collected and stored below deck. Drilling operations require the most supplies, equipment, and personnel, and therefore, generate more solid trash than production operations.

It is expected that all solid waste generated during production well drilling will either be incinerated aboard the MODU or FPSO, or transported to shore by service vessels for disposal at approved landfill facilities. Based on historical data for a typical drillship, monthly solid waste is expected to be about 40,000 kg.

Disposal of trash and debris in the ocean is prohibited under MARPOL, and drilling rigs operate under a Garbage Management Plan to ensure adherence to MARPOL. In addition, most petroleum companies have waste management programs that apply the principles of source reduction, reuse, and recycling to reduce the amount of waste generated.

3.5.5 Seafloor Disturbance and Areal Exclusion

While two MODUs will be drilling in the Jubilee Field, only one will use bottom-founded anchors for station keeping. The *Eirik Raude* will be in DP mode for the duration of its operations on the Jubilee Field. The *Blackford Dolphin* is equipped with eight anchors, each with approximate dimensions of 6.4 by 6.9 m. Anchor chain touchdown will also disturb sediments during anchor deployment and anchor set; the area potentially affected by touchdown may measure 10 m wide and as much as 100 m long. The *Blackford Dolphin* is slated to drill and complete four wells, indicating the anchor deployment will be required three times (i.e., at Drill Centres P1, P5, and G1).

The FPSO *Ohdoh* mooring will use a total of nine anchors, clustered in three groups of three. The areal extent of seafloor disturbance caused by anchors and anchoring is related to the size and configuration of the anchor and mooring system, the length of chain or mooring lines that may rest on the bottom, and the swing arc that a chain could have as a result of currents or winds. A conservative, estimated seafloor disturbance footprint for each anchor and the swing arc of its mooring line is approximately 5 ac (2 ha), per MMS (2008). An additional area of seafloor will be disturbed by the installation of subsea production facilities, such as manifolds, trees, umbilicals, flowlines, injector lines, and riser bases, as well as the FPSO turret mooring and anchors. A summary of Phase 1 facilities and its expected footprint on the seafloor or sea surface areal exclusion is provided in **Table 3.10**.

Table 3.10. Seafloor disturbance and surface area exclusion for the Jubilee Field, Phase 1 facilities offshore Ghana, West Africa.

Facility	Dimensions (m)	Total Seafloor Affected (ha)	Surface Area Excluded (ha)
MODU			
MODU	<i>Eirik Raude</i> : 119.38 (l) x 85.5 (w); 23.75 operating draft <i>Blackford Dolphin</i> : 108.3 (l) x 84.1 (w)	NA	<i>Eirik Raude</i> : 0.0102; <i>Blackford Dolphin</i> : 0.0091; 500-m radius safety zone (80 ha) possible
Anchors (8)	<i>Eirik Raude</i> : DP capable <i>Blackford Dolphin</i> : 8 anchors est. dimensions of 6.4 x 6.9, nominal; wire/chain combination	<i>Eirik Raude</i> : None, DP mode only <i>Blackford Dolphin</i> : 353 (est.) per set 3 sets: 0.1	NA
Anchor Chain Touchdown	10 x 100 per anchor, variable	0.8 (est.) per set (8 anchors); 3 sets: 2.4	NA
FPSO Facility			
FPSO <i>Ohdoh</i>	330 x 59	NA	34.21
SPM	50-m radius	See Anchors	0.80
Anchors (9), including Anchor Chain Touchdown	VLA or suction pile anchors; dimensions TBD during FEED	18 (2 ha per anchor, per MMS, 2008)	NA
Shuttle Tanker, moored	250 (l) x 50 (w) (est.)	NA	105.7 (includes FPSO)
Production Wells (9)			
Manifolds (5)	6.1 x 9.1, with suction piles measuring 4.6-5.2 in diameter	.0005 x 56 = 0.028	NA
Trees/Production Wells (9)	4.4 x 4.4	.0005 x 20 = 0.010	NA
Water Injection Wells (5)			
Manifolds (2)	6.1 x 6.1, with suction piles	.0002 x 37 = 0.0074	NA
Trees/Injection Wells (5)	4.4 x 4.4	.0002 x 20 = 0.0040	NA
Gas Injection Wells (3)			
Manifolds (1)	6.1 x 6.1, with suction piles	.0002 x 37 = 0.0074	NA
Trees/Injection Wells (3)	4.4 x 4.4	.0002 x 20 = 0.0040	NA
Flowlines, Injector Lines, Umbilicals and Risers/Riser Bases			
Production	29,669 m of 10-in. flowlines	0.75	NA
Water Injection	10,724 m of 10-in. water injection lines	0.27	NA
Gas Injection	3,024 m of 8-in. gas injection lines	0.06	NA
Umbilicals	19,843 m of 8-in. umbilicals	0.40	NA
Risers (10) and Riser Bases (3)	Riser Base: 100 m x 24 m (est., Ceiba Field)	0.72	NA
SDUs	10 m x 10 m (est.) ; 3 units	0.03	NA
Total		22.79	220

DP = dynamically positioned.

FPSO = floating production, storage, and offloading.

MMS = Minerals Management Service.

MODU = mobile offshore drilling unit.

SPM = single position mooring.

FEED = front end engineering design.

SDU = subsea distribution unit.

3.5.6 Personnel Requirements and Local Employment

Trained personnel normally accompany drilling rigs and support vessels under contract. Similarly, the FPSO will be manned by trained operators, technicians, engineers, and vessel crew. Jubilee Joint Venture has estimated the personnel manning levels for the specific vessels and Phase 1 stages (i.e., drilling from the MODUs, installation and operation of the FPSO and shuttle tanker, and support operations), as summarized in **Table 3.11**. Projected local content is also noted.

Table 3.11. Summary of personnel requirements, by stage.

Stage of Phase 1 Activity	Duration (months)	Manning Level	Local Content Target (%)
Drilling			
MODU <i>Eirik Raude</i>	24	50	10
Anchor Handler #1	24	10	10
Work Boat #1	24	6	10
Work Boat #2	24	6	10
MODU <i>Blackford Dolphin</i>	8	50	0
Anchor Handler #2	8	10	0
Work Boat #1	8	6	0
Work Boat #2	8	6	0
Onshore Support			
Port Support – marine	Duration	40	80
Aviation Support	Duration	20	30
Service Company Support	24	200	50
FPSO Installation			
FPSO field installation spread, commissioning and start-up	3	200	10
FPSO Operation (Production, Oil Transfer)			
FPSO Production Phase	Duration	50	20
FPSO Anchor Handler	Duration	10	10
FPSO Work Boat	Duration	6	10
In-country management and administrative support	Duration	20	50

Notes:

- (1) Duration denotes the need for designated manning levels for the entire stage of the project; e.g., duration of Port Support – Marine will be for the life of the project, until reserves are depleted, or 10 years minimum inclusive of drilling, installation, and production.
- (2) Services Company Support – five major services companies supporting drilling and completion activities on Phase 1 wells.
- (3) Local content target – indicates a target level for local employment; actual levels will be dependant upon available personnel and training results.

FPSO = floating production, storage, and offloading.

MMS = Minerals Management Service.

3.6 Contingency and Safety Plans

The Jubilee Joint Venture is committed to premier performance in EHS during design, construction, installation, and operation of the proposed Jubilee Field, Phase 1 development. They will conduct their business with respect and care for their employees, contractors, communities, and the environment in which they operate. Their goal is to create enduring value by practicing stewardship through corporate social responsibility and operating in an environmentally sustainable manner.

Many of the pollution prevention capabilities of the Jubilee Field, Phase 1 development project have been built into the design and execution of the project. Kosmos and its joint venture partners have employed, and will continue to employ, proven concepts, systems and technologies in order to simplify the Phase 1 development process and ensure operational reliability. This portion of the project description provides a general discussion of design capabilities and contingency and safety plans being developed to methodically and efficiently address safety issues.

3.6.1 Design Capabilities

3.6.1.1 Well Design and Wellheads

The wellbores have been designed and equipped with materials and equipment that represent generally accepted standards of the petroleum industry. Materials such as cement, gravel packing materials, and well completion and stimulation fluids are designed for the wellbore conditions found in the Jubilee Field. The wellbore equipment, such as casing, tubing, packers, and downhole safety devices (surface-controlled subsurface safety valve [SCSSVs]) have been selected by Kosmos and its contractors to be "fit for purpose" and capable of withstanding all expected well conditions. The SCSSV (located in the well below the ocean bottom) is controlled by subsea and FPSO safety control systems that will shut the valve in the event of a major problem in the well or process. Well drilling and completion practices include provisions to test the operability of all equipment prior to initiating well production.

The subsea wellhead equipment has been selected for its operational reliability and design specifications, which also represent generally accepted standards of the petroleum industry. The wellhead also uses safety control systems to shut off the flow of hydrocarbons from individual wells in the event of an emergency or operational upset. The subsea wellhead and control systems were manufactured by industry-leading companies in the U.S. and Europe and will be tested during installation and start-up.

3.6.1.2 Subsea Flowlines and Risers

Kosmos and its partners will employ generally accepted standards of the petroleum industry used in designing and manufacturing the subsea pipe, flexible flowlines/risers and electro/hydraulic umbilicals. Development of the subsea infrastructure was specifically conducted to accommodate the anticipated environmental conditions of the Jubilee Field, as well as current and future development activity. Leading manufacturers and proven equipment were selected for this development. All subsea lines are to be tested during the installation and hookup process.

3.6.1.3 Process Facilities and Topsides

The processing facilities to be outfitted aboard the FPSO have been designed and will be installed according to generally accepted standards of the petroleum industry. Kosmos, in conjunction with its FPSO contractor MODEC, have chosen proven concepts and technologies for the processing equipment. The processing equipment is protected by safety systems that monitor critical information and activate process controls to reduce the risks of accidents and injuries. All operational controls and safety systems implemented within the processing equipment are based on

international safety system design standards and generally accepted operations practices and standards for the offshore oil and gas industry.

The drain system on the processing deck consists of both open and closed drain systems. The open drain system collects storm water and washdown water in the processing area and directs it to the slop oil tanks for oil/water separation and recycling through the processing facility. Decanted water will be discharged in accordance with acceptable discharge limitations. The closed drain collects oily fluids from equipment drains and various points in the processing area. The closed drain fluids are drained or pumped to the cargo tank.

3.6.1.4 Crude Storage

During the conversion and recommissioning of the FPSO, all crude oil storage tanks will be cleaned, inspected, and recoated with anti-corrosive compounds. The ship will be classed by an appropriate international classification organisation (e.g., Detnorskeveritas) and rated for a 20-year life.

3.6.1.5 Shuttle Tanker Operations

All crude oil transfers from the FPSO to a moored shuttle tanker will be governed by the Jubilee Field Marine Terminal Regulations currently being developed. These regulations provide for strict controls over all vessel activities, including shuttle tankers, attending vessels, and miscellaneous marine traffic. The Marine Terminal Regulations will be based on international guidance, including the International Safety Guide for Oil Tankers and Terminals, and will be designed to ensure all parties involved maintain a high degree of safety and emergency preparedness during oil transfer.

3.6.1.6 General Pollution Risks from an FPSO

Use of FPSO systems during the past several decades has evolved to incorporate advancing material and design technologies, as well as increasing experience in conducting successful operations at greater ocean depths, in harsh environments, and at remote locations. Given the technological advances and accumulated operational experience regarding the use of FPSO systems, the oil industry considers FPSOs to be an appropriate and viable means for developing deepwater areas.

Analysis of FPSO operations worldwide has resulted in the following determinations:

- A 1999 review of FPSO historical data worldwide identified 97 ongoing or completed FPSO operations – a combined total of 460 years of FPSO service and processing of an estimated 6.4 billion barrels of crude oil.
- Spill information for 20 operations represents a combined total of 119 years of FPSO service, production of 1.6 billion barrels of oil, and a combined total of 206 reported oil spills totalling 4,641 barrels of oil (i.e., 2.9 barrels spilled for every 1 million barrels produced).
- By comparison, platform operations monitored since 1980 in the U.S. Gulf of Mexico have produced approximately 5.5 billion barrels of crude oil and spilled 61,500 barrels, or 11.2 barrels spilled for every 1 million barrels produced.

Given the technological advances and accumulated operational experience regarding the use of FPSO systems, the oil industry considers FPSOs to be an appropriate and environmentally safe means for developing deepwater areas.

3.6.2 Contingency and Safety Plan Development

The following plans and procedures are currently under development and will be utilised by the Jubilee Joint Venture, Kosmos, the drilling contractors, FPSO contractor, and all other contractors employed for this project. Maintenance and training will be completed by the appropriate plan holder.

3.6.2.1 MODU Operation Bridging Document

The Bridging Document compares the existing Environmental, Health, and Safety (EHS) plans and procedures of Kosmos, as lead for the Jubilee Joint Venture, and those of the project-assigned contractors. The Bridging Document ensures high EHS standards by synthesizing all existing plans and procedures into a coherent and uniform framework to eliminate any possible misunderstandings between Kosmos and its contractors.

3.6.2.2 Emergency Response Plan

The Emergency Response Plan (ERP) provides the mechanisms to implement and coordinate response efforts in the event of an emergency. The primary purpose of the ERP is to protect the lives of personnel, to protect the environment, and to safeguard property. The ERP covers procedures for medical evacuation, search and rescue, fire prevention and protection, and other incident responses. Medical evacuation procedures will address any vehicle, vessel, or aircraft (e.g., helicopter, fixed wing aircraft) that may be used as an ambulance. A Medical Evacuation Plan permits the rapid transport of seriously injured persons, particularly trauma patients, from the rig to the hospital. By describing the evacuation procedures and medical resources in a specific area, a Medical Evacuation Plan helps coordinate the evacuation process in case of a medical incident.

3.6.2.3 Waste Management Plan

The Waste Management Plan is intended to provide a system for the identification, classification, economic minimization, handling, and disposal of all solid wastes generated by company operations, and to ensure documentation of waste management from generation to final disposal. The plan will be consulted when making waste management decisions. Guidelines for preferred methods of managing each type of waste are provided.

3.6.2.4 Oil Spill Response Plan

The Oil Spill Response Plan (OSRP) describes actions to be taken to prevent spills as well as the resources and procedures for responding to a spill. Typically, the OSRP addresses following items:

- Operating procedures that prevent oil spills;
- Control measures installed to prevent a spill from spreading; and
- Countermeasures to contain, clean up, and mitigate the effects of an oil spill.

The OSRP for Jubilee Joint Venture is under development. Jubilee Joint Venture is a member of Oil Spill Response Limited (OSRL). As an OSRL member, the Jubilee Joint Venture will have access to Tier III equipment housed in Southhampton and Tier II response equipment and supplies pre-staged in west and central Africa. Ghana also has limited in-country oil spill response capabilities. Oil and gas operators in Ghana also intend to establish a mutual aid agreement to give each other access to dispersant, boom, and equipment; at present, the shore-based location for these materials will be Takoradi.

3.6.2.5 Hydrogen Sulfide Program

The Hydrogen Sulfide (H₂S) Program protects employees from exposure to the harmful health effects of H₂S gas. No H₂S problems are anticipated in this project, because no H₂S is expected to be encountered; however H₂S detection equipment will be in place to ensure employee health and safety.

3.6.2.6 Safe Work Permit

The Safe Work Permit is a contractor program that establishes the expectations, conditions, and procedures applicable to performing Safe Work activities on the MODUs, FPSO, and shuttle tanker. This includes defining Safe Work, when a Safe Work Permit is required, and requesting, completing, and closing a Safe Work Permit.

A Safe Work Permit is an authorization and approval document that specifies the location and type of work to be performed and assures that hazards have been evaluated and necessary protective measures have been taken. Examples of those permits include hot work, confined space, and hot-tap.

3.6.2.7 Hazardous Communication Program

The Hazard Communication (HAZCOM) Program establishes expectations, conditions, and procedures applicable to working with hazardous chemicals that are produced, used, or stored aboard Kosmos vessels or facilities. Compliance with the HAZCOM Program includes the following activities:

- Reviewing new chemicals introduced into the workplace;
- Maintaining a current Hazardous Chemical Inventory List;
- Maintaining current material safety data sheets (MSDSs) on hazardous chemicals;
- Providing information on labeling systems;
- Establishing procedures for nonroutine tasks;
- Providing employees information, education, and training;
- Addressing a multi-employer worksite; and
- Informing contractors of hazardous chemicals present in the workplace.

3.6.2.8 Helicopter Operation Plan

The helicopter service provider will either develop or have on file a Helicopter Operation Plan to address the hazards associated with helicopter activities to and from the offshore facilities, including support of MODU and FPSO operations. The goal of this plan is to prevent and/or properly address incidents related to helicopter transportation.

3.6.2.9 Well Control Plan

The primary purpose of a Well Control Plan is to minimise danger to life and protect the environment. Well control is addressed in both the drilling program and the contractor's operating procedures, and includes a strategy on how to respond to a well kick. As a result, separate well control plans will be developed for 1) drilling and completion operations completed from each MODU, and 2) production operations monitored and controlled aboard the FPSO.

3.6.2.10 Transport, Storage, and Handling of Hazardous Materials

Personnel shall comply with United Nations regulations associated with the transportation of hazardous material by air, water, land, and rail. Personnel will receive training on the proper shipment of hazardous materials and will mark and label hazardous material accordingly.

4.0 Description of the Environment

4.1 Regional Setting

The Jubilee Unit is located on the continental slope offshore Ghana in equatorial West Africa (**Figure 4.1**). The project area is approximately 132 km west-southwest of the port city of Takoradi, 63 km from the nearest shoreline of Ghana, and 75 km from the nearest shoreline of Côte d'Ivoire.

Ghana shares borders with the nations of Côte d'Ivoire to the west, Togo to the east, and Burkina Faso to the north. Ghana covers an area of about 239,000 km² and the coastline is about 550 km long (Armah et al., 2004).

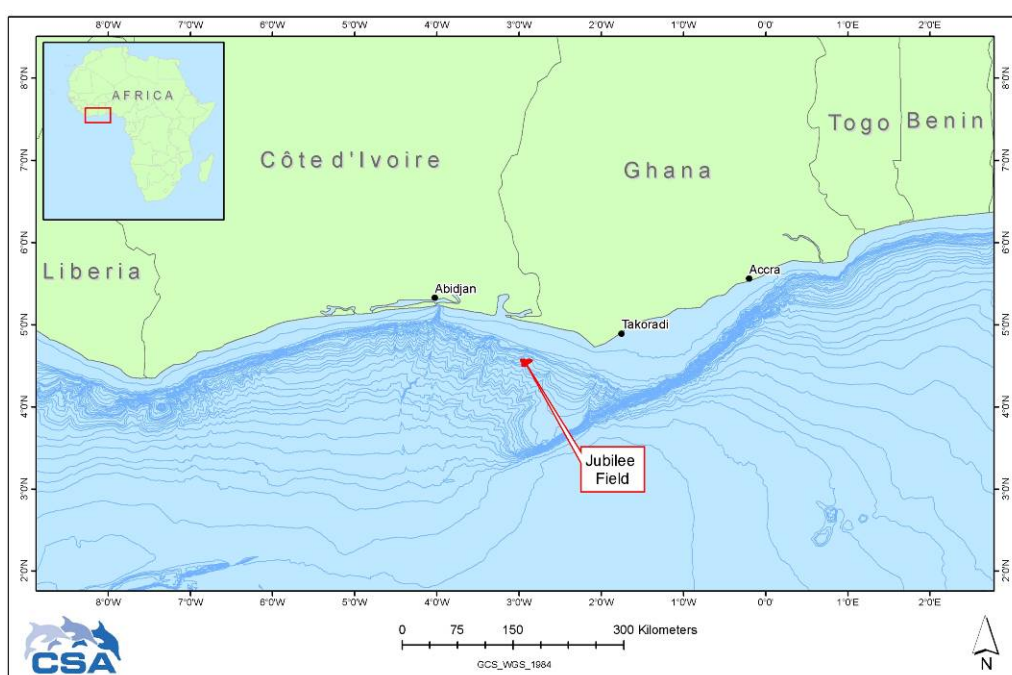


Figure 4.1. Project location and regional setting of the Jubilee Field offshore Ghana, West Africa.

4.2 Physical and Chemical Environment

4.2.1 Meteorology and Air Quality

Ghana has a tropical climate. Weather in the region is controlled by the position and intensity of the North and South Atlantic Subtropical Highs and the equatorial low pressure system located between these two systems. Typically in the tropical Atlantic, winds blow from these high-pressure centres toward the equator with deflection towards the west by Coriolis forces, resulting in northeasterly and southeasterly trade winds. The zone of convergence between these trade winds is known as the Intertropical Convergence Zone (ITCZ) (**Figure 4.2**).

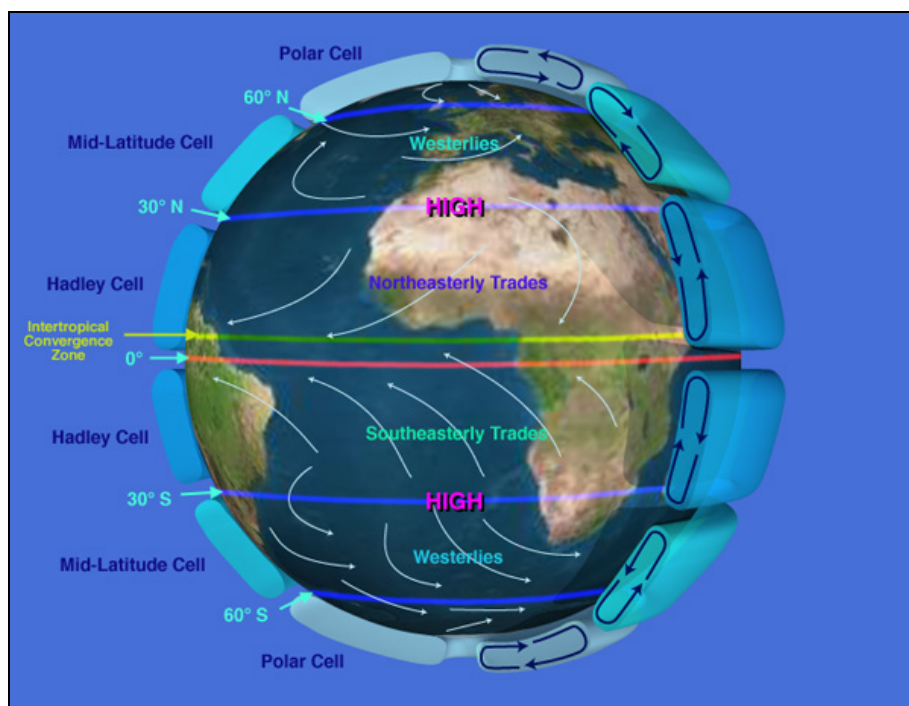


Figure 4.2. Location of the Intertropical Convergence Zone (From: National Aeronautics and Space Administration, Jet Propulsion Laboratory).

During summer, there is an intensification of southerly winds in the Gulf of Guinea (the African monsoon), coupled with the strengthening of the South Atlantic Subtropical high-pressure system. In winter, the winds tend to be more variable and a dry, warm flow of northeasterly trade winds known as *harmattan* may be felt at the coast for short periods in December and January. The only exception to the benign wind climate is the squalls associated with local thunderstorms that are a regular feature in the area.

Along the Ghana coast, two rainy seasons occur, one reaching a maximum in May and June and the other from September to November. Annual rainfall along the coast ranges from about 2,000 mm in the west to 750 mm at Accra (WorldClimate, 2008). Daily average temperatures vary little throughout the year; the average at Accra is about 27°C.

National ambient air quality monitoring results indicate that air quality of Ghana's urban centres is generally good (United Nations Department of Economic and Social Affairs, 2008). However, Aboh (2006) reports that industrial activities and increasing automobile use are contributing to significant increases in air pollution.

No site-specific air quality data were found for the project area. However, because of the offshore location, air quality is expected to be good with low concentrations of pollutants.

4.2.2 Geology

The Jubilee Unit (i.e., Jubilee Field) is located on the continental slope offshore Ghana. **Figure 4.3** shows the regional geology, and **Figure 4.4** shows the distribution of seafloor types offshore Ghana. The continental shelf offshore Ghana ranges from

about 13 to 80 km wide, with the widest part in the middle. The bathymetry of the continental shelf is generally regular with isobaths running parallel to the coast. The shelf drops off sharply at about the 75-m depth contour, where there is a band of dead coral (Madreporaria). Soft sediment (mud and sandy mud) predominates along the coast and offshore of the coral belt. The central part of the continental shelf has extensive hard bottom areas, which are widest off Takoradi and Cape Coast and extend eastward. They consist of flat rocks and shoals and are covered by large gorgonians, branched corals, and bryozoans (Rijavec, 1980). Mixed gravel and pebble bottoms, on the other hand, are usually covered with coralline algae.

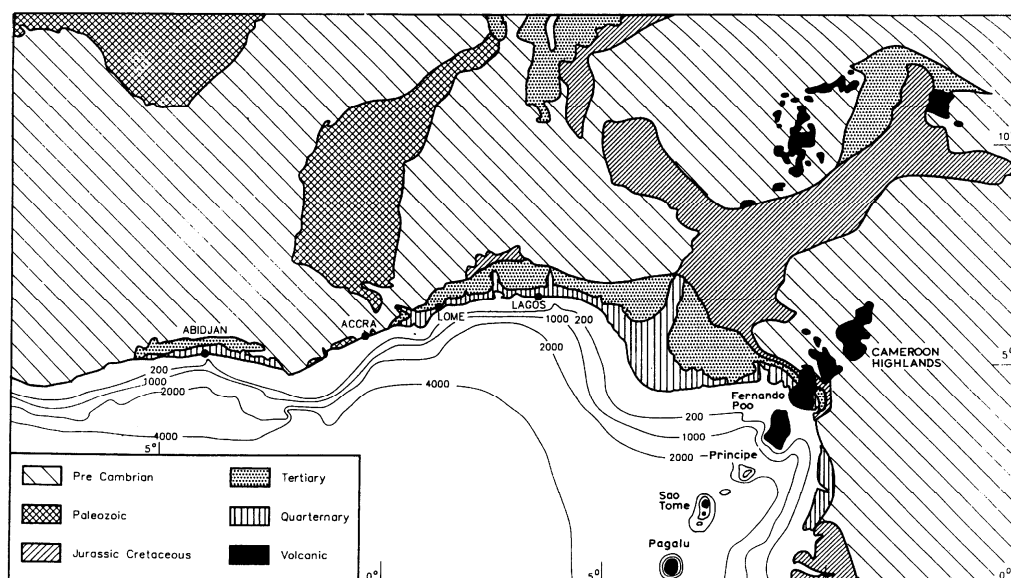


Figure 4.3. Regional geology (From: Allersma and Tilmans, 1993).

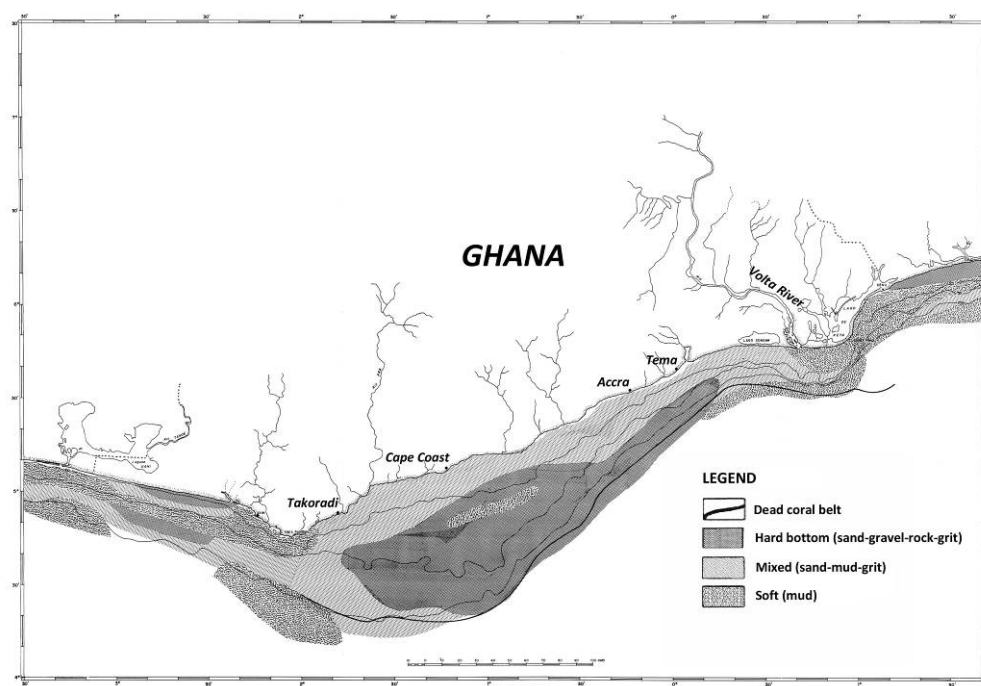


Figure 4.4. Distribution of seafloor types offshore Ghana, West Africa (From: Martos et al., 1991).

Offshore the mouth of the Volta River, there is a large submarine delta formed by river deposits. The Volta River delta is incised by a radial canyon system consisting of eight canyons (Nibbelink and Huggard, 2002).

According to Armah et al. (2004), sediments range from coarse sand on the inner shelf to fine sand and dark gray mud on the outer shelf. Sediments on the shelf and upper slope are predominantly terrigenous, with smaller amounts of detrital sands, glauconite-rich (iron silicate) sediments, and biogenic carbonate from mollusc shells.

The Jubilee Unit comprises parts of the Deepwater Tano and West Cape Three Points blocks, with water depths ranging from 1,020 to 1,720 m (**Figure 4.5**). According to a geohazards study by Gardline Surveys, the seafloor in the project area is composed of soft to firm clays and silts that form a generally smooth and sloping seabed to the southwest. The most significant features are two broad seabed canyons occurring in the western portion of the West Cape Three Points block. Within the eastern relict seabed canyon, a much smaller active sediment drainage channel is present, passing centrally down the axis of the larger inactive canyon. Seabed dip is generally between 1° and 6° in the area outside the ancient seabed canyons. Within the canyons, gradients range from 7° to 20°. Isolated seabed gradients reaching up to 25° occur along the flanks of channels in the northwest of the study area. Otherwise, the seabed is benign and featureless.

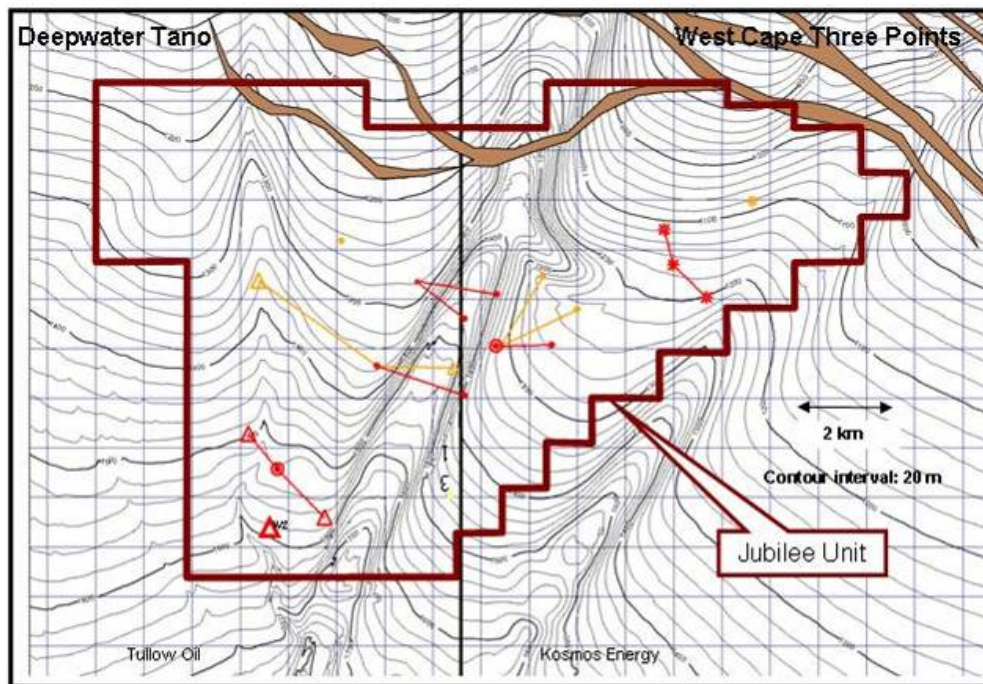


Figure 4.5. Bathymetric map of the Jubilee Field offshore Ghana, West Africa.

4.2.3 Oceanography

4.2.3.1 Currents and Circulation

The main currents affecting the area are the Guinea Current, the North Equatorial Countercurrent (NECC), and the South Equatorial Current (SEC) (**Figure 4.6**). The Guinea Current flows eastward at about 3°N along the west coast of Africa (Gyory et

al., 2005). When it reaches the Gulf of Guinea, it can reach velocities of nearly 100 cm/s. There are two main sources for the Guinea Current: the NECC and the Canary Current. The Guinea Current is generally strongest during May through September and weakest during November through February.

The NECC runs between 3°N and 10°N and serves as the northern boundary for the SEC (Bischoff et al., 2004). The mean eastward velocity is 15 cm/s. The greatest flow for the NECC occurs during July to September, with eastward flows up to 29 cm/s. There is a reversal of most of the current's flow in the western part of the basin during the early part of the year.

The SEC is a broad, westward flowing current that extends from the surface to a depth of 100 m (Bonhoure et al., 2004). Its northern boundary is usually near 4°N, while the southern boundary is usually between 15°S and 25°S, depending on longitude and season. The SEC flows west toward Brazil and splits into two branches, with the stronger of the two heading north as the North Brazil Current and the other heading south as the Brazil Current.

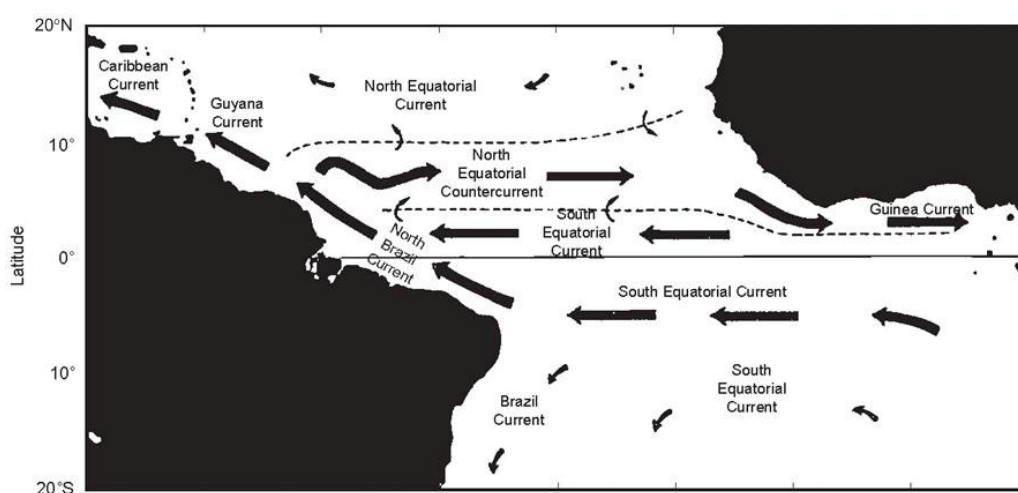


Figure 4.6. Major surface currents offshore West Africa (From: Philander, 2001).

4.2.3.2 Waves and Tides

The wave climate in the area is mild, with relatively low significant wave heights. Waves reaching the coast are of two distinct origins: the seas generated by the weak local monsoon and the swell generated by high-latitude storms linked to eastward migrating low-pressure cells in the south Atlantic (Allersma and Tilmans, 1993).

The tidal regime in Ghana is semi-diurnal, with two high waters and two low waters per day. Tidal ranges are relatively small, with spring and neap tidal ranges averaging 1.2 m and 0.6 m, respectively, at Takoradi (Allersma and Tilmans, 1993). Tidal range decreases rapidly offshore. The tidal streams run parallel to the coast, to the west on a rising tide and to the east on a falling tide. However, these streams are weak and generally not noticeable offshore.

4.2.3.3 Hydrography

There are five main layers of water masses offshore Ghana (Longhurst, 1962). On top is Tropical Surface Water, a warm layer of variable salinity, extending from the surface to about 40 m depth. Below this is South Atlantic Central Water – cool, high salinity water extending from the thermocline to a depth of about 700 m. Three colder layers are found below this – the Antarctic Deep Water (700 to 1,500 m), North Atlantic Deep Water (1,500 to 3,500 m), and Antarctic Bottom Water (3,500 to 3,800 m).

Sea surface temperature generally ranges from about 27° to 29°C except during upwelling seasons (see below). During most of the year, a strong thermocline is present in continental shelf waters, extending to a depth of about 40 m (Koranteng, 2001). Salinity in coastal waters ranges from 32 to 36, except near major rivers, where salinities as low as 28 may be recorded during the rainy season (Armah et al., 2004).

4.2.3.4 Upwelling

Upwelling is an important oceanographic phenomenon in the region and a key influence on productivity and fishery resources. Marine waters offshore Ghana are within the Central West African Upwelling System, which extends from Côte d'Ivoire to Benin. During upwelling periods, sea surface temperature drops, surface salinity increases, and dissolved oxygen decreases (Mensah and Koranteng, 1988). Nutrients from deep, offshore waters are carried up into the photic zone, resulting in increased primary productivity. According to Armah et al. (2004), upwelling intensity is greater offshore Takoradi than elsewhere in Ghana.

The upwelling along the Ghana coast is highly seasonal. The major upwelling season occurs from July through September when sea surface temperature falls below 25°C. The minor upwelling season normally lasts for only about 3 weeks and can occur any time from December through March. The rest of the year consists of warm seasons during which sea surface temperature is relatively high.

In addition to the seasonality, there are significant interannual and longer-term changes in upwelling intensity due to basin-scale variations in the Atlantic Ocean circulation and large-scale atmospheric changes caused by El Niño Southern Oscillation (ENSO) events in the tropical Pacific Ocean (Perry et al., 2007).

4.2.4 Water and Sediment Quality

No site-specific data concerning water or sediment quality were identified for the project area. However, because of its offshore location, waters and sediments of the project area are expected to have low concentrations of anthropogenic contaminants.

In Ghana's near-coastal waters, pollution from human activities is a significant problem. According to the United Nations Environment Programme (UNEP, 1999), the principal land-based sources of pollution in Ghana are human, domestic, municipal, mining, manufacturing, and agricultural discharges, which are often untreated and unregulated. Pollutants entering coastal waters from these activities include organic matter and nutrients from sewage, trace metals and hydrocarbons from industrial and municipal wastes, and persistent organic pollutants from synthetic pesticides and industrial discharges. According to Serfor-Armah et al. (2006), a wide range of metallic

elements are discharged into the ocean from industrial and mining activities, along with urban and agricultural runoff.

Gilbert et al. (2006) reported on trace metal and hydrocarbon concentrations in Fosu lagoon near Cape Coast, Ghana. They noted some contamination including elevated concentrations of cadmium, manganese, nickel, and polycyclic aromatic hydrocarbons. These were attributed to industrial sources including a mechanical shop and burning of wood and coal in nearby residential areas.

Nutrient enrichment (eutrophication) due to sewage discharges is another important problem along the coast. Nixon et al. (2007) reported concentrations of ammonia and phosphate in Korle Lagoon, near Accra, that may be the highest yet reported for an estuarine system. They found a strong correlation between population density and dissolved inorganic nitrogen concentrations among the wide range of systems studied.

4.3 Biological Environment

4.3.1 Plankton and Productivity

As noted previously, marine waters offshore Ghana are within an upwelling zone. Other upwelling zones in West Africa occur to the south offshore Gabon and Congo and to the northwest offshore Senegal (Herbland et al., 1983) (**Figure 4.7**). In Ghana, during the major upwelling season from July through September and the minor upwelling season from December through March, the upwelling of cool, nutrient-rich water results in enhanced primary production.

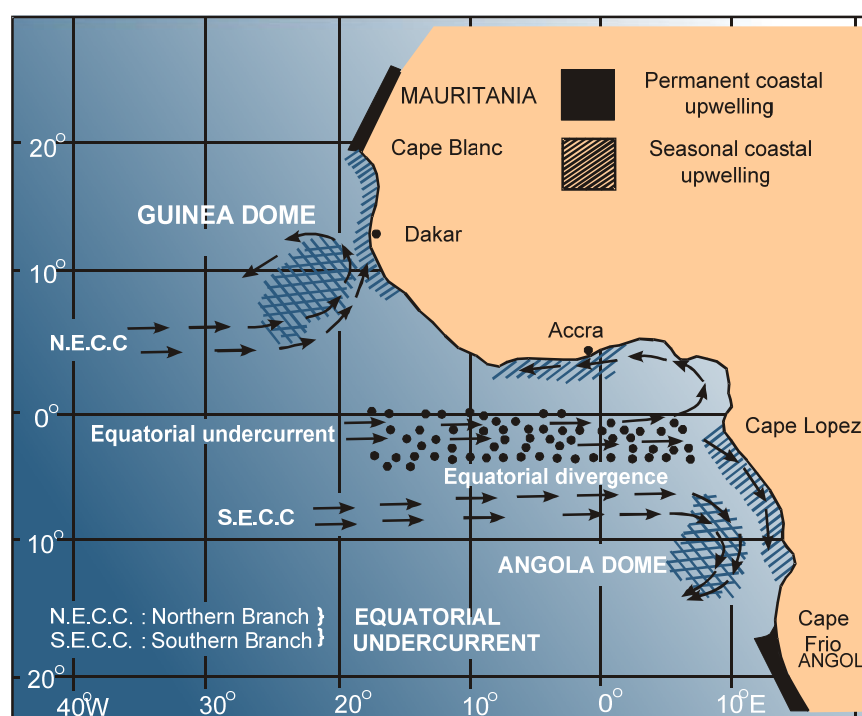


Figure 4.7. Large-scale currents and various enrichment zones in the tropical eastern Atlantic (From: Herbland et al., 1983).

The effect of upwelling on primary productivity is illustrated in **Figure 4.8**, which shows productivity as estimated from satellite imagery during upwelling and non-upwelling seasons. High nutrient concentrations also lead to the development of large phytoplankton cells and, consequently, high concentrations of zooplankton. Le Borgne et al. (1983) showed a linear relationship between phytoplankton and zooplankton biomass in these systems. This situation is characteristic of productive systems with temporal stability and conducive to fish production (Jones and Henderson, 1987).

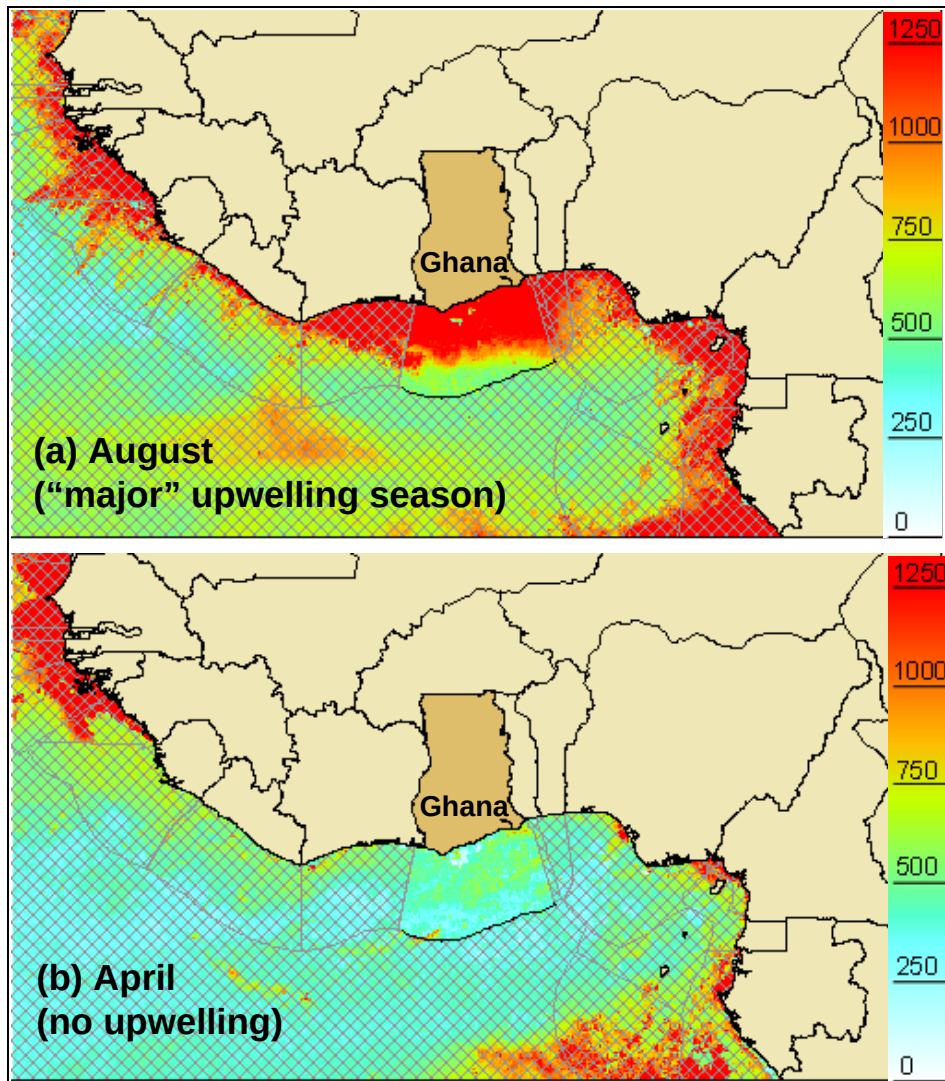


Figure 4.8. Primary productivity ($\text{mg C m}^{-2} \text{d}^{-1}$) offshore Ghana during (a) August (major upwelling season) and (b) April (non-upwelling period) (From: Sea Around Us Project, 2008).

Egg and larval stages of important fish stocks such as sardines, sardinellas, and tuna are also represented in the plankton. Yellowfin tuna larvae are present in the Gulf of Guinea throughout the year. Similarly, skipjack and bigeye larvae occur in the continental shelf region off the coasts of Equatorial Guinea and Gabon (Fonteneau et al., 1993). *Sardinella eba* and *S. aurita* eggs and larvae are more likely to be restricted to continental shelf waters (Wysokinski, 1986).

4.3.2 Fishes and Fishery Resources

The FishBase online database lists 483 marine species native to Ghana (Froese and Pauly, 2008). Of these, 184 are specifically associated with deepwater habitats. Widely represented families in the deepwater fish fauna include Myctophidae (lanternfishes, 29 species), Stomiidae (dragonfishes, 21 species), Alepocephalidae (smooth-heads, 11 species), Gonostomatidae (bristlemouths, 11 species), Macrouridae (grenadiers, 8 species), and Platytroctidae (tubeshoulders, 8 species).

Over 300 different species of commercially important fishes are caught from marine sources in Ghana (Food and Agriculture Organization of the United Nations [FAO], 2008). Three groups of fishery resources are recognized: (1) large pelagic fishes such as tunas and tuna-like species; (2) small pelagic species of the families Clupeidae (Sardinellas), Scombridae (chub-mackerels), and Engraulidae (anchovies); and three demersal species of the families Sparidae, Lutjanidae, Mullidae, Pomadasysidae, Serranidae, Polynidae, and Penaeidae.

Commercially important large pelagic species include yellowfin (*Thunnus albacares*), bigeye (*T. obesus*), and skipjack (*Katsuwonus pelamis*) tunas as well as tuna-like species such as little tunny (*Euthynnus alletteratus*), Atlantic bonito (*Sarda sarda*), and rainbow runner (*Elagatis pinnulata*). Historically, the region has supported high tuna catches (Figure 4.9).

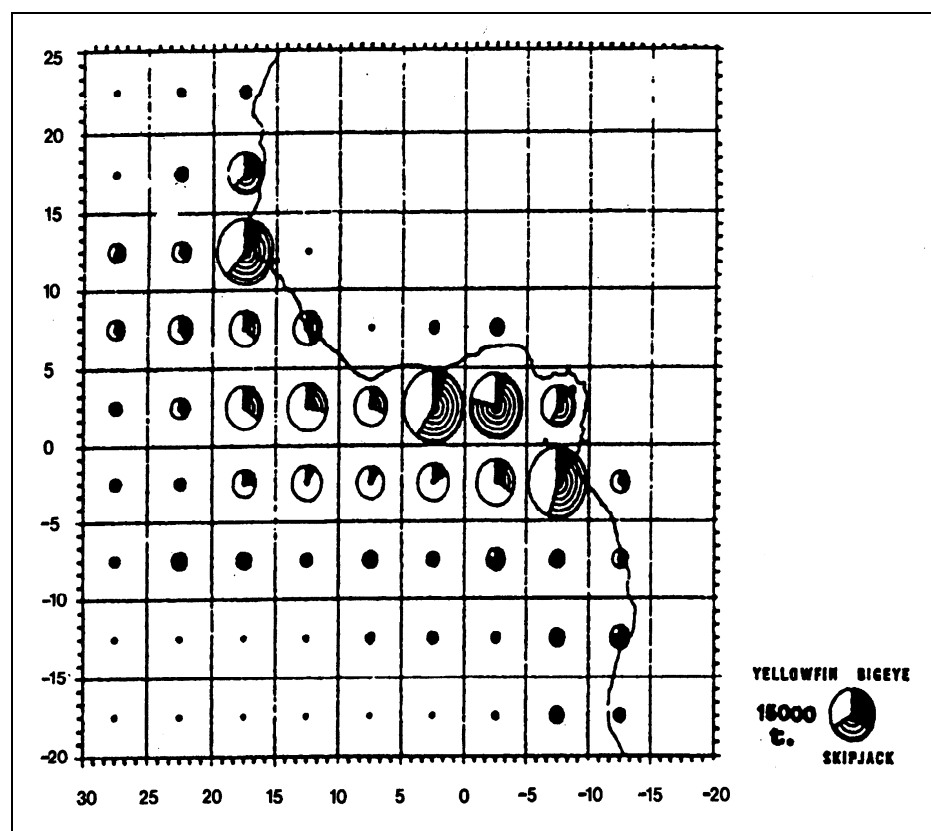


Figure 4.9. Average catch (in tonnes) by 5° square by all industrial fisheries of yellowfin, skipjack, and bigeye tuna for the period 1978 to 1982 (From: Stretta, 1993).

Most marine fish landings in Ghana are from artisanal fishing in nearshore waters, and the most important resources are small pelagic fishes, especially the round sardinella (*Sardinella aurita*), flat sardinella (*Sardinella maderensis*), European anchovy (*Engraulis encrasicolus*), chub mackerel (*Scomber japonicus*), and bigeye grunt (*Brachydeuterus auritus*). According to FAO fisheries data compiled by the Sea Around Us Project (2008), these five species accounted for over 70% of the catch in 2004. Historical catch data from 1950 through 2004 are shown in **Figure 4.10**.

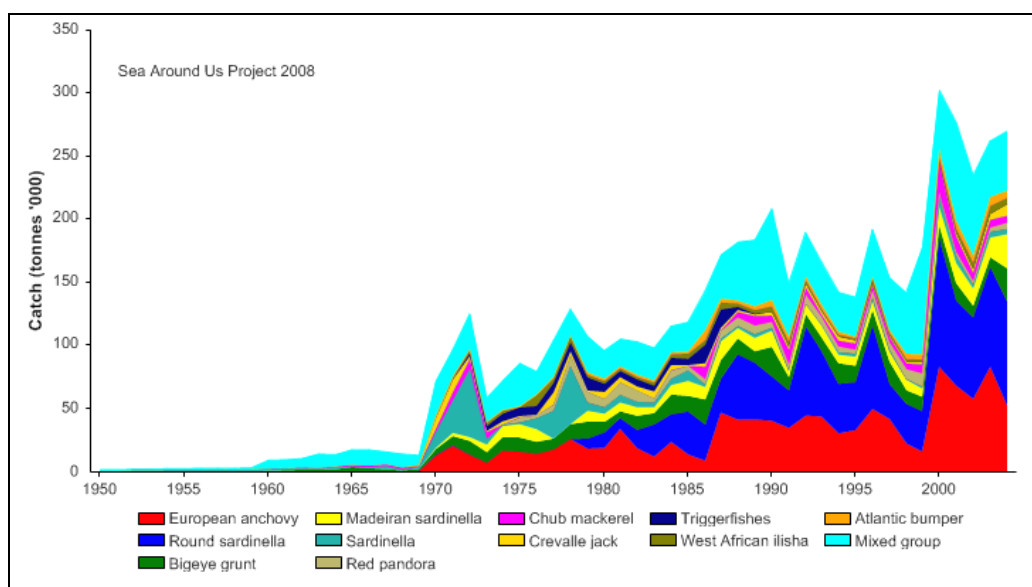


Figure 4.10. Historical fish catches offshore Ghana (From: Sea Around Us Project, 2008).

Over time, Ghana's fishery resources have been subjected to increasing exploitation, resulting in a "boom and bust" pattern with huge variations in the abundance of some targeted species (Koranteng and Pauly, 2002; Atta-Mills et al., 2004). The sardinella fishery essentially collapsed in 1973, and triggerfishes became increasingly important, only to collapse also in the late 1980s. Shrimp fisheries in inshore waters collapsed during the mid-1970s and again in recent years (Koranteng and Pauly, 2002). Fishing activities are discussed further in **Section 4.4.6**.

Table 4.1 lists marine fish species native to Ghana that are designated as critically endangered, endangered, or vulnerable by the International Union for the Conservation of Nature and Natural Resources (IUCN) (2008). Among these are several sharks and rays, two groupers (usually associated with hard bottom habitats), three sawfishes (inshore demersal species), and one offshore pelagic species (bigeye tuna).

Table 4.1. Marine fish species native to Ghana and listed as critically endangered, endangered, or vulnerable by the International Union for the Conservation of Nature and Natural Resources (IUCN) (2008).

Common Name	Scientific Name	IUCN Status ¹
African wedgefish	<i>Rhynchobatus luebberti</i>	EN
Bigeye tuna	<i>Thunnus obesus</i>	VU
Blackchin guitarfish	<i>Rhinobatos cemiculus</i>	EN
Bottlenose skate	<i>Rostroraja alba</i>	EN
Common guitarfish	<i>Rhinobatos rhinobatos</i>	EN
Common sawfish	<i>Pristis pristis</i>	CR
Dusky grouper	<i>Epinephelus marginatus</i>	EN
Goliath grouper	<i>Epinephelus itajara</i>	CR
Great white shark	<i>Carcharodon carcharias</i>	VU
Grey nurse shark	<i>Carcharius taurus</i>	VU
Gulper shark	<i>Centrophorus granulosus</i>	VU
Largetooth sawfish	<i>Pristis perotteti</i>	CR
Longfin mako	<i>Isurus paucus</i>	VU
Night shark	<i>Carcharhinus signatus</i>	VU
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	VU
Smalltooth sawfish	<i>Pristis pectinata</i>	CR
Spiny butterfly ray	<i>Gymnura altavela</i>	VU
Whale shark	<i>Rhincodon typus</i>	VU

¹ International Union for the Conservation of Nature and Natural Resources (IUCN) categories: CR = critically endangered; EN = endangered; VU = vulnerable.

4.3.3 Benthic Communities

4.3.3.1 Soft Bottom Communities

Quantitative knowledge of the ecology of benthic communities off the West African coast is very limited. Zoogeographically, benthic communities in the region closely resemble those of the Mediterranean and Western Europe (Le Loeuff and Zabi, 2002). Factors controlling benthic community composition include water depth, sediment texture (e.g., sandy vs. silty offshore river mouths), and upwelling. The region offshore Ghana is characterized as a tropical region affected by upwelling. Upwelling areas are exposed to periods of relatively cold water temperatures and tend to support higher numbers of species than non-upwelling areas.

According to Armah et al. (2004), recent benthic studies offshore Ghana have identified 359 taxa including 255 species of polychaetes, 49 species of crustaceans, 36 species of molluscs, and 19 others (including echinoderms, oligochaetes, and sipunculids). Polychaetes were the most abundant group (71%), followed by crustaceans and molluscs (14% and 10%, respectively).

Koranteng (2001) studied the demersal (benthic) fish assemblages of the continental shelf and upper slope offshore Ghana. The analyses of community structure identified six species assemblages on the continental shelf and upper slope off Ghana. Water depth and sediment type were cited as the most likely environmental influences affecting community structure.

4.3.3.2 Hard Bottom Communities

Extensive hard bottom areas occur offshore Ghana (see **Figure 4.4**). These include a band of dead coral (Madreporaria), and widespread areas of flat rocks and shoals covered by large gorgonians, branched corals, and bryozoans (Rijavec, 1980 as cited by Martos et al., 1991). There are also mixed gravel and pebble bottoms covered with coralline algae. No further information about the ecology of these communities was found. A geohazards study by Gardline Surveys indicated there are no hard bottom features in the project area.

ReefBase (2008) does not identify any active coral reefs offshore Ghana. However, an internet search indicates several named reefs in nearshore waters (e.g., Bosum Accra reef, Kassa reef, Pampendi reef, Roani bank, Suchu reef, and Takoradi reef) (SatelliteViews, 2008).

4.3.3.3 Chemosynthetic Communities

Chemosynthesis is a mechanism by which bacteria are able to oxidize simple compounds such as hydrogen sulfide (H₂S) and methane (CH₄) (Jannasch, 1989). At water depths beyond those supporting photosynthesis and where seepage of hydrocarbons, venting of hydrothermal fluids, or other geological processes supply abundant reduced compounds, chemosynthesis can become the dominant component of the ecosystem. While the underlying process is microbial, chemosynthetic communities in the deep sea achieve prominence because of the symbiotic partnership between chemosynthetic bacteria and invertebrate hosts such as tubeworms and mussels (Fisher, 1990). Chemosynthetic communities can have unusually high biomass (MacDonald, 2002).

The potential for chemosynthetic communities exists in the region. Brooks and Bernard (2006) reported finding two sites with chemosynthetic communities in water depths of about 1,600 and 2,200 m offshore Nigeria. These discoveries were made during piston-coring operations over small mounds associated with presumed deeper faulting. The cores retrieved carbonate rubble, shell hash, and live and disarticulated mussel shells. Follow-on work with box cores showed a high density of mussels. Associated fauna included tubeworms, clams, shrimps, limpets, crabs, brittle stars, heart urchins, and sponges.

In a study of submarine canyons offshore the Volta River Delta in Ghana, Nibbelink and Huggard (2002) noted evidence of gas seeps on seismic data and oil slicks on radar images. They interpreted the flat floors of the canyons as carbonate formed by chemosynthetic communities that feed on hydrocarbons seeping from the depleted free gas zones below the canyons.

Studies conducted in the Gulf of Mexico indicate that high-density chemosynthetic sites typically are associated with recognizable geophysical features such as hydrocarbon-charged sediments associated with surface faulting, acoustic void zones associated with surface faulting, mounds or knolls, and gas or oil seeps (MacDonald, 2002). Gardline Surveys (2007a,b) conducted geohazards studies in the Jubilee Field area including the West Cape Three Points Block and the Deepwater Tano Prospect. No areas with the potential to harbour chemosynthetic communities were detected. Both studies concluded that, “after a thorough examination of the seabed and detailed investigation for any of the aforementioned features, seismic sections in combination with seabed amplitudes reveal no significant evidence to support any sensitive habitats or chemosynthetic communities within the study area.”

4.3.4 Marine Mammals

The West African region supports a diverse marine mammal fauna (Jefferson et al., 1997). Coastal waters off West Africa represented one of the prime whaling areas of the world during the early part of the 20th century (Richards and Du Pasquier, 1989).

Table 4.2 lists the marine mammal species most likely to occur in the region. At least 6 species of baleen whales and over 20 species of toothed whales and dolphins may occur. According to the IUCN (2008) Red List, three of these cetacean species are endangered (i.e., sei, blue, and fin whales), two are vulnerable (i.e., sperm whales and Atlantic humpbacked dolphins), and several others are in lower-risk categories.

Table 4.2. Marine mammals potentially occurring in the project area.

Common Name	Scientific Name	IUCN Status ¹	Offshore	Coastal
MYSTICETES (baleen whales)				
Minke whale	<i>Balaenoptera acutorostrata</i>	LC	X	---
Sei whale	<i>Balaenoptera borealis</i>	EN	X	---
Bryde's whale	<i>Balaenoptera edeni</i>	DD	X	---
Blue whale	<i>Balaenoptera musculus</i>	EN	X	---
Fin whale	<i>Balaenoptera physalus</i>	EN	X	---
Humpback whale	<i>Megaptera novaeangliae</i>	LC	X	---
ODONTOCETES (toothed whales)				
Common dolphin	<i>Delphinus capensis, D. delphis</i>	LC	X	---
Pygmy killer whale	<i>Feresa attenuata</i>	DD	X	---
Short-finned pilot whale	<i>Globicephala macrorhynchus</i>	DD	X	---
Risso's dolphin	<i>Grampus griseus</i>	LC	X	---
Dwarf sperm whale	<i>Kogia simus</i>	DD	X	---
Pygmy sperm whale	<i>Kogia breviceps</i>	DD	X	---
Fraser's dolphin	<i>Lagenodelphis hosei</i>	LC	X	---
Blainville's beaked whale	<i>Mesoplodon densirostris</i>	DD	X	---
Gervais' beaked whale	<i>Mesoplodon europaeus</i>	DD	X	---
Killer whale	<i>Orcinus orca</i>	DD	X	---
Melon-headed whale	<i>Peponocephala electra</i>	LC	X	---
Sperm whale	<i>Physeter macrocephalus</i>	VU	X	---
False killer whale	<i>Pseudorca crassidens</i>	DD	X	---
Atlantic humpbacked dolphin	<i>Sousa teuszii</i>	VU	---	X
Pantropical spotted dolphin	<i>Stenella attenuata</i>	LC	X	---
Clymene dolphin	<i>Stenella clymene</i>	DD	X	---
Striped dolphin	<i>Stenella coeruleoalba</i>	LC	X	---
Atlantic spotted dolphin	<i>Stenella frontalis</i>	DD	X	---
Spinner dolphin	<i>Stenella longirostris</i>	DD	X	---
Rough-toothed dolphin	<i>Steno bredanensis</i>	LC	X	---
Bottlenose dolphin	<i>Tursiops truncatus</i>	LC	X	X
Cuvier's beaked whale	<i>Ziphius cavirostris</i>	LC	X	---
SIRENIANS				
African manatee	<i>Trichechus senegalensis</i>	VU	---	X

¹ International Union for the Conservation of Nature and Natural Resources (IUCN) categories: DD = data deficient; EN = endangered; LR/CD = lower risk/conservation dependent; LR/LC = lower risk/least concern; LR/NT = lower risk/near threatened; VU = vulnerable.

Apart from their possible presence, little is known of the distribution and abundance of marine mammals in specific areas. Species likely to be found in deep, offshore waters include the sperm whale, pilot whale, clymene dolphin, pantropical spotted dolphin, spinner dolphin, striped dolphin, and various beaked whales. Marine mammals more

likely to occur in coastal waters include Atlantic humpbacked dolphin, bottlenose dolphin, and African manatee.

While sperm whales and many other toothed whales and dolphins may be present offshore West Africa all year, the baleen whales typically are more seasonal in occurrence. With the exception of Bryde's whale, which may occur year-round, the baleen whales likely are present only during the austral winter (i.e., May to October). These large whales migrate between their winter grounds and summer feeding grounds in Antarctica.

Coastal areas offshore West Africa are critical breeding and nursery areas for the humpback whale, which migrates along the coast of southern Africa to mate, calve, and nurse its young during the austral winter (Best et al., 1995). The breeding ground of this humpback whale stock extends along the coast from 6°N to 6°S latitude (Bannister, 2005); the project area is near the northwestern edge of this range. There have been sightings offshore Ghana (e.g., Allen et al., 2007), and it is assumed that humpback whales could occur seasonally in the area. The IUCN (2008) Red List recently changed the designation of humpback whales from vulnerable to least concern.

The African manatee (*Trichechus senegalensis*), a sirenian classified by the IUCN (2008) as vulnerable, occurs from Senegal to Angola. It inhabits swamplands, coastal lagoons, estuaries, and rivers. Armah et al. (2004) report that manatees are found in the Abby Lagoon and the Volta River estuary. Because of their coastal habitat preferences, manatees would not be expected to occur in the offshore project area.

According to the IUCN (2008), the African manatee population in the region is depleted due to hunting and other human activities. Sheppard (2007) reports that hunting is not a major threat in at least one part of Ghana (the Lake Volta area of eastern Ghana). However, certain fishing practices may adversely affect manatees, including the removal of floating vegetation and the use of purse seine nets, which may accidentally trap manatees. Legal protection has been established for manatees in Ghana, and the Wildlife Division of the Forestry Commission prohibits trade and hunting of manatees (Sheppard, 2007).

Appendix E discusses critical habitat for marine mammals, focusing on the three endangered cetaceans that may occur in the region (blue whale, fin whale, and sei whale). The analysis concludes that neither the project area nor the adjacent coast of Ghana includes critical habitat for endangered marine mammals.

4.3.5 Sea Turtles

Five species of sea turtles have been recorded from Ghana (**Table 4.3**) (Carr and Campbell, 1995; Beyer and Benefo-Twum, 2006). The hawksbill and leatherback turtles are critically endangered and the green, loggerhead, and olive ridley turtles are endangered (IUCN, 2008). All are common in the Gulf of Guinea (Castroviejo et al., 1994; Formia et al., 2003; Rader et al., 2006). The olive ridley is the most common sea turtle in Ghana.

About 70% of Ghana's coastline is suitable for turtle nesting, and 80 km of the coast is densely nested (Carr and Campbell, 1995). There are historical reports of all five species nesting along the coast, but recent studies show only the green, leatherback,

and olive ridleys currently nest there (Beyer and Benefo-Twum, 2006; HLAMI Association for Turtle Conservation and Hope, 2008). The nesting season extends from August through March, but the peak months are from September through January.

Table 4.3. Sea turtles occurring in Ghana.

Common Name	Scientific Name	IUCN Status ¹	Nesting in Ghana
Green turtle	<i>Chelonia mydas</i>	EN	Yes
Hawksbill turtle	<i>Eretmochelys imbricata</i>	CR	No
Leatherback turtle	<i>Dermochelys coriacea</i>	CR	Yes
Loggerhead turtle	<i>Caretta caretta</i>	EN	No
Olive ridley turtle	<i>Lepidochelys olivacea</i>	EN	Yes

¹ International Union for the Conservation of Nature and Natural Resources (IUCN) categories: CR = critically endangered; EN = endangered.

Sea turtles have been exploited for their eggs and meat throughout their ranges in West Africa (Castroviejo et al., 1994). Hunting methods include nets, harpoons, and diver-operated spearguns (Formia et al., 2003). In addition, turtles are caught accidentally in fishing gear. Coastal erosion, sand removal for construction projects, and predation by dogs and pigs are also problems affecting the success of turtle nesting and hatching (Armah et al., 2004; Beyer and Benefo-Twum, 2006).

Appendix E discusses critical habitat for sea turtles, all of which are endangered or critically endangered as noted above. The analysis concludes that nesting beaches along the Ghanaian coast constitute critical habitat for the green, leatherback, and olive ridley sea turtles.

4.3.6 Marine and Coastal Birds

Ghana's coastal wetlands provide feeding and roosting sites for thousands of resident and migratory birds (Armah et al., 2004). According to the Ghana Wildlife Society (2008), 11 species of tern can be found along the coast. Four species – Common Tern (*Sterna hirundo*), Black Tern (*Chlidonias niger*), Royal Tern (*Thalasseus maximus*) and Sandwich Tern (*Thalasseus sandvicensis*) – make up 80% of what can be as many as 50,000 terns. In addition, 42 species of wading birds have been recorded, of which 34 are migratory and 11 occur in internationally important numbers.

BirdLife International (2008) lists eight globally threatened bird species in Ghana. None are seabirds or are specifically associated with offshore marine habitats. However, four species – the Western Wattled Cuckooshrike (*Campephaga lobata*), Rufous Fishing-Owl (*Scotopelia ussheri*), Green-tailed Bristlebill (*Bleda eximius*), and Yellow-bearded Greenbul (*Criniger olivaceus*) – are associated with coastal lowland forests and swamps.

BirdLife International (2008) has designated 36 sites in Ghana as Important Bird Areas, of which five are along the coast (**Table 4.4**). Two of these sites, the Anlo-Keta and Songor Lagoons, each support over 100,000 shore birds as well as internationally important numbers of several species of wading birds (Armah et al., 2004).

Table 4.4. Coastal Important Bird Areas (IBAs) (From: BirdLife International, 2008).

IBA Name and Number	Latitude, Longitude	Area (km ²)	Notes
Amansuri wetland (GH031)	4°55'N, 2°15'W	380	Includes the freshwater Amansuri lagoon, flood plains of the Amansuri river, coastal Amansuri lagoon and estuary, and Esiama beach. Includes the largest stand of intact swamp forest in Ghana. Key bird species include Royal Tern and Sanderling.
Anlo-Keta Lagoon Ramsar site (GH033)	5°55'N, 0°59'E	530	Part of the Volta estuary, comprising several small islands and a complex of lagoons with varying salinity. Most important site for waterbirds on the Ghana coast – at least 76 species with maximum numbers over 100,000 birds.
Muni-Pomadze Ramsar Site (GH034)	5°19'N, 0°40'W	95	Includes a shallow, saline, semi-closed, coastal lagoon, and its surrounding flood-plains. Key species include Black Tern, Common Tern, Royal Tern, and Sandwich Tern.
Sakumo Lagoon Ramsar Site (GH035)	5°37'N, 0°3'W	39	Lagoon connected to the sea by a small sluice. Key species include Black Tern, Sandwich Tern, and Spotted Redshank.
Songor Lagoon Ramsar Site (GH036)	5°49'N, 0°28'E	232	Brackish lagoon with extensive mudflats and islands, saltpans, a broad sandy beach, and flood plains of several small streams. Second-most important site for waterbirds on the coast (over 100,000 birds). Important roosting site for terns.

4.3.7 Coastal Habitats

The Environmental Sensitivity Atlas of the Coastal Areas of Ghana (Armah et al., 2004) recognizes six types of ecosystems along the coast: (1) sandy shores; (2) rocky shores; (3) coastal lagoons; (4) mangrove forests; (5) estuarine wetlands; and (6) depression wetlands. **Table 4.5** summarizes their occurrence in Ghana.

Table 4.5. Coastal ecosystems of Ghana (From: Armah et al., 2004).

Ecosystem	Locations/Examples
Sandy shores	Côte d'Ivoire border to Axim; Prampram to the border town of Aflao
Rocky shores	Senya Bereku; Cape Three Points
Coastal lagoons	Open: Korle Lagoon; Closed/semi-closed: Songor Lagoon; Muni Lagoon
Mangrove forests	Lower reaches of Volta, Oyibi, Kakum, and Ankobra Rivers
Estuarine wetlands	Mouths of Volta, Pra, Butre, and Ankobra Rivers
Depression wetlands	Belibangara, Ndumakaka, Efasu

The coast of Ghana can be divided into three parts: western, central, and eastern (**Figure 4.11**). The Western Coast (west of Cape Three Points) consists of predominantly rocky shores interspersed with pocket beaches. The Central Coast (from Cape Three Points to Tema) consists of rocky headlands and short stretches of sandy beach. The Eastern Coast is predominantly sandy with numerous lagoons opening onto it (**Figure 4.12**).

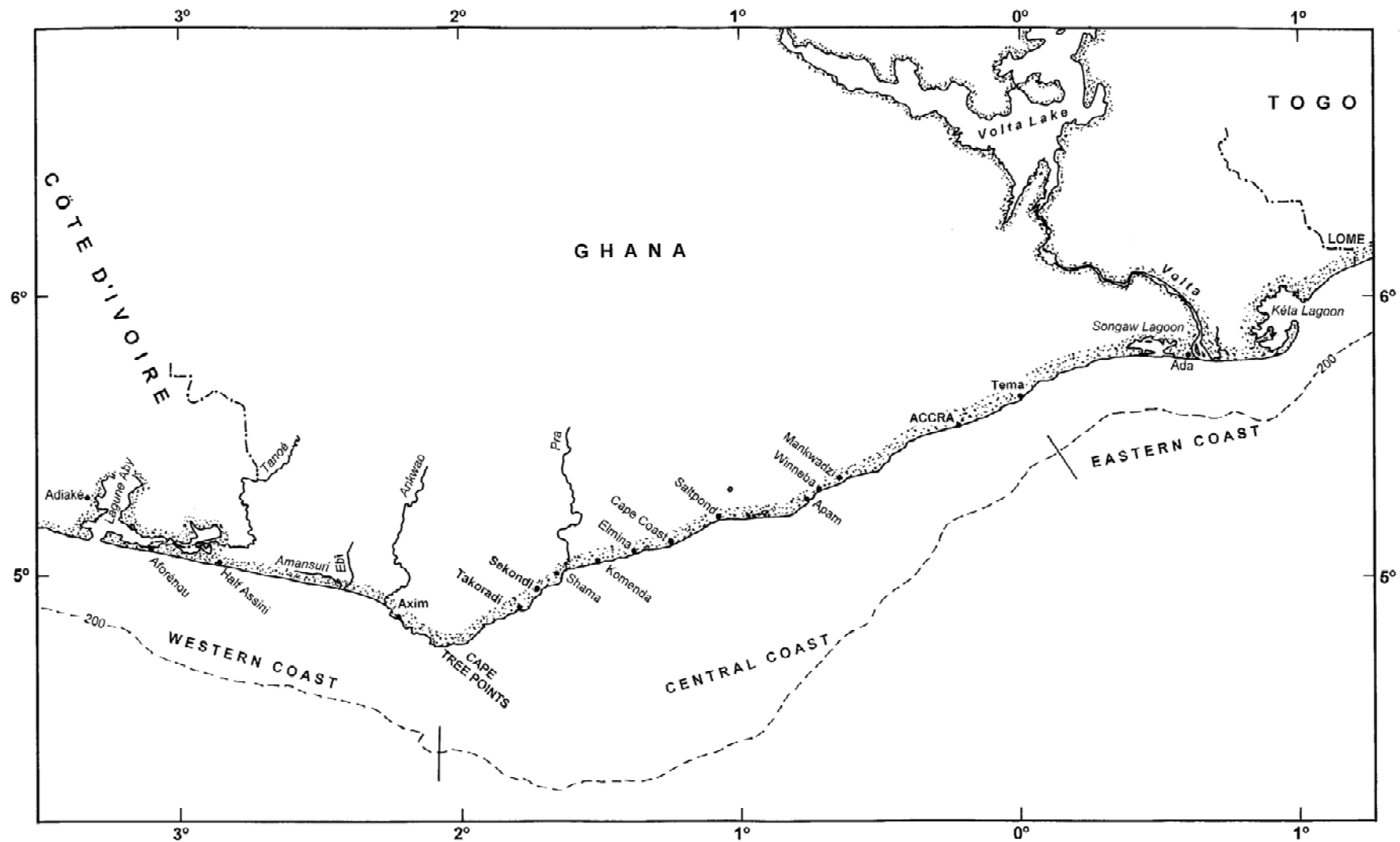


Figure 4.11. The coastline of Ghana, West Africa (From: Ly, 1980).

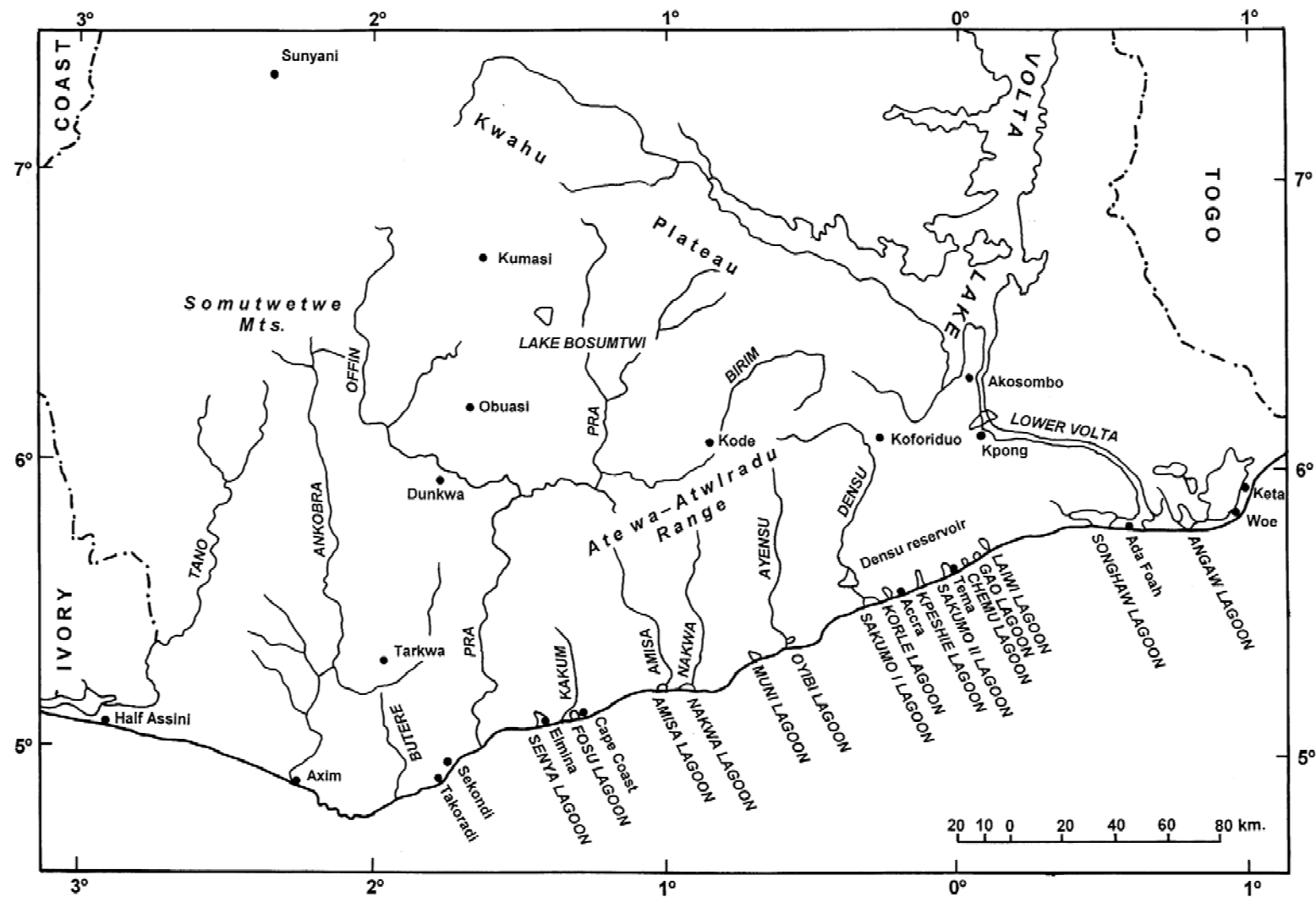


Figure 4.12. Major rivers and lagoons along the coast of Ghana, West Africa (From: Biney, 1986).

4.3.7.1 Sandy Shores

Sandy shores are the predominant coastal habitat in Ghana, accounting for as much as 70% of the coastline (Armah et al., 2004). Gauld and Buchanan (1956) discussed the characteristics of open sandy beaches of Ghana. They recognized two types: (1) a narrow type, dropping down steeply to the low-water mark where a trench of about 1 m deep and 5 m wide separates it from an almost flat bank about 40 m wide, lying approximately at the low-water mark, and (2) a wider and less steep beach with no trench or bank at the level of low water.

The narrow and steep beaches in Ghana possess an impoverished fauna, with the ghost crab *Ocypoda cursor* at the uppermost part of the shore and a sparse population of bean clam (*Donax rugosus*) near the low-water mark. Another more terrestrial ghost crab, *O. africana*, occurs in some places. Such beaches have a low water-retaining capacity due to the larger particle size of the sand, and therefore represent an inhospitable environment for burrowing animals during low water.

4.3.7.2 Rocky Shores

Rocky shores are present mainly between Axim and Tema, typically consisting of outcroppings alternating with sandy bays (Armah et al., 2004).

Along rocky shores, the littoral fringe is dominated by gastropods of the genus *Littorina* and crusts or mats of algae forming the *Bostrychia-Murrayella-Lophosiphonia* association. Beneath the littoral fringe is the Eulittoral zone divided into the upper barnacle sub-zone and the lower lithothamnia sub-zone. Characteristic organisms of the barnacle sub-zone include balanoid barnacles of the genus *Chthalamus*, the oyster *Saccostrea cucullata*, the limpet *Siphonaria* sp., and the gastropod *Nerita atrata*. Algae such as *Gelidium pusillum*, *Enteromorpha* sp., *Ulva* sp., and *Chaetomorpha antennina* may be present. The regional endemic crustose brown alga *Basispora africana* often forms a distinct belt at the junction of the barnacle and lithothamnia subzones (John and Lawson, 1988).

The lithothamnia subzone is generally algae-dominated, mainly red-algal genera such as *Gelidium*, *Herposiphonia*, *Laurencia*, *Polysiphonia*, *Taenioma*, and *Wrangelia*. Common animals include the large mussel *Perna perna*, limpets *Patella* sp. and *Fissurella* sp., and carnivorous snails of the genus *Thais*.

The sublittoral fringe is characterized by the brown algae *Dictyopteris delicatula* and *Sargassum vulgare* and the sea urchin *Echinometra lucunter*.

4.3.7.3 Coastal Lagoons

There are more than 90 lagoons along the coast of Ghana (Armah et al., 2004). They are important habitats for fishes, shrimps, crabs, and molluscs. They serve as nursery areas for juvenile fishes, overwintering sites for migratory birds, and roosting sites for local waterfowl.

The lagoons are of two main types, open or closed (**Table 4.6**). The amount of annual rainfall has an important effect on the nature of the coastal lagoons. West from Takoradi, all the coastal lagoons have a permanent opening to the sea (open lagoon). East of Takoradi, only four rivers (the Pra, Kakum, Densu, and Volta) have a sufficient volume of water at all seasons to maintain a permanent outflow from the coastal

lagoons at their mouths. The other watercourses, mostly rivers and streams, flow into closed lagoons that are open only for one or two months between June and September.

Table 4.6. Physical characteristics of Ghana coastal lagoons (From: Biney, 1986).

Lagoon	Lagoon Type	Associated Major River	Surface Area (km ²)	Mean Depth (m)	Maximum Depth (m)	Salinity
Keta	Closed	Volta	250	0.80	2.0	18.7
Angaw	Closed	Volta	50	1.75	4.0	2.3
Laiwi	Closed	---	0.7	0.70	2.5	13.6
Gao	Closed	---	1.1	0.77	2.0	12.1
Chemu	Open	---	0.16	0.48	0.8	18.0
Sakumo II	Open	---	3.5	0.55	1.0	1.9
Kpeshie	Closed	---	2.8	*nd	*nd	22.7
Korle	Open	Odaw	2.7	0.45	1.0	32.4
Sakumo I	Open	Densu	20	0.90	3.0	13.1
Oyibi	Open	Ayensu	1.5	*nd	*nd	1.1
Muni	Open	---	4.5	0.6	1.0	39.3
Nakwa	Open	Nakwa	8.0	0.75	2.0	31.5
Amisa	Open	Amisa	3.0	05.0	1.5	11.4
Fosu	Closed	---	2.5	0.55	1.5	8.7
Benya	Open	---	4.5	*nd	*nd	38.0

*nd = not determined.

Closed lagoons mainly occur in the eastern coastal region where rainfall is low and normally seasonal. Closed lagoons may be in contact with the sea for the greater part of the year due to the inlets being kept artificially open: the sand-bars are deliberately breached by local people who fish in the lagoons.

4.3.7.4 Mangrove Forests

Mangrove forests are sparse along the coast of Ghana. **Figure 4.13** shows mangrove forests in the area according to the World Mangrove Atlas. According to the FAO (2007), there were 137.3 km² of mangroves in Ghana in the year 2000. This represents only 0.42% of Africa's total mangrove forest area. About 25% of the mangroves in Ghana have been lost since 1980. According to Armah et al. (2004), well-developed mangroves are limited to the Elmina area in the western region; near Iture, west of Cape Coast, and at the Volta Delta (only the latter is visible on **Figure 4.13**).

The principal mangrove species is *Rhizophora racemosa*. Six other species occur in the region: *Acrostichum aureum*, *Avicennia germinans*, *Conocarpus erectus*, *Laguncularia racemosa*, *Rhizophora harrisonii*, and *R. mangle* (FAO, 2007).

The major threats to mangroves include cutting for fuel and the conversion of mangrove swamps to agricultural land. The construction of the Akosombo Dam on the Volta River in 1964 has also exacerbated the problem. The damming of the Volta River has resulted in reduced flooding and an increase in mangrove cutting due to the virtual collapse of agriculture and fishing in the estuary. Another ecological consequence of the reduced level of flooding has been reduced dispersal of seedlings of the principal mangrove *R. racemosa* (Rubin et al., 1998).

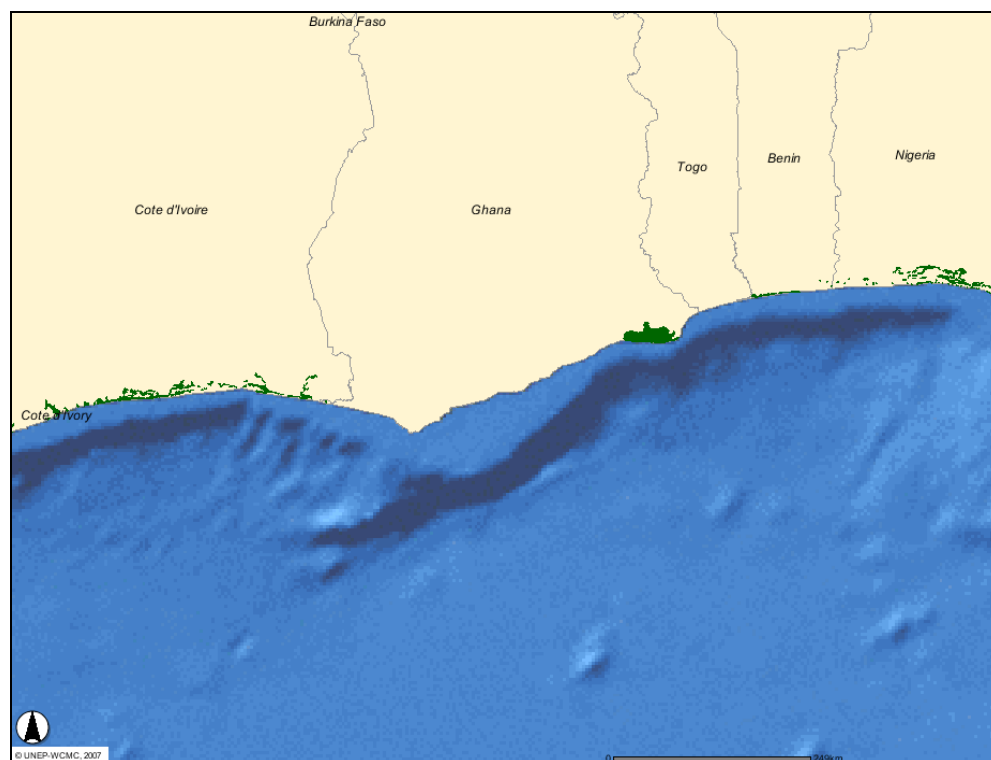


Figure 4.13. Mangrove areas (shown in green) along the coast of Ghana, West Africa (based on the 1997 World Mangrove Atlas) (From: United Nations Environment Programme, 2008).

4.3.7.5 Estuarine Wetlands

Estuarine wetlands are those associated with river mouths along the coast. The largest by far is associated with the Volta River and encompasses an area of about 700 km² (Armah et al., 2004). The damming of the Volta River has significantly altered the ecology of these wetlands. Nevertheless, they serve as important fish and wildlife habitat.

4.3.7.6 Depression Wetlands

Depression wetlands are small wetland areas that are not connected to any large watercourse (Armah et al., 2004). They are found mostly along the western part of the Ghanaian coast and are dependent on seasonal rainfall for flooding.

4.3.8 Protected Areas

There are no marine protected areas at or near the Jubilee Field. There are five designated Ramsar wetland sites along the coast (**Table 4.7**). A sixth Ramsar site (Owabi) is inland. Ghana also has one UN Biosphere Reserve and two World Heritage Convention sites, but all are located inland (United Nations Environment Programme-World Conservation Monitoring Centre [UNEP-WCMC], 2008). According to EarthTrends (2003b), Ghana has more than 1,000 IUCN-management protected areas, the vast majority of which are inland. Ghana has 317 Forest Reserves, five Game Production Reserves, seven National Parks, two Resource Reserves, one Strict Nature

Reserve, and four Wildlife Sanctuaries (United Nations Environment Programme-World Conservation Monitoring Centre [UNEP-WCMC], 2008).

Table 4.7. Coastal Ramsar sites in Ghana (From: Wetlands International, 2008).

Name and Site Number	Latitude, Longitude	Area (km ²)	Comments
Muni Lagoon (563)	5°22'N, 0°40'E	86.7	Sand dunes, open lagoon, degraded forest and scrubland. Lagoon opens into the sea during the rainy season
Densu Delta (564)	5°31'N, 0°20'E	58.9	Sand dunes, lagoons, salt pans, marsh, and scrub. Scattered stands of mangrove with extensive areas of open water
Sakumo Lagoon (565)	5°30'N, 0°08'E	13.6	Brackish lagoon with narrow connection to the sea. Main habitats are the open lagoon, surrounding flood plains, freshwater marsh, and coastal savanna grasslands
Songor Lagoon (566)	5°45'N–6°00'N, 0°20'E–0°35'E	287.4	Closed lagoon with high salinity, and a large mudflat with scattered mangroves
Anlo-Keta Lagoon complex (567)	5°55'N, 0°50'E	1,277.8	Open lagoon with brackish water influx from Volta River. Coastal savannah grasses with patches of trees and shrubs. Largest seabird populations of all coastal wetlands of Ghana

4.3.9 Critical Habitat Areas

According to IFC Performance Standard 6, critical habitat includes areas with high biodiversity value, including (i) habitat required for the survival of critically endangered or endangered species; (ii) areas having special significance for endemic or restricted-range species; (iii) sites that are critical for the survival of migratory species; (iv) areas supporting globally significant concentrations or numbers of individuals of congregatory species; (v) areas with unique assemblages of species or which are associated with key evolutionary processes or (vi) provide key ecosystem services; and (vii) areas having biodiversity of significant social, economic or cultural importance to local communities.

Appendix E discusses critical habitat for endangered or critically endangered marine mammals and sea turtles. The analysis concludes that neither the project area nor the adjacent coast of Ghana includes critical habitat for endangered marine mammals. Nesting beaches along the Ghanaian coast would constitute critical habitat for the green, leatherback, and olive ridley sea turtles. The Jubilee Field is approximately 60 km from the nearest Ghana shoreline where turtle nesting could occur.

There are no marine protected areas at or near the Jubilee Field that could be considered critical habitat under IFC Performance Standard 6. Chemosynthetic communities are known from the region and could be considered critical habitat based on their “unique assemblages of species.” However, geohazards survey data indicate there are no seafloor features in the project area that could support chemosynthetic communities. Gardline Surveys (2007a,b) conducted geohazards studies in the Jubilee Field area including the West Cape Three Points Block and the Deepwater Tano Prospect. No areas with the potential to harbour chemosynthetic communities were detected. Both studies concluded that, “after a thorough examination of the seabed and detailed investigation for any of the aforementioned features, seismic sections in

combination with seabed amplitudes reveal no significant evidence to support any sensitive habitats or chemosynthetic communities within the study area.”

Other protected areas (e.g., Important Bird Areas and Ramsar sites) exist along the coast as explained in **Section 4.3.6** and **Section 4.3.8**. These could be considered critical habitat under IFC Performance Standard 6 because they include sites that are critical for the survival of migratory birds, support globally significant concentrations or numbers of individuals of birds and provide key ecosystem services.

4.4 Socioeconomic Environment

This section provides an overview of the existing socioeconomic environment in which the proposed Jubilee project is located. The profile is disaggregated according to the various governmental levels in Ghana, i.e., national level, regional level, district level and finally town/village level.

Four districts are potentially affected by the proposed Jubilee Field, Phase 1 development, including 1) Jomoro, including various coastal villages such as Efasu; 2) Nzema East, containing various coastal villages; 3) Ahanta-West, containing various coastal villages; and 4) the Sekondi-Takoradi Metropolitan Area, spanning the entire combined city of Sekondi-Takoradi (**Figure 4.14**).



Figure 4.14. Districts of coastal Ghana potentially affected by Jubilee Field, Phase 1 development activities.

The three study areas of interest to the socioeconomic analysis include the offshore Jubilee Field, the onshore support base at Sekondi-Takoradi, and the closest coastal village to the MODUs, Efasu. Characterization of the socioeconomic environment was

focused on a national level (e.g., fishing off the Ghanaian coast which is highly similar in all areas); on the Sekondi-Takoradi Metropolitan Area, as the onshore support will emanate from this area; and the Jomoro District, given that the closest coastal villages that may be affected by the project are located in this District.

4.4.1 Ghana National Characteristics

Ghana's ten administrative regions are subdivided into 138 distinctive metropolitan, municipal, and district assemblies (Ghana Districts, 2008).

4.4.1.1 Population Distribution and Characteristics

The population of Ghana is approximately 23 million people (July 2008 estimate; Central Intelligence Agency [CIA], 2008; Ministry of Health, Ghana, 2008). Ethnic groups include Akan (45.3%), Mole-Dagbon 15.2%, Ewe 11.7%, Ga-Dangme 7.3%, Guan 4%, Gurma 3.6%, Grusi 2.6%, Mande-Busanga 1%, other tribes 1.4%, and other 7.8% (CIA, 2008).

The average life expectancy in Ghana was estimated at 58 years in 2001, with a high infant mortality rate (66 deaths per 1,000 births, placing Ghana as the country with the 50th highest infant mortality rate in the world) (Ministry of Health, Ghana, 2001). Other Human Development Index indicators indicate that Ghana is a developing country that is battling with many socioeconomic issues – high total fertility rates, high levels of malnutrition of children, and high incidences of diseases (Ministry of Health, Ghana, 2001).

The estimated average annual population growth rate is 2.6% in rural areas and 4.2% in urban areas, with approximately 38% of the population living in urban areas in 2000 (Earthtrends, 2003b).

4.4.1.2 Education and Employment

Ghana has a free basic education system that is compulsory up to age 15. The country has high primary school enrolment rates, in excess of 70% for both males and females. However, the secondary school enrolment rates tend to be lower than that of primary schools. In 1995, the secondary school enrolment rate was 44% for males and 28% for females (UNESCO, 1995). According to the 2000 census statistics, 53% of the population of Ghana above 15 years of age is literate in either English or a major Ghanaian language (West African Pipeline Company, 2004). The national average of completion of Senior Secondary Schools for Ghana is approximately 17% (Ghana Districts, 2008). Earthtrends (2003b) indicate the adult literacy rate for adult females to be 66%, while that for adult males is 82%, and that for youth of both genders (15 to 24 years of age) is 92%.

4.4.1.3 Community Leadership and Governance

In Ghana, two parallel government systems operate at the local level – the district assembly administrative structure and traditional administrative system. While the district administration consists of elected representatives as well as central-government-appointed personnel, the traditional administration derives from the chieftaincy institutions. At the community level, the elected assembly person serves as the main link between the district assembly and the community.

Chiefs and elders who constitute the traditional administrative institution also fill both judicial and executive functions within the communities. Chiefs, elders, and other opinion leaders are important figures in the leadership structure in the coastal regions, as well as within other parts of the country. The preferred dispute resolution mechanisms in the coastal regions are courts of law and, to a lesser extent, traditional councils, followed by meetings among concerned parties, and then with an independent arbitrator. The district assembly and police are the least preferred arbiters of disputes (West African Gas Pipeline Company, 2004).

4.4.1.4 Economic Activities

Ghana is well endowed with natural resources and has about twice the per capita output of the poorest countries in West Africa (CIA, 2008). However, it remains heavily dependent on international financial and technical assistance. Gold and cocoa production, and individual remittances, are major sources of foreign exchange. The domestic economy continues to revolve around agriculture, which accounts for about 35% of Gross Domestic Product and employs about 55% of the work force, mainly small landholders (Baah, 2003; CIA, 2008).

At the national level, the agriculture sector employs approximately 52.1% of the population, mining and quarrying employs approximately 15.0%, and manufacturing employs approximately 11.0% (Ghana Districts, 2008).

Ghana's economy has been growing at a steady rate of approximately 4% annually, but high inflation rates (15% at the end of 2002) and depreciation of the Ghanaian currency (15% depreciation in 2002 against the U.S. dollar) have hampered investment activities in Ghana (Baah, 2003).

4.4.1.5 The Oil Sector

The oil sector is an emerging sector in the Ghanaian economy, with major oilfields being discovered in 2007. The Deepwater Tano block at Cape Three Points contains the majority of the oil find. The Ghana National Petroleum Corporation (GNPC) was established in 1983 to promote, explore, and develop the hydrocarbon resources of Ghana.

4.4.1.6 Agriculture

Agriculture is one of the predominant economic sectors in Ghana, and accounts for approximately 56% of the national employment opportunities (FAO, 2006). Agriculture accounts for approximately 38% of the total Gross Domestic Product (GDP) of the Ghanaian economy, with agriculture valued at approximately US\$3.3 million (FAO, 2006). The agriculture GDP is estimated to have grown by 4.2% between 1994 and 2004, which is slightly lower than the total GDP of 4.4% (FAO, 2006).

Approximately 28% of the surface area of Ghana is cultivated or has the potential to be arable. The major agricultural production systems include yams, cassava, and cocoa beans, with cocoa beans accounting for approximately 67% of the foreign trade agricultural exports valued at approximately US\$1200 million (FAO, 2006). Cassava and its derivative products accounts for the majority of food consumption in Ghana (24%), whereas maize accounts for approximately 13% and yams approximately 12%.

The major farming activity along the coast of Western Ghana is coconut farming (Armah et al., 2004).

4.4.1.7 Commercial and Artisanal Fisheries

Historically, Ghana was a major fishing nation, but the fishery has declined significantly in recent decades (Atta-Mills et al., 2004, as cited in Anchor Environmental Consultants CC, 2008). Factors in the decline include trade policies, globalization of the fishing industry, the dominance of Europe's distant water fleets, declarations of exclusive economic zones by neighboring West African nations, overfishing, and a lack of adequate regulation. The country's marine environments have been affected by overexploitation of stocks and the use of destructive methods. Large-scale spatial and temporal variability in the marine ecosystem has also been a factor (Perry and Sumaila, 2007, as cited in Anchor Environmental Consultants CC, 2008).

In spite of this decline, fishing remains one of the primary economic activities of the population in the coastal regions of Ghana. Ghana's coastal zone represents about 6.5% of the land area of the country, yet it houses 25% of the national population who engage primarily in fishing as economic activity (Amlamlo, 2006, as cited in Anchor Environmental Consultants CC, 2008). It is estimated that 230,000 people in Ghana are employed in the fishing industry; fish protein forms 19% of the population's total protein supply and Ghanaian fish exports were worth some US\$78 million in 2000 (<http://earthtrends.wri.org>, 2000). It is estimated that another half a million people in other subsectors are dependent on fishing activities for employment (Armah et al., 2004).

The marine fishing industry in Ghana consists of three main sectors: artisanal, semi-industrial (or inshore), and industrial. At the Jubilee Field location, due to the water depth (1,020 to 1,720 m) and distance from shore (at least 63 km), it is expected that only industrial fishing would be occurring.

The following section provides a synopsis of fishing activities in Ghana, as adapted from the FAO (2008) fishery profile for Ghana and other sources.

Artisanal Fishing

Artisanal (subsistence) fishing is a major livelihood source for rural communities. Artisanal fishing for pelagic and demersal fishes with hook-and-line, gill nets, seine nets, cast nets, and beach seine nets accounts for between 65% and 80% of the total catch of marine fish (Koranteng, 1998, as cited in Anchor Environmental Consultants CC, 2008).

Approximately 185 villages on the coast of Ghana utilise approximately 304 landing sites to haul up the majority of the 10,000 canoes and vessels that these villages use. It is estimated that there is approximately one landing site per 2 km of coast line, with an average number of 30 canoes per landing site. Several landing sites can be located nearby the same village (Armah et al., 2004).

In a 2001 census, there were 9,981 marine artisanal canoes operating, many of which were wooden. Some large canoes are motorised, while others use sails. Commonly used fishing gears include purse seines, beach seiners, set nets, drift gill nets, and hook-and-line. There is also a fleet of motorised canoes that specialize in hook-and-line fishing, using ice to preserve high-value fish in insulated containers;

some of these vessels use electronic fish-finding devices such as echo-sounders. Beach seining is another common mode of artisanal fishing that is widely practised on Ghana's sandy beaches (Nunoo et al., 2006, as cited in Anchor Environmental Consultants CC, 2008).

Beach seine fishery is highly common along the coast of Ghana, with more than 800 beach seine nets located at the 304 landing sites. It is estimated that approximately half of the landing sites in the Western Region use beach seine nets, while the remainder use canoes or boats (Armah et al., 2004).

Beach seines are operated from the beach with gear consisting of a net bag and two net wings to each of which are attached a long drag rope. The seine is set from the beach using a canoe and dragged to land by two groups of men and women pulling on each of the two drag ropes (Armah et al., 2004).

A number of open lagoons can be found on the coastal region between Efasu and Takoradi. A thriving artisanal fishery in coastal lagoons of both subsistence and commercial importance can be found along the coastline. It is estimated that more than 40 lagoons along the entire coastline host some form of local fishery (Armah et al., 2004).

For artisanal fishermen, the prime fishing season (upwelling period) occurs for two to three months between July and September, with the majority of a fisherman's annual income earned during this period. Some fishing activity is also conducted during the minor upwelling period in January and February. Fishing is reduced to subsistence levels outside of the upwelling periods (Acres, 1995, as cited in West African Pipeline Company, 2004). The fishing industry also readily creates other economic opportunities. Women traditionally are prohibited from fishing activities, and therefore are often involved in fish preparation (i.e., trading, selling, and processing) (West African Pipeline Company, 2004). Artisanal fishing and inshore fishing appear to be mostly restricted to inshore of the Jubilee Field, with artisanal fishers mostly fishing to a maximum of 40 km offshore.

Semi-industrial Fishing

The semi-industrial fleet consists of locally built wooden vessels 8 to 37 m in length with in-board engines of between 60 and 400 hp. Most vessels are dual purpose; they are able to use trawls or purse seines. The latter are more commonly used during the major and minor upwelling seasons and trawling is practiced in shallow waters during off-season. In 2000, there were 169 inshore vessels (Mensah et al., 2001).

Industrial Fishing

Industrial vessels are large, steel-hulled foreign-built trawlers, shrimpers, tuna pole and line vessels, and purse seiners. As deep-sea vessels, the industrial trawlers by law are required to operate in waters deeper than 30 m. The industrial fleet is equipped with freezing facilities for preserving fish at sea and is capable of remaining at sea for months. The industrial fleet has undergone a radical expansion since 1984 when government policy targeted industrial fishing as a mechanism for promoting nontraditional exports (FAO, 2008).

The industrial fleet is currently made up of 47 trawlers, 6 shrimpers, 23 tuna baitboats, and 10 tuna purse seiners which operate from Tema and Takoradi where there are deepwater ports (National Fisheries Association of Ghana, 2004, as cited in Anchor

Environmental Consultants CC, 2008). The trawlers and shrimpers exploit demersal and semi-pelagic species. The tuna fishing vessels catch mainly yellow fin, skipjack, and big eye tunas in the pelagic zone.

Tuna fisheries (including bait boats and purse seiners) operate farther offshore than artisanal and semi-industrial fishers, often farther than 40 km offshore (see **Figure 4.15**). Prawn trawling in Ghanaian waters takes place in depths shallower than 40 m and closer to the shore (i.e., between 5 and 7.4 km, respectively) (Nunoo, 1998, as cited in Anchor Environmental Consultants CC, 2008). Furthermore, much of the Ghanaian continental shelf is deeper than 75 m and is too rocky for trawling, except towards the western side (Koranteng, 1998, as cited in Anchor Environmental Consultants CC, 2008).



Figure 4.15. West African fishing areas of tuna bait boats and tuna purse seine boats (From: Bard and Herve, 1993).

A total of 64 motorised fishing vessels are currently registered in the Sekondi Fishing Harbour. The majority of these vessels are 12 m in length.

4.4.1.8 Tourism and Other Recreational Activities

Tourism is an important yet relatively underdeveloped industry in Ghana, in general, and along the coastal zone, in particular. Although the tourism industry is not yet operating at full potential, it is growing and the country features on travel websites such as www.travelexcite.co.uk. The most important tourist season is from October to March.

The various tourism sites include hotels located on the waterfront (i.e., 28 hotels are registered in Ghana, with numerous minor resorts and campsites), recreational facilities (e.g., restaurants) located at the coastal areas, and historical monuments

(i.e., 26 forts and castles are located along the coast of Ghana, included on the list of the United Nations Educational, Scientific and Cultural Organization [UNESCO] as World Heritage Monuments) located in the vicinity of the coastal areas (Armah et al., 2004). Other tourism sites include national parks or villages such as Nzulezu village, the latter of which are discussed in the following section.

4.4.1.9 Other Economic Activities

Among other miscellaneous economic activities, salt production is prevalent. It is estimated that salt production occurs in approximately 14 coastal lagoons along the Ghanaian coast. The salt production industry is important to the national economy and provides employment opportunities to coastal villages.

Three methods of salt production are possible – first, salt can be collected from lagoon flats in the dry season when salt crystallises out of the super-saturated lagoon water. Alternately, dedicated saltpans with low dikes are used, where the pans are filled with lagoon water at high tides and dikes are closed and left for weeks, allowing water to evaporate. A third method involves pumping water from the lagoon to salt concentration pans located at higher levels. As the water evaporates, increasingly saline water is conveyed to lower lying saltpans (Armah et al., 2004).

4.4.1.10 Infrastructure and Services

Infrastructure and services in Ghana include energy, water, and sanitation; industrial activity; and marine traffic. Each of these components is briefly summarized in the following sections.

Energy, Water, and Sanitation

Estimates by Earthtrends (2003b) indicate that approximately 74% of the urban population and 70% of the rural population in Ghana have access to improved sanitation facilities, while 91% of the urban population and 62% of the rural population have access to safe water.

Industrial Plants

The Takoradi Thermal Power Plant lies on the coast approximately 17 km east of Sekondi-Takoradi, and relies on marine water for cooling purposes. The Thermal Plant started operation in 1997, initiated by the Volta River Authority to compliment the existing Hydro Plant at Akosombo and Kpong. The Takoradi Thermal Power Plant is therefore a facility of strategic importance for meeting Ghana's energy needs (Volta River Authority, 2006).

Marine Traffic

Ghana has two main ports, Tema and Takoradi (Ghana Ports and Harbours Authority, 2008). The Port of Tema has 11 berths located on two quays with a total frontage of about 2,000 m. These common user berths handle about half of the port's total throughput. The port also has a dedicated bulk terminal and an oil terminal. To the east of the main harbour are the Inner and Outer Fishing Harbours and the tuna wharf. There is a range of facilities and sheds alongside these berths to serve the needs of the fishing industry.

Takoradi is the oldest port in Ghana. It serves as gateway for Sahelian transit cargo and as a cruise destination. The port has recently expanded, and with the completion

of its three modern sheds, it now has a covered storage area of 140,000 m² and an open storage area of 250,000 m². In addition, there are also private warehouses in the Port area.

The Port of Takoradi also has a fishing harbour located at Sekondi, which has an ice plant that can accommodate vessels with up to 3-m draft. Takoradi will also serve as the support base to offshore activities in the proposed Jubilee Field, Phase 1 development project.

Other ship traffic in the region is associated with ports such as Abidjan (Côte d'Ivoire) and Lagos (Nigeria). There is considerable oil and gas support vessel traffic offshore Nigeria that operates mainly from Port Harcourt.

The general coastal area of Ghana has heavy shipping traffic, hence proper permitting and diligence during the performance of the development drilling, facility installation, and FPSO operation will be necessary to ensure that there is no disturbance to or from shipping activities (Anchor Environmental Consultants CC, 2008).

Ghana has a large number of fish landing sites, both along the coast and on Lake Volta, serving industrial, inshore, and artisanal vessels. A typical industrial vessel landing site is equipped with a landing berth, net mending sheds, fish discharge sheds, fish market, offices, and a boatyard. Tema Fishing Harbour is the main landing site for industrial vessels, though Takoradi Harbour also has berthing facilities for industrial vessels.

Inshore landing sites typically include some of the following: berthing bay, boatyard, boat repair facilities, net mending shed, workshop for repair and maintenance of outboard motors and marine engines, net drying area, and fish market. The most important landing sites for inshore vessels are Tema Fishing Harbour, Takoradi fish landing facilities, the old Sekondi Fishing Harbour, and the Albert Bosomtwe Fishing Harbour.

Typically, artisanal landing sites are characterized by a dearth of the facilities available at the industrial and inshore vessel landing sites. Important artisanal landing sites include Teshie, Jamestown, Chorkor, Shama, Axim, Elmina, Winneba, Mumford, Akplabonya, Adina, Atiteti, Abutiakope, and Moree (FAO, 2008).

4.4.2 Western Administrative Region

The Western Administrative Region contains 13 District Assemblies, covers nearly 10% of Ghana, and is home to approximately 2 million people. The Jomoro District (located closest to the proposed Jubilee Field, Phase 1 development) and the Sekondi-Takoradi Metropolitan Area (i.e., proposed location for Phase 1 onshore support base) are both located in this Administrative Region.

4.4.2.1 Population Distribution and Characteristics

The Sekondi-Takoradi Metropolitan Area has the largest proportion of persons (19.2%) in the region. The district capital, Sekondi, and its twin city Takoradi, have the infrastructure and economic influence to attract migrants and to retain its indigenous residents. Juabeso-Bia (12.7%), Wassa Amenfi (12.2%) and Wassa West (12.1%) also account for a substantial proportion of the regional population (Ghana Districts, 2008).

Recent analyses estimate the total population for the Western Administrative region to be slightly less than 2.5 million people (Ministry of Health, Ghana, 2008). Roughly 40% of all household members are children of the household head, and there are more male-headed households than female-headed households. In most of the districts in this region (8 out of 11), there are more males than females and more than 90% of inhabitants are Ghanaians by birth. The Akans, who include the indigenous Wassas and Sefwis, and the migrant Fantes, constitute more than two-thirds of Ghanaians by birth in every district.

All the districts depict the same pattern of a declining population as age increases, indicating the effect of mortality. Sekondi-Takoradi has the lowest significant proportion (37.8%) for the children's age group (0 to 14 years), compared with the other districts with figures ranging from 42% to 44%. However, Sekondi-Takoradi also has the largest proportion (57.6%) in the working age group of 15 to 64 years in the region. Wassa West (54.6%) and Jomoro (53.4%) also have a substantial proportion of this population category.

4.4.2.2 Education and Employment

The Western Region has seen some improvements in educational attainment and enrolment rates at the basic level over the last two decades. For instance, the proportion that had attained basic education increased from 28% in 1984 to 34% in 2000 (Ghana Districts, 2008).

There are 1,320 primary schools in the region comprising 1,240 public and 80 private schools. There are only half as many junior secondary schools (JSS) as there are primary schools, indicating that access to these schools is more difficult for some of the children, and children living in localities where junior secondary schools are not within reasonable distances are likely to drop out of school after primary school (Ghana Districts, 2008).

Access to senior secondary school (SSS) in the region is very poor compared to the primary schools and JSS. There are 42 senior secondary schools in the region, with most concentrated in the Sekondi-Takoradi area. Understandably, this district has the highest level of SSS completion (13.6%) followed by Jomoro (10.5%). The Western Region average for SSS completion is 12.1%, far below the national average of about 17%; post secondary level educational levels are also very low (Ghana Districts, 2008).

4.4.2.3 Economy

The four major occupations in the region are similar to the national trend: agriculture is the predominant occupation accounting for about 60% of the regional GDP and employing about 57% of the total labour force. There are more females than males in agriculture (including hunting and fishing). Production and transport work (14.5%), sales work (10.2%), and professional and technical work (5.0%) follow agriculture as prevalent occupations in Ghana (Ghana Districts, 2008).

The major industrial activities in the region differ slightly from the national trend: at the national level, agriculture (52.1%), mining and quarrying (15.0%), and manufacturing (11.0%) are major industrial activities. At the regional level, out of the total number of employed persons, 61.2% are in the agriculture sector. Remaining prominent employer categories include manufacturing (11.9%), wholesale and retail

trade (10.3%), and mining and quarrying (2.9%) sectors. The hotel and restaurant industry also accounts for about 2.0% of the working population (Ghana Districts, 2008).

Gender distribution characteristics by occupation indicate that 59% of females in the Western Region are involved in the agricultural sector, whereas 51% of males are involved in agriculture (West African Pipeline Company, 2004).

For all districts, the private sector (both formal and informal) provides employment to more than 70% of the working population. It is only in Sekondi-Takoradi that about a tenth of the working population is in the public sector. The metropolis also has a larger proportion of workers in the private formal sector than other districts (Ghana Districts, 2008).

4.4.2.4 Infrastructure and Services

The main sources of lighting within the Western Region are provided via kerosene lamp and electricity. These sources provide lighting for about 99% of households in the region. In the urban areas of Sekondi-Takoradi (83.2%) and Wassa West (56.5%), electricity is used by the majority of households while in the rural districts, kerosene is the source of lighting for majority of households (Ghana Districts, 2008).

The main source of cooking fuel in the region is wood. The great majority of households in all the districts use wood for cooking, except Sekondi-Takoradi, where charcoal is used by about 60% of households. About 16% of the households in Sekondi-Takoradi use wood. Other districts where charcoal is used fairly intensively are Ahanta-West (25%), Wassa West (38.3%), Nzema East (20.0%), Jomoro (16.5%), and Bibiani (14%) (Ghana Districts, 2008).

In the region as a whole, only 32% of houses have access to treated pipe-borne water with only 8.5% having this available within the dwelling place. The availability of toilet facilities seems to be a major problem in the region, as about 40% of dwellings in the region have either no toilet facility or occupants rely on the availability of a public toilet. Only four districts have a majority of their households equipped with a toilet facility in the housing unit.

Various types of medical facilities and personnel provide primary health care in the region. These include hospitals and allopathic (orthodox) doctors and their support staff including nurses, pharmacists, and public health personnel, and traditional healing facilities and traditional healers including herbalists, spiritualists, homeopaths, and other nonconventional health service providers. The official national norm is that no citizen should be more than 8 km away from the nearest health facility.

The Western Region exhibited a 2001 population health facility ratio (i.e., population to publicly-owned health facility) of 10,140, slightly below the national average of 11,289, and third lowest in Ghana. However, not every community has easy access to a hospital. For instance, in Nzema East, Mpohor-Wassa East, and Juabeso-Bia, about 60% of homesteads are situated more than 30 km from a hospital. In contrast, in Sekondi-Takoradi, more than 80% of homesteads have access to such a facility within a 10 km radius. Ahanta-West has over 60% of its homesteads within the same radius of a clinic.

4.4.3 Sekondi-Takoradi Metropolitan Area

The Sekondi-Takoradi Metropolitan Area, with Sekondi as the administrative capital, occupies the south-eastern part of Western Region. It shares boundaries with Ahanta-West, Mpohor Wassa East, and Komenda-Edina-Eguafo-Abrem Districts.

This region became a separate administrative structure during the 1960s with the establishment of Sekondi as its capital. Present day urbanised settings have made Sekondi and Takoradi one big metropolis. Being the third largest metropolis in Ghana, it is one of the most developed districts of Ghana in spite of its small size (Ghana Districts, 2008). This can be ascribed mainly to the harbour located in Takoradi (one of two major ports in Ghana) and the military base that is established at Sekondi.

4.4.3.1 Population Distribution and Characteristics

The Sekondi-Takoradi Metropolitan Area has a population of roughly 360,000 people, with an additional estimated floating population of 80,000 comprising people from neighbouring districts who commute into the city on a daily basis for civic, trade, and industrial activities. The Sekondi-Takoradi Metropolitan Area covers approximately 390 km² (Ghana Districts, 2008).

The population in the area has experienced a major growth rate in the past seven years due to the construction and establishment of the Takoradi Thermal Plant and the concomitant migration into the community.

4.4.3.2 Infrastructure and Services

Sekondi-Takoradi is fairly well supplied with basic infrastructure such as urban roads, electricity, piped water, permanent market structures, police posts, hospitals and other health centres, schools, and postal and communication facilities (West African Pipeline Company, 2004). However, more recent reports indicate that most of the infrastructural facilities in the Metropolis, particularly those within the urban centres, have been overstretched. There is rapid development taking place in the hinterland and a significant number of these areas are without access roads (Ghana Districts, 2008).

Energy

The power requirement of the Sekondi-Takoradi Metropolitan Area is about 49 MW. Approximately 90% of the metropolis has access to electricity. Some of the areas that have not been connected include Awuna Beach and Aboso Nkran. The power requirement is partially produced by a 330 MW combined cycle thermal plant that has been established at Aboadze near Sekondi. This plant supplements hydro-electricity, which is vulnerable and dependent on rainfall (Ghana Districts, 2008).

Waste Disposal

The collection, transportation, and disposal of solid and liquid waste is the sole responsibility of the Metropolitan Assembly, which operates through the Waste Management Departments. The tonnage of waste generated in the Sekondi-Takoradi Metropolitan Area has been increasing over the years as a result of population increases. The estimated total solid waste generation is 206 tonnes per day, or 75,293 tonnes per year. The actual collection in the years 2005 was 58,690 tonnes, a collection rate of about 70% (Ghana Districts, 2008).

Water

With regard to water, the supply coverage is between 60% to 65%, mainly in the urban areas of Takoradi, Sekondi and Shama. Supply of water is irregular at most places; however, the quality of water has fairly improved and is largely free from dirt and its salty taste. Nevertheless, the production and supply of water in the metropolis is fraught with constraints, including encroachment on land reserves for utility services, frequent power interruption, illegal connections, unplanned and uncontrolled housing development, and frequent damage to pipes by contractors, as well as long service pipeline connections (Ghana Districts, 2008).

Roads

Conditions of the road network in the Sekondi-Takoradi Metropolitan Area is variable, with 51.6% of the roads rated as good, 28.2% rated as fair, and 19.6% rated as poor. The total length of all weather roads in the metropolis has increased from 330.9 km in 1996 to over 400 km. Out of a total length of 212.9 km for urban roads, over 150 km has been tarred, 40 km are covered with gravel, and 23 km are composed of simple earth (Ghana Districts, 2008).

Healthcare

Sekondi-Takoradi has the highest concentration of health delivery facilities and services in the region. There are 31 private hospitals, five government health centres, and another five community clinics/maternalities, some of which offer 24-hour maternity and casualty services. The metropolis also has a rehabilitation clinic for mentally ill patients. In addition, there are 18 private general medical practitioners, five private registered midwives, a total of 186 Traditional Birth Attendants (TBA), and three private medical laboratories. Substantial success has been achieved in delivering healthcare to the populace and eradicating endemic diseases (Ghana Districts, 2008).

Economy

Sekondi-Takoradi is one of the hubs of industrial activity in Ghana. It is the third most industrialized city in the country and can boast of some of the big manufacturing industries in the country. In spite of this, commerce continues to be the dominant sector of the economy (Ghana Districts, 2008).

The agricultural sector employs about 18% of the population in the metropolis. Agriculture is thus an important sector due to the large rural settings. A total of 50.8% of the land area in the Sekondi-Takoradi Metropolitan Area is estimated to be cultivable and as many as 52,000 people are estimated to be engaged in agriculture, 11% of whom are fishermen. The average farm size is about 5 acres; however, yield per acre is comparatively low and varied. Crops produced in the metropolis include maize, rice, and cassava (Ghana Districts, 2008).

The main industrial area has about 28 industries, including some of the major ones in the country, and accounts for 25% of all manufacturing activities in the Western Region (Acres, 1995, as cited in West African Pipeline Company, 2004). Most of these companies process agricultural, forest, or mining products.

The harbour area has two giant factories – the Ghana Cement Works Factory and the Takoradi Flour Mills. The Sekondi sector has sawmills, a railway yard, and Limestone Products, another major company. The sand winning and stone quarrying industries

engage about 0.42% of the entire labour force; these activities are carried out at several locations (Ghana Districts, 2008).

Most trading activity take place in the Central Business District in Takoradi, which harbours, among other services, the main central market, departmental and retail stores, several filling stations, and banks. While Takoradi market is heavily congested, markets such as those at Sekondi and Effia-Kuma are under-utilised. Virtually all the major banking and insurance institutions are located in the metropolis and are concentrated in Takoradi (Ghana Districts, 2008).

4.4.4 Ahanta-West District and Nzema East District

The Ahanta-West District is one of four districts that are associated with the discovery of oil in Ghana. The district was formally under the jurisdiction of the Sekondi-Takoradi Metropolitan Authority (STMA). In 1988, the Ahanta-West District was carved out of the then STMA (then termed the Shama Ahanta East Metropolitan Assembly, and subsequently renamed the Sekondi-Takoradi Metropolitan Assembly). The District capital is Agona-Nkwanta.

The Nzema East District is located to the east of the Ahanta-West District, and contains approximately 70 km stretch of coastline with about 21 villages. The District capital is Axim.

4.4.4.1 Population Distribution and Characteristics

The Ahanta-West District is located at the southernmost point of Ghana and the entire West-African Region with its capital at Agona Nkwanta. It has it total land area of about 591 square km and is occupied by 95,140 people based on the 2000 population and housing census survey. Recent projections estimate the current population to be approximately slightly in excess of 122,400 (Ministry of Health, Ghana, 2008). The District is about 15 minutes drive from the commercial capital of the Western Region, Takoradi, about a 25-minute drive from the administrative capital, Sekondi.

The Nzema East District contains an estimated population of slightly more than 183,800 (Ministry of Health, Ghana, 2008).

4.4.4.2 Infrastructure and Services

Electricity services have been expanded to include such communities as Media, Boakrom, Aboadi, Kubekor, Aboagyekrom, Enmokanwo, Boekrom, Ellobankata, and others under Self Help Electrification Project (SHEP IV). Incidents of regular power outages are characteristic features of the company. Water to most of the villages and towns in these districts are provided by boreholes. Roads are generally in a poor condition in the districts.

4.4.4.3 Economy

The major economic activities in the Districts include farming, fishing, and, to a lesser degree, tourism.

Farming

Farming is by far the major venture undertaken in the districts. It is estimated that about 65% of the active population is directly involved in agricultural production. The agricultural production in the district is mainly subsistence in nature with simple implements such as cutlass and hoes. Farmers depend solely on rainfall for their crops, with an average farm size of 0.35 ha, resulting in low agricultural production. Major crops grown in the district are maize, cassava, oil palm, and coconut. Coconut tree farming remains one of the highly lucrative small-scale business industries in the districts, particularly within coastal areas.

Fishing

Fishing activities are very important economic activities for the coastal areas in the districts. Dixcove, one of the coastal villages, is noted all over the western region for its bumper catch of sharks, tuna, and lobsters. It is the oldest community in the country.

One of the challenges confronting the fishing industry in the coastal villages in the districts is the lack of cold stores to preserve fish. Fishermen have no bargaining power regarding their catch since the fish must be sold prior to it wasting. This results in fishermen being forced to sell to Market Queens from Accra, Kumasi, and Tamale at low prices. Unsold fish is bought by local entrepreneurs for smoking.

Tourism

The Ahanta-West District can boast of one of the finest beaches in the country, and therefore has a high potential for tourism. Unfortunately, tourism development in the district has not been given the needed impetus. The Busua Beach resort is one of three hotels that form the Golder Beach Hotels in Ghana, and is considered one of the foremost hotels in Ghana.

4.4.5 Jomoro District

The Jomoro District is the westernmost district in the Western Region that borders the Ivory Coast. The Jomoro District spans a surface area of approximately 1,350 km². The capital of the Jomoro District is Half-Assini.

4.4.5.1 Population Distribution and Characteristics

Based on the last census, the Jomoro District contained 110,300 individuals (Law, 2008, as cited in Anchor Environmental Consultants CC, 2008). Recent projections estimate the population in the Jomoro District at approximately 143,300 people (Ministry of Health, Ghana, 2008).

4.4.5.2 Infrastructure and Services

Fuel wood is the main source of energy for domestic use (cooking). Although other alternative energy sources are available (i.e., electricity, kerosene, liquefied petroleum gas), firewood usage remains the most preferred choice (Ghana Districts, 2008). Water is primarily supplied by boreholes to the larger villages, as ascertained from a site reconnaissance visit. Some of the larger villages such as Kengen and Elloin have access to electricity for lighting. For most communities that were visited during a brief site visit in 2008, existing infrastructural development is nonexistent.

The district has only three health centres and two in the project area – at Half-Assini (the only governmental hospital) and Ekabaku. These facilities are remote from the project site, making accessibility to healthcare for villages difficult.

Malaria ranks first of the top ten diseases in the district. For instance, a total of 13,303, 21,817, and 14,949 malaria cases were reported in 2003, 2004, and 2005, respectively (Ghana Districts, 2008). Results from the reconnaissance survey, focus group discussions, and interviews conducted by Golder in 2008 revealed that the trend has not changed and the incident of malaria has risen sharply in recent years.

4.4.5.3 Economy

The predominant small-scale industries in most of the communities in the Jomoro District are all agriculturally-based, including coconut, oil palm, and cassava farming. The entire coastal stretch is covered by coconut plantations. The dried fruit is crushed, sent to mills, and processed into oil. The chaff is used to feed pigs while the husk is used as fuel. Palm trees also have many uses like the coconut because all its parts are useful. Juice is extracted from the fruits and processed into palm oil which is sold to companies like Unilever and PZ Cassons for soap making and other industrial use. Local gin "akpeteshie" is brewed from the stem and exported. Some of this gin is also sold at local breweries. Cassava is also used for local dishes like "Akyeke," "Fom fom," fufu, and gari.

The District has an extensive rainforest which has given rise to timber extraction. Lumbering activities can be found in the vicinity of Mpataba, Nuba, Ankasa, Tikobo 1, Ellenda, and Anwiafutu. There are no established timber processing companies except for several illegal chain-saw operators (Ghana Districts, 2008).

The activities of timber extractors in the District have had negative effects, including:

- Depleting economic trees as a result of the neglect of afforestation and reafforestation programmes and the destruction of young trees all leading to micro-climate and ecological imbalance; and
- Destruction of crops through the indiscriminate manner in which the trees are felled and conveyed from the bush.

The forests are also used for crop farming. Major crops are cassava, coconut, maize, cocoa, and palm oil. Farmers use traditional methods for farming, including slash and burn techniques. Extraction of wood fuel is gradually having a deleterious effect on the natural environment.

The Jomoro District, including all communities from Benyin to Effasu, has a 50 km-deep stretch of sandy beach extending from Ekabaku to New Town. The beach is fringed with coconut plantations and is considered of sufficient aesthetic value to be potential tourism sites. The beaches are also nesting habitat for marine turtles which are of global conservation interest.

These beaches have yet to be developed into resorts and/or ecotourism sites. Currently, the Ghana Wildlife Society is implementing a marine turtle watch ecotourism facility to generate income for the communities in the project area.

Private investors who are natives of Benyin are also developing beach resorts near Ekabaku and Ngelekeso for recreation and beach tourism.

A number of pristine wetlands are also located in the Jomoro District. The major wetlands are the Amensuri, Dormuli, and Abby Lagoon wetlands located near Benyin, Old Kabenlasuaso, and Jaway Wharf, respectively. Tourism potential in the three wetlands includes boating, sport fishing, nature watch, medicinal plants trail, and industrial tourism (especially alcohol distillation).

The largest of these wetlands, the Amensuri wetlands, has the only known swamp peat forest in Ghana; nationally, Amensuri is the best example of an intact swamp forest. It has been selected as an Important Bird Area based on Birdlife International criteria. The Ghanaian government is taking measures to designate this area as a Ramsar site.

The Dormuli wetlands, although small, has beautiful, intact mangrove stands. Important animals found within the Dormuli wetlands include monkeys, Nile monitors, and crocodiles.

The Abby Lagoon is a trans-boundary wetland important to both Ghana and Ivory Coast due to its high productivity (especially fish). It is believed that the West African manatee (*Trichechus senegalensis*) exists in Abby Lagoon.

The Nzulezu village (i.e., the “Stilt Village”) is one of Ghana’s main tourism attraction sites, and is located in the Amensuri wetlands. Major efforts have recently been undertaken to improve tourism to this village.

Further tourist sites in the Jomoro District include the Ankasa National Park, which is renowned for its high plant diversity, as well as birds, monkeys, chimpanzees and forest elephants.

The Jomoro District has a few known historical sites, including fort and castles. Prominent sites include the Appolonia Fort in Benyin, the Miegyinla community, Captain Williams Tomb in Half Assini, and the mysterious site in Kengen. These are recognized as tourism destinations, although tourism in general is an underdeveloped sector in Ghana.

4.4.6 Efasu and Other Coastal Villages

A list of villages located along the coast that may be potentially affected by the proposed project, broken down per district, can be found in **Table 4.8**, as adapted from Armah et al. (2004). **Table 4.8** also provides information on the main activities that occur at the various coastal villages, such as artisanal fishing, tourist attractions located nearby, salt production, etc.

A total of 72 coastal villages are located between Sekondi-Takoradi and Efasu (bar New Town, which is located farther to the west). Twenty-nine of these villages are located in the Jomoro District, 21 are located in the Nzema-East District and 22 are located in the Ahanta-West District. Artisanal fishing is the predominant activity being undertaken at these coastal villages. Lower Axim contains the greatest number of artisanal fishermen, while remaining coastal villages typically have several hundred fishermen or less.

The Jubilee Field is located approximately 60 km from the closest coastal village of Efasu. Other villages on the coast close to the project include Mangyea, approximately 2 km to the east of Efasu; and Nzimtianu, approximately 4 km to the east of Efasu. Reconnaissance visits indicated that these coastal villages have inadequate service provision in terms of water, sanitation, and electricity.

Table 4.8. Coastal villages of Ghana inshore of the Jubilee Field and their main activities, disaggregated by district.

District Assembly	Village	Main Activities	Number of Fishers	Number of Canoes	Number of Motorised Canoes
Ahanta-West District	Funkoe	Artisanal fishing, salt production	411	88	28
	Amanful	Artisanal fishing	N/A	N/A	N/A
	Punpunei	Artisanal fishing	96	34	---
	Enyiwaehu	Artisanal fishing	N/A	N/A	N/A
	Adjoa (upper)	Artisanal fishing	206	---	14
	Adjoa (lower)	Artisanal fishing	39	3	3
	Asemko	Artisanal fishing	N/A	N/A	N/A
	Ampatano	Artisanal fishing	N/A	N/A	N/A
	Busua	Artisanal fishing, hotels at waterfront, minor resorts, recreational beaches	N/A	N/A	N/A
	Butre	Artisanal fishing, tourism attraction (fort), recreational beaches	417	80	48
	Upper Dixcove	Artisanal fishing, tourism attraction (fort)	230	40	33
	Lower Dixcove (Alatakrom)	Artisanal fishing	431	68	61
	Achonwa	Artisanal fishing	37	16	1
	Katakul	Artisanal fishing	N/A	N/A	N/A
	Akodaa	Artisanal fishing, tourist attraction (fort)	459	118	39
	Cape Three Point	Artisanal fishing, Takoradi Thermal Power Plant	96	49	3
	Princess Town	Artisanal fishing, lagoon fishing (closed lagoon), mangrove logging at lagoon, tourist attraction (fort)	306	46	31
	Akitekyi	Artisanal fishing, lagoon fishing (closed lagoon), mangrove logging at lagoon	562	52	34
	Miamea	Artisanal fishing	N/A	N/A	N/A
	Modrokenli	Artisanal fishing	N/A	N/A	N/A
Nzema East District	Nkubem	Artisanal fishing	N/A	N/A	N/A
	Egyembra	Artisanal fishing, recreational beach	30	24	---
	Egyan	Artisanal fishing	99	64	4
	Domunli	Artisanal fishing	10	10	---
	Ankobra	Artisanal fishing	150	---	---
	Upper Axim	Artisanal fishing, tourist attraction (fort), two waterfront hotels	N/A	N/A	N/A
	Lower Axim	Artisanal fishing	4,781	277	374
	Sawoma	Artisanal fishing, tourist attraction (monument)	N/A	N/A	N/A
	Ahyenzezo	Artisanal fishing	N/A	N/A	N/A
	Asanta	Artisanal fishing	293	---	---
	Esiana	Artisanal fishing	256	---	---
	Kikam	Artisanal fishing	185	---	1
	Ampain	Artisanal fishing	N/A	N/A	N/A
	Azulenoan	Artisanal fishing, open lagoon mangrove logging	N/A	N/A	N/A
	Sanzule	Artisanal fishing	190	---	---
	Bakanta	Artisanal fishing, open lagoon mangrove logging	230	---	1
	Baku	Artisanal fishing	172	---	---

Table 4.8. (Continued).

District Assembly	Village	Main Activities	Number of Fishers	Number of Canoes	Number of Motorised Canoes
	Ngalechie	Artisanal fishing	117	---	---
	Ngalekpole	Artisanal fishing	90	---	---
	Eikwe	Artisanal fishing	156	---	---
	Krisan	Artisanal fishing	86	---	---
	Atuabo	Artisanal fishing	60	---	---
	Anokyi	Artisanal fishing	121	---	---
Jomoro District	Beyin	Artisanal fishing, tourist attraction (fort)	186	6	2
	Kabaku	Artisanal fishing	N/A	N/A	N/A
	Kengen	Artisanal fishing	224	11	4
	Elonyi	Artisanal fishing	160	5	---
	Agyeza	Artisanal fishing	N/A	N/A	N/A
	Twene	Artisanal fishing	40	1	---
	Bonyere	Artisanal fishing	150	5	---
	Ezinlibo	Artisanal fishing	N/A	N/A	N/A
	New Ahobre	Artisanal fishing	N/A	N/A	N/A
	Egbazo	Artisanal fishing	88	4	---
	Atwebanso	Artisanal fishing	20	1	---
	New Edobo	Artisanal fishing	30	1	---
	Old Edobo	Artisanal fishing	70	2	---
	Old Ahobre	Artisanal fishing	74	36	35
	Awiane Ewe	Artisanal fishing	175	5	---
	Awiane Fanti	Artisanal fishing	235	2	---
	Half Assini Ewe	Artisanal fishing	337	27	27
	Half Assini Fanti	Artisanal fishing	201	5	---
	Ekpu	Artisanal fishing	243	21	10
	Gyawe	Artisanal fishing	28	3	2
	Metika	Artisanal fishing	108	5	4
	Mpeasem	Artisanal fishing	195	12	2
	Buakwaw	Artisanal fishing	157	4	---
	Efasu	Artisanal fishing	69	5	5
	Mangyera	Artisanal fishing	255	19	17
	Nzimtianu	Artisanal fishing	140	8	5
	New Town	Artisanal fishing	342	33	24
	Aloumatoapim (Fanti)	Artisanal fishing	178	20	20
	Anlomatoapim (Ewe)	Artisanal fishing	217	6	---
Total	72		9,457	1,216	832

5.0 Impact Assessment

This chapter focuses on potentially significant impacts associated with the Jubilee Field, Phase 1 development. Impacts of routine activities are discussed in **Section 5.1** (environmental) and **Section 5.2** (socioeconomic). Impacts of accidents are addressed separately in **Section 5.3**, followed by a discussion of cumulative impacts in **Section 5.4**. A summary table, including impact ratings, is provided in **Section 5.5**.

5.1 ENVIRONMENTAL IMPACTS OF ROUTINE ACTIVITIES

This section discusses impacts on the physical, chemical, and biological environment. Eight impact factors were identified for routine activities: (1) drilling discharges; (2) seafloor disturbance; (3) presence of structures; (4) operational effluent discharges; (5) marine debris; (6) air pollutant emissions; (7) support activities; and (8) structure removal.

5.1.1 Drilling Discharges

The Phase 1 development plan includes drilling of 15 new wells. Both water-based-fluids (WBFs) and an enhanced mineral oil-based fluid (EMOBF) will be used during drilling. WBFs will be used in the upper sections of the well bore and the EMOBF will be used during later well intervals. The EMOBF will be recovered and returned to the vendor for recycling; it will not be discharged except for small amounts adhering to cuttings. The base fluid for an EMOBF is a highly refined mineral oil that has low aromatic content and low toxicity.

Drilling discharges for each well are estimated to include 1,014 bbl (161.1 m³) of WBFs, 1,497 bbl (237.8 m³) of WBF cuttings, and 1,478 bbl (235 m³) of cuttings with adhering EMOBF. Cuttings discharged while using the EMOBF system will have an oil retention range of 6% to 8%. Both MODUs will use a cuttings dryer to minimise retention on cuttings.

The fate and effects of drilling discharges have been reviewed extensively (National Research Council, 1983; Neff, 1987; Hinwood et al., 1994; Neff et al., 2000; International Association of Oil & Gas Producers [OGP], 2003; Neff, 2005).

Effects on Water Quality, Plankton, and Fishes

Drilling fluid and cuttings discharges will produce a visible plume that will move with the currents as these materials are diluted and settle to the seafloor (**Figure 5.1**). In general, turbid water may extend between a few hundred meters and several kilometers down-current from the discharge point and persist for several hours after each bulk discharge. Studies have demonstrated reductions in water clarity within a few hundred meters to about 2 km of drilling rigs during drilling fluid discharges (Ayers et al., 1980a,b; Ray and Meek, 1980). Dispersion to background levels typically requires several minutes to several hours (Neff, 1987).

During well intervals when the EMOBF is used, only the cuttings will be discharged, along with a low percentage of adhering drilling fluids. Drilling fluids associated with nonaqueous based drilling fluids cuttings typically adhere tightly to cuttings particles

and probably would not produce much turbidity as the cuttings sink through the water column (Neff et al., 2000).

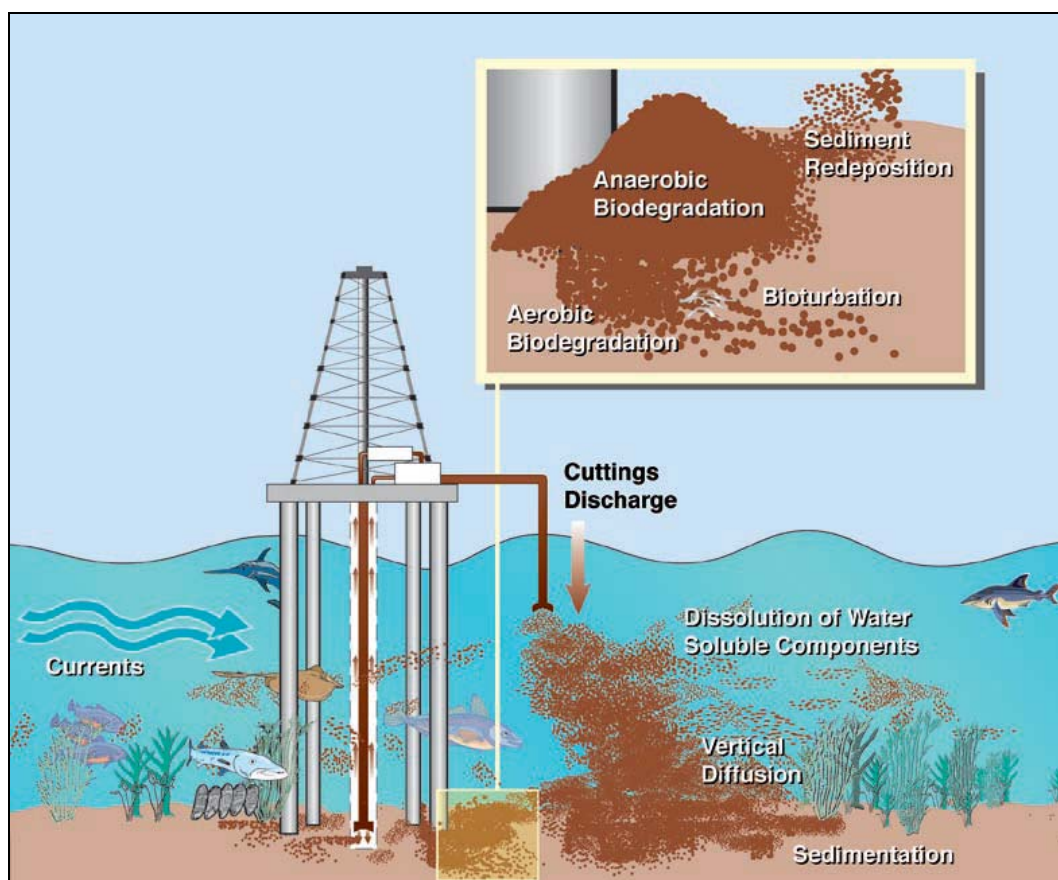


Figure 5.1. Fate of cuttings discharges (From: International Association of Oil & Gas Producers, 2003).

Discharges of drilling fluids and cuttings are likely to have little or no impact on plankton or fish due to the low toxicity and rapid dispersion of these discharges (National Research Council, 1983; Neff, 1987; Hinwood et al., 1994). Water-based drilling fluids typically have low toxicity. Therefore, there is little chance of toxic effects on fishes or other water column organisms.

Effects on Sediments/Geology and Benthic Communities

Drilling fluids and cuttings will accumulate on the seafloor, resulting in changes in bottom contours, grain size, barium concentrations, and perhaps concentrations of other metals (National Research Council, 1983; Boothe and Presley, 1989; Hinwood et al., 1994). These changes occur primarily within a few hundred meters around each wellsite and may persist for several years (Continental Shelf Associates, Inc., 2006).

Benthic community effects of drilling discharges have been reviewed extensively by the National Research Council (1983), Neff (1987), and Hinwood et al. (1994). Due to the low toxicity of most drilling fluids, the main mechanism of impact to benthic communities is increased sedimentation, possibly resulting in burial or smothering. Monitoring programmes have shown that benthic impacts of drilling are minor and localised within a few hundred meters of the wellsite (EG&G Environmental

Consultants, 1982; National Research Council, 1983; Neff, 1987; Continental Shelf Associates, Inc., 2006). The water depth and strong currents are expected to facilitate the dispersion of drilling fluids and cuttings discharged from drilling rigs and should minimise benthic impacts. Use of a cuttings dryer is also expected to reduce the chance of producing discernable cuttings piles. The thickest accumulations may result from release of cuttings and water-based “spud mud” during the initial well interval before the marine riser is set. These materials will bury and smother benthic organisms around the wellbore.

Seafloor Releases

During the first well interval when the hole is being jetted into the seafloor, cuttings and “spud mud” will be released at the seafloor. These initial discharges will create a mound with a diameter of several meters to tens of meters. Also, during setting of the casing, cement slurry will be pumped into the well to bond the casing to the walls of the hole. Excess cement slurry will emerge from the hole and accumulate on the seafloor, generally within about 10 to 15 m around the wellbore (Shinn et al., 1990). Cement slurry components typically include cement mix and some of the same chemicals used in water-based drilling fluids (Boehm et al., 2001).

The main impacts resulting from the release of these materials will be burial and smothering of benthic organisms within several meters to tens of meters around the wellbore. Soft bottom sediments disturbed by cuttings, drilling fluids, and cement slurry will eventually be recolonised through larval settlement and migration from adjacent areas. Recovery may require several years.

Rig Discharges – WBFs and WBF Cuttings

After the initial well interval, the marine riser is set allowing drilling fluids and cuttings to be returned to the drilling rig, where they will be processed through solids control equipment. Cuttings will be separated and discharged overboard, whereas drilling fluids will be recirculated into the hole until their properties become degraded and they must also be discharged.

Cuttings and water-based drilling fluids will be released almost continuously from drilling rigs during drilling. Cuttings typically are coarse particles that settle rapidly to the seafloor near the discharge point, primarily within a few hundred meters. A layer of fine particles (primarily drilling fluids) will be dispersed and deposited over a much broader area (Boothe and Presley, 1989). Due to the water depth and strong currents in the area, it is likely that drilling fluids will be widely dispersed and only the coarse cuttings will settle near the drillsites.

Barite (barium sulfate) is a major insoluble component of drilling fluid discharges, and therefore barium concentrations will increase in bottom sediments around the wellsites. Concentrations of other metals in drilling fluids are similar to those in marine sediments, but some metals such as cadmium, copper, lead, mercury, and zinc may be elevated within a few hundred meters of the wellsite (Boothe and Presley, 1989). However, metals in drilling fluids show very low bioavailability to marine animals and do not pose a risk to benthic organisms or their predators (Neff et al., 1989a,b).

Benthic communities within a few hundred meters of each drillsite may be buried or smothered (EG&G Environmental Consultants, 1982; National Research Council, 1983; Neff, 1987; Continental Shelf Associates, Inc., 2006). Soft bottom areas buried by

cuttings and drilling fluids will eventually be recolonised through larval settlement and migration from adjacent areas. Recovery may require several years.

Rig Discharges – EMOBF Cuttings

During intervals when EMOBF is used, only the cuttings will be discharged, along with small percentages of adhering mineral oil. The behaviour of these cuttings will differ somewhat from that of WBF cuttings (Neff et al., 2000; International Association of Oil & Gas Procedures [OGP], 2003). In shallow water, cuttings with adhering nonaqueous based fluids tend to clump together and form piles close to the drilling rig. However, the water depth in the project area is a natural mitigating factor that is expected to reduce the chance for thick cuttings piles to accumulate. Use of a cuttings dryer is expected to reduce the chance of producing discernable cuttings piles around wellsites (Getliff et al., 1997; Hanni et al., 1998).

Continental Shelf Associates, Inc. (2006) studied drilling discharge impacts at several sites on the Gulf of Mexico continental slope in water depths of 1,033 to 1,125 m. Two sites were sampled post-exploration and three sites were sampled post-development. Both WBFs and synthetic based fluids (SBFs) were used at these sites. Cuttings deposits covered a maximum area of 108 ha at one post-development site, compared with about 13 ha for a single exploratory well. At both post-exploration and post-development sites, areas of SBF cuttings deposition were associated with elevated organic carbon concentrations and anoxic conditions. Areas within about 500 m of drillsites had patchy zones of disturbed benthic communities, including microbial mats, areas lacking visible benthic macroinfauna, zones dominated by pioneering stage assemblages, and areas devoid of surface-dwelling species. Infaunal and meiofaunal densities generally were higher near drilling, although some faunal groups were less abundant near drillsites. Some stations near drilling had lower diversity, lower evenness, and lower richness indices compared with stations away from drilling. Some stations affected by drilling were dominated by high abundances of one or a few deposit-feeding species, including known pollution indicators. The severity of these impacts was greatest at two post-development sites that had the largest discharge volumes of SBF cuttings during drilling.

The seafloor in the project area is expected to consist of soft-bottom benthic habitat (see **Section 4.3.3**). The main concern with regard to potential impacts is the accumulation of cuttings around wellsites in areas such as deepwater hard bottom communities or chemosynthetic communities. These areas are associated with elevated densities of epifauna and fishes, and are considered relatively rare and ecologically important. However, a geohazards study by Gardline Surveys indicated there are no hard bottom areas or features that could support chemosynthetic communities in the project area.

Mitigation

Drilling fluid and cuttings discharges are subject to effluent limits as summarized in **Table 2.3**. These include a requirement for no free oil (visual sheen test); limitations on cadmium and mercury concentrations in stock barite; and base oil retention on cuttings of 6% to 8%. Solids control equipment including a cuttings dryer will be used to minimise retention of base oil on cuttings in accordance with these limits. No additional mitigation is recommended.

5.1.2 Seafloor Disturbance

Seafloor-disturbing activities include anchoring of drilling rigs, mooring of the floating production, storage, and offloading (FPSO) vessels, and installation of subsea facilities such as manifolds, flowlines, and risers. These activities will resuspend bottom sediments, crush benthic organisms, and produce turbidity. A summary of the expected footprint of Phase 1 facilities is provided in **Table 5.1**. The total area affected is about 23 ha.

Table 5.1. Estimated areal extent of seafloor disturbance.

Facility	Dimensions	Total Seafloor Affected (ha)
DRILLING RIG ANCHORING		
Anchors (8)	<i>Blackford Dolphin</i> : 8 anchors est. dimensions of 6.4 x 6.9 m, nominal; wire/chain combination	0.1 (3 sets of 8 anchors)
Anchor chain touchdown	10 x 100 m per anchor set	2.4 (3 sets of 8 anchors)
FPSO MOORING		
Anchors (9), including anchor chain touchdown	VLA or suction pile anchors; dimensions TBD during FEED	18 (9 anchors)
SUBSEA FACILITY INSTALLATION		
Production Wells (9)		
Manifolds	6.1 x 9.1 m, with suction piles measuring 4.6 to 5.2 m in diameter	0.028
Trees	4.4 x 4.4 m	0.010
Water Injection Wells (5)		
Manifolds	6.1 x 6.1 m, with suction piles	0.0074
Trees	4.4 x 4.4 m	0.0040
Gas Injection Wells (3)		
Manifolds	6.1 x 6.1 m, with suction piles	0.0074
Injectors	4.4 x 4.4 m	0.0040
Flowlines, Injector Lines, Umbilicals and Risers/Riser Bases		
Production	29,669 m of 10-in. flowlines	0.75
Water injection	10,724 m of 10-in. water injection lines	0.27
Gas Injection	3,024 m of 8-in. gas injection lines	0.06
Umbilicals	19,843 m of 8-in. umbilicals	0.40
Risers (10) and riser bases (3)	Riser Base: 100 x 24 m (est., Ceiba Field)	0.72
Subsea Distribution Units	10 x 10 m (est.) ; 3 units	0.03
Total		22.79

FPSO = floating production storage and offloading; FEED = front end engineering design; TBD = to be determined; VLA = vertically loaded plate anchor.

Of the two mobile offshore drilling units (MODUs) that will be drilling in the Jubilee Field, only one (the *Blackford Dolphin*) will use bottom-founded anchors for station keeping. The other (the *Eirik Raude*) will be in dynamically positioned (DP) mode for the duration of its operations. The *Blackford Dolphin* is slated to drill and complete four wells, requiring three anchor deployments. It is equipped with eight anchors, each with approximate dimensions of 6.4 by 6.9 m. The area directly affected by anchors would be 0.035 ha per set, or 0.1 ha for three sets. Anchor chain touchdown will also disturb sediments during anchor deployment and anchor set; the area potentially affected may measure 10 m wide and as much as 100 m long. The estimated impact area is 0.8 ha per set, or 2.4 ha total.

The FPSO will be moored using a total of nine anchors, clustered in three groups of three. The areal extent of seafloor disturbance caused by anchors and anchoring are related to the size and configuration of the anchor and mooring system, the length of chain or mooring lines that may rest on the bottom, and the swing arc that a chain could have as a result of currents or winds. A conservative estimate of the seafloor disturbance footprint for each anchor and the swing arc of its mooring line is 2 ha (Minerals Management Service [MMS], 2008). Therefore, the total seafloor disturbance would be about 18 ha.

An additional area of seafloor will be disturbed by the installation of subsea production facilities, such as manifolds, trees, umbilicals, flowlines, injector lines, and riser bases. The largest area will be caused by flowlines, injection water lines, and the riser base. The total seafloor area disturbed by placement of subsea facilities will be about 2.3 ha.

The seafloor in the project area is expected to consist of soft-bottom benthic habitat (see **Section 4.3.3**). The main concern with regard to potential impacts is the placement of anchors in areas such as hard bottom communities or chemosynthetic communities. These areas are associated with elevated densities of epifauna and fishes, and are considered relatively rare and ecologically important. However, a geohazards study by Gardline Surveys indicated there are no hard bottom areas or features that could support chemosynthetic communities in the project area.

Anchor scars and footprints created during the project will likely remain on the bottom for months to years (EG&G Environmental Consultants, 1982; Shinn et al., 1990, 1993; Dustan et al., 1991). In a recent study of drillsites in the Gulf of Mexico at depths of about 1,000 m, Continental Shelf Associates, Inc. (2006) detected anchor scars up to 14 years after drilling was completed. Individual anchor scars ranged from less than 100 m to over 3 km in length. Anchor scars and footprints will eventually disappear as sediments are redistributed by currents and benthic organisms.

Mitigation

No mitigation is recommended.

5.1.3 Presence of Structures (including Noise and Lights)

Offshore structures and the associated noise and lights are a source of impacts in the marine environment. Structures refers to the two drilling rigs, the FPSO, and the associated subsea facilities including manifolds, risers, flowlines, and umbilicals.

The two drilling rigs will be present in the project area only during the initial phase of the development. The *Blackford Dolphin* will be onsite for about 8 months and the *Eirik Raude* for about 30 months. In contrast, the FPSO, once installed, is expected to be onsite for 20 years.

Effects on Benthic Communities

Over time, the FPSO and mooring cables will develop an attached community of epibiota. Boukinda Mbadinga et al. (2007) studied biofouling communities on offshore structures in the Gulf of Guinea. Their nearest study area was in the northeastern Gulf of Guinea near Cameroun and Bioko Island. During the first two years, an assemblage of barnacles, sponges, seaweeds, hydroids, bryozoans, and (in shallow water) oysters

begins developing. After 5 years, barnacles and sponges were the most common groups (**Figure 5.2**). Corals also colonized between the sea surface and about 50-m depth. The development of a mature, climax fouling community typically requires several years on newly exposed hard substrates.

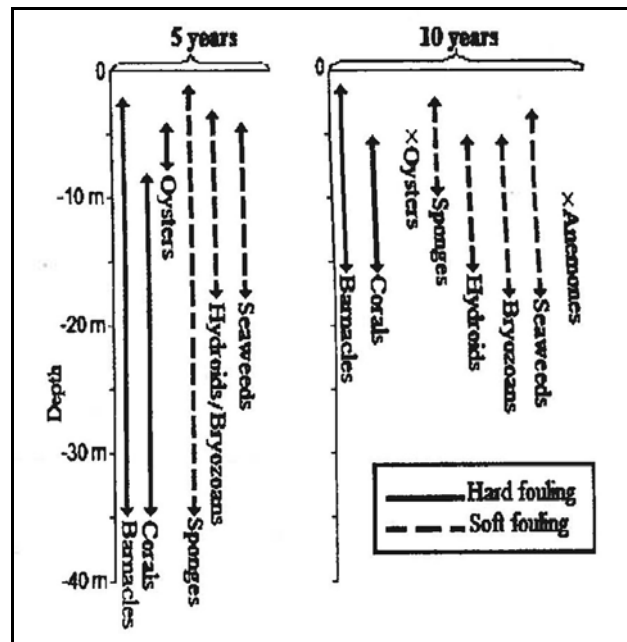


Figure 5.2. Biofouling assemblages on offshore structures in the Gulf of Guinea (From: Boukinda Mbadinga et al., 2007).

The Phase 1 development subsea layout includes eight, four-well manifolds as well as associated flowlines, risers, and umbilicals. The presence of these structures on the seafloor will likely attract fish and epibiota.

A possible indirect effect from the presence of structures is the sporadic sloughing of biological debris from the biofouling community, which may produce organic enrichment underneath the FPSO (Wolfson et al., 1979). Effects may include increased total organic content of sediments and altered benthic communities.

Effects on Plankton and Fishes

Zooplankton and ichthyoplankton may be attracted to lights associated with offshore structures. Fish larvae are strongly attracted to lights at night (Victor, 1991). Light emissions from operations are likely to have negligible impacts on planktonic communities due to the small area of ocean affected.

Offshore structures attract fishes, providing shelter and food in the form of attached fouling biota (Gallaway and Lewbel, 1982; Wilson et al., 2003, 2005). Offshore structures typically attract epipelagic fishes such as tunas, dolphin, billfishes, and jacks (e.g., Holland et al., 1990; Higashi, 1994). Stanley and Wilson (2000) reported finding 10,000 to 30,000 fishes associated with individual platforms; the lowest numbers were found at the largest and deepest structures. The density of fishes around platforms was 10 times greater than in open water. This “artificial reef effect” is generally considered a beneficial impact.

Effects on Marine Mammals

Some marine mammals may avoid areas around offshore production facilities due to noise. Others might be attracted to fish populations around the structures. The most likely impacts would be short-term behavioural changes such as diving and evasive swimming, disruption of activities, or departure from the area.

Richardson et al. (1995) defined four zones of potential noise effects on marine mammals. In order of increasing severity, they are (1) audibility; (2) responsiveness (behavioural effects); (3) masking; and (4) hearing loss, discomfort, or injury (physical effects). The levels of sound produced during drilling are sufficient to be audible and produce behavioural responses, but are much lower than those known to cause hearing loss, discomfort, or injury.

Low-frequency noise from offshore production activities can be detected by marine mammals (Richardson et al., 1995). Mysticetes (baleen whales such as fin whales) are more likely to detect low-frequency sounds than are most odontocetes (e.g., dolphins), who have their best hearing in high frequencies. There are other offshore drilling and production activities in the region (e.g., offshore Nigeria), so this would not represent a novel source. However, noise associated with drilling is relatively weak in intensity, and the animals' exposure to these sounds would be transient. Some of the noise (from vessel engines and propellers) would be similar to the existing noise associated with shipping traffic in the region.

Effects on Sea Turtles

Some sea turtles may be attracted to offshore structures (Rosman et al., 1987; Lohoefer et al., 1990). However, any impacts on turtle populations are likely to be negligible. In the Gulf of Mexico where thousands of offshore structures are present, platform lighting is considered unlikely to appreciably reduce the reproduction, numbers, or distribution of sea turtles (National Marine Fisheries Service, 2001).

Turtle hatchlings are attracted to and can be disoriented by artificial lighting (National Research Council, 1990). It has been hypothesized that they may be attracted to brightly lit offshore structures, where they could be subject to increased predation by birds and fishes that also are attracted to these structures. However, the platform would be far from the nearest shoreline and any turtle nesting beaches. Therefore, the risk of any impacts on hatchlings is small.

Effects on Marine Birds

Both positive and negative impacts of offshore structures on birds have been noted. Some birds may be attracted to offshore structures because of the lights and fish populations that aggregate around these structures. Birds may use offshore structures for resting, feeding, or as temporary shelter from inclement weather (Russell, 2005). However, birds migrating over water at night have been known to strike offshore structures, resulting in death or injury (Wiese et al., 2001; Russell, 2005).

Visual/Aesthetic Effects

The FPSO and drilling rigs are not likely to be visible from shore. Offshore structures such as drilling rigs and platforms typically are visible from shore at distances of 5 to 16 km, with small structures (e.g., a single drilling rig) barely visible at 5 km from shore.

On a clear night, lights on top of offshore structures could be visible to a distance of approximately 32 km (MMS, 2007b). The Jubilee Field is about 63 km from the nearest shoreline.

Mitigation

No mitigation measures are recommended.

5.1.4 Operational Effluent Discharges

Effluent discharges during routine operations have been summarized in **Section 3.5.2**. These include produced water, completion and workover fluids, sanitary waste (black water), domestic waste (gray water), deck drainage, noncontact cooling water, and other miscellaneous effluents. The impacts of drilling fluid and cuttings discharges have been discussed previously in **Section 5.1.1**.

Produced water is likely to be the largest effluent discharge during production. Quantities will be low levels during initial production, but may reach a maximum of 160,000 barrels of liquids per day. Produced water discharges would affect water quality near the FPSO by adding hydrocarbons, trace metals, and biochemical oxygen demand to the environment. Studies indicate that produced water has low intrinsic toxicity (OGP, 2005). Environmental effects have been evaluated in several studies. Studies have demonstrated accumulation of produced water contaminants in sediments around discharging facilities, but limited environmental effects (Neff, 2002; OGP, 2005). The results of ecological and human health risk assessments indicate that constituents in produced water discharges present very little, if any, toxicological risk to the biota or to humans eating fish or shellfish from the area (Continental Shelf Associates, Inc., 1997).

Completion and workover fluids (brines) are expected to be diluted rapidly and have little or no impact on water quality. In the open ocean, these discharges will be diluted rapidly to ambient concentrations and conditions within tens of meters of the discharge point.

Sanitary waste (black water) and domestic waste (gray water) from manned production facilities and support vessels may affect concentrations of suspended solids, nutrients, and chlorine, as well as generating biological oxygen demand (BOD). It is assumed that one person generates 100 L/d of sanitary waste and 220 L/d of domestic waste. It is predicted that sanitary wastes have an associated BOD of 240 mg/L. These discharges are expected to be diluted rapidly in the open ocean (MMS, 2007b). Impacts would likely be undetectable beyond tens of meters from the source.

Deck drainage consists of all waste resulting from rainfall, rig washing, deck washings, tank cleaning operations, and runoff from curbs and gutters, including drip pans and work areas. Assuming a surface area of about 20,000 m² based on the dimensions of the FPSO, and a maximum monthly rainfall of about 170 mm, the monthly average deck drainage for the FPSO would be 3,400 m³. During the drilling period when both MODUs are on site, total average deck drainage would be about the same, but when only one rig is on site, it would drop back down to about 1,700 m³. Offshore production facilities are designed to contain runoff and prevent oily drainage from being discharged. Because of the separation and treatment of water from oily areas prior to

discharge, deck drainage is not expected to produce a visible sheen or any other detectable impacts on water quality.

Additional miscellaneous discharges typically occur from numerous sources on an offshore platform. Examples include uncontaminated freshwater and seawater used for cooling water and ballast, desalination unit discharges, blowout preventer fluids, and boiler blowdown discharges (U.S. Environmental Protection Agency [USEPA], 1993). These discharges must meet the International Convention for the Prevention of Pollution from Ships (MARPOL) requirements and are expected to be diluted rapidly in the open ocean. Impacts on water quality would likely be undetectable beyond tens of meters from the source.

Mitigation

Discharges of produced water and completion/workover fluids are subject to effluent limits (International Finance Corporation [IFC], 2007a). The expected oil and grease content of produced water discharges is 20 mg/L. This is less than the IFC (2007a) limits, which specify a daily limit of 42 mg/L and a 30-day average not to exceed 29 mg/L.

The FPSO and support vessels must also comply with MARPOL requirements including provisions concerning sanitary waste, domestic waste (including food waste), oily waste, and garbage. No additional mitigation is recommended.

5.1.5 Marine Debris

All solid waste generated during development and production will be incinerated or transported to shore for disposal. Monthly solid waste based on historical data for a typical drillship is expected to be about 40,000 kg, including general waste, galley waste, used waste oil and oil/fuel filters, absorbents, oily water, cardboard, plastic, paper, batteries, wood, etc.

Disposal of trash and debris in the ocean is prohibited under MARPOL. The drilling rigs and FPSO will operate under Waste Management Plans to ensure adherence to MARPOL. However, occasionally material may accidentally fall overboard, such as welding rods, buckets, and pieces of pipe.

Pieces of metal debris that fall overboard are eventually colonized by epibiota. They also attract fishes due to their physical structure on the otherwise flat seafloor, resulting in a minor, local impact on the benthic community (Shinn et al., 1993). The impact is limited to a few meters to tens of meters of the wellbore.

Floating marine debris, especially plastics and monofilament line, can harm marine mammals, turtles, and birds. Marine mammals can become entangled in and ingest trash and debris, including materials lost overboard during offshore oil and gas operations (Laist, 1996). Marine debris is among the threats affecting the population status of both humpback whales and sperm whales (National Marine Fisheries Service, 1991, 2006). Similarly, ingestion of, or entanglement with, accidentally discarded debris can kill or injure sea turtles (Laist, 1996; Lutcavage et al., 1997) and is among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). Leatherback turtles are especially attracted to floating debris, particularly plastic bags, because it resembles their preferred food,

jellyfish. Ingestion of plastic and styrofoam can result in drowning, lacerations, digestive disorders or blockage, and reduced mobility. Finally, marine debris can also injure or kill birds that ingest or become entangled in it.

Mitigation

The FPSO and support vessels must comply with MARPOL requirements including the prohibition of disposing trash into the sea. The Jubilee Joint Venture plans to implement a Waste Management Program that applies the principles of source reduction, reuse, and recycling to reduce the amount of waste generated. The Jubilee Joint Venture also plans to work with the local business community and governmental agencies in Ghana to enhance in-country waste management capabilities to ensure that risks associated with improper treatment and disposal activities are minimised. Also, a site clearance survey will be conducted to ensure that any debris from drilling activities is removed from the seafloor around the wellsites. No additional mitigation is recommended.

5.1.6 Air Pollutant Emissions

Table 5.2 summarizes estimated emissions for the project. Platform equipment typically are powered by natural gas or diesel engines that emit air pollutants including nitrogen oxide (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), volatile organic compounds (VOCs), as well as particulate matter (PM) and greenhouse gases (GHG) such as CO₂ and CH₄. Support vessels and helicopters will also emit air pollutants from combustion of diesel fuel (vessels) and aviation fuel (helicopters).

Table 5.2. Estimated air pollutant emissions for the Jubilee Field, Phase 1 development.

Source	Estimated Emissions (tons)					
	PM	SOx	NOx	VOC	CO	GHG
Drilling/completion activities (Eirik Raude) (entire period, 1,092 days)	626.22	2872.79	21526.35	645.79	4696.66	1,030,975.21
Drilling/completion activities (Blackford Dolphin) (entire period, 266 days)	106.61	489.06	3664.64	109.94	799.56	175,512.98
Installation of subsea facilities (entire period, 90 days)	33.87	155.40	1164.45	34.93	254.06	55,769.71
FPSO installation (entire period, 2 days towing, 90 days to install)	14.58	66.89	501.19	15.04	109.35	24,003.95
FPSO production operations (annual)	92.07	406.01	3160.22	96.21	732.86	160,871.47

CO = carbon monoxide; GHG = greenhouse gases (expressed as CO₂ equivalent); NO_x = nitrogen oxides; PM = particulate matter; SO_x = sulfur oxides; VOC = volatile organic compounds.

Under certain conditions, some of these gases are known to degrade to form different compounds, and these degradation products and transformation processes are important in the context of problems such as global warming and acidification.

Air pollutant emissions from the drilling rigs and the FPSO are expected to be rapidly diluted and dispersed in the offshore atmosphere. There may be some decrease in air quality within several hundred meters around these emission sites. However, no

detectable impacts on air quality in Ghana or Côte d'Ivoire are expected based on the relatively small quantities of pollutants emitted and the distance from shore.

Annual GHG emissions for Ghana in 2005 were estimated to be approximately 15 million metric tons of CO₂ (4.1 million metric tons of carbon) (Marland and Boden, 2008). Ghana's emissions represent less than 0.1% of global GHG emissions. Annual GHG emissions during drilling by the *Eirik Raude* represent about 2% of Ghana's 2005 emissions. Annual GHG emissions during production represent about 1% of Ghana's 2005 emissions.

Offshore platforms and support vessels must comply with MARPOL Annex VI, which sets limits on sulfur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances including halons and chlorofluorocarbons. MARPOL also sets limits on emissions of nitrogen oxides from diesel engines and prohibits the incineration of certain products on board such as contaminated packaging materials and polychlorinated biphenyls. Routine inspection and maintenance of engines, generators, and other equipment is recommended to minimise excess noise and air emissions. Use of low-sulfur diesel fuel is recommended if it is available locally.

5.1.7 Support Activities

During the project, offshore service vessels and helicopters will provide support from an onshore base at Takoradi, approximately 130 km from the Jubilee Field.

Anchor handling support for the *Blackford Dolphin* will consist of two anchor handling vessel/anchor handling tug supply (AHV/AHTS) vessels. No anchor handling is necessary for the *Eirik Raude*, which will use dynamic positioning. While each rig is onsite, a total of two work boats will make at least one round trip per day between the shorebase and the drilling rig. One helicopter is assumed to make four round trips per day during drilling. Support vessels and helicopters will normally follow the most direct route between the wellsites and the onshore base, weather and traffic permitting.

Once the FPSO has been installed and begins operations, a single work boat will visit the FPSO on a daily basis. In addition, two helicopter trips to the FPSO will be required daily.

Effects on Marine Mammals

There is a small possibility of a service vessel striking a marine mammal during routine operations. The risk is similar to that associated with existing vessel traffic in the region. Collisions with dolphins or whales are considered highly unlikely; most dolphins are agile swimmers and are unlikely to collide with vessels. Of 11 marine mammal species known to have been hit by vessels, fin whales are struck most frequently, sperm whales are hit commonly, and records of collisions with Bryde's whales are rare (Laist et al., 2001). Although all sizes and types of vessels can collide with whales, most lethal or severe injuries are caused by ships 80 m or longer and traveling 14 knots or faster (Laist et al., 2001).

Vessel strikes are among the threats affecting the population status of both humpback whales and sperm whales (National Marine Fisheries Service, 1991, 2006). Sperm

whales are vulnerable to ship strikes because they typically spend up to 10 minutes “rafting” at the surface between deep dives (Jaquet et al., 1998). There have been many reports of sperm whales of different age classes being struck by vessels, including passenger ships and tug boats. There were also instances in which sperm whales approached vessels too closely and were cut by the propellers (National Marine Fisheries Service, 2006).

There is a remote possibility of a service vessel striking a sea turtle during routine operations. Vessel strikes are among the threats affecting the endangered population status of several sea turtle species (National Research Council, 1990). The risk is similar to that associated with existing vessel traffic in the region. Studies indicate that sea turtles are at the sea surface only about 10% of the time and readily sound (dive) to avoid approaching vessels (Byles, 1989; Lohofener et al., 1990; Keinath and Musick, 1993; Keinath et al., 1996).

Due to the relatively low level of support vessel traffic, the likelihood of striking a marine mammal or turtle is considered low.

Effects on Marine Birds

Vessel and helicopter traffic could periodically disturb individuals or groups of coastal birds. It is likely that individual birds would experience at most a short-term, behavioural disruption.

While the impact in general would be minor, it could be significant if helicopters traveled over Important Bird Areas (IBAs). There are five coastal IBAs in Ghana (see **Section 4.3.6**). Only one of these, the Amansuri wetland, is between the Jubilee Field and Takoradi, although it is not along the direct line of flight (**Figure 5.3**).

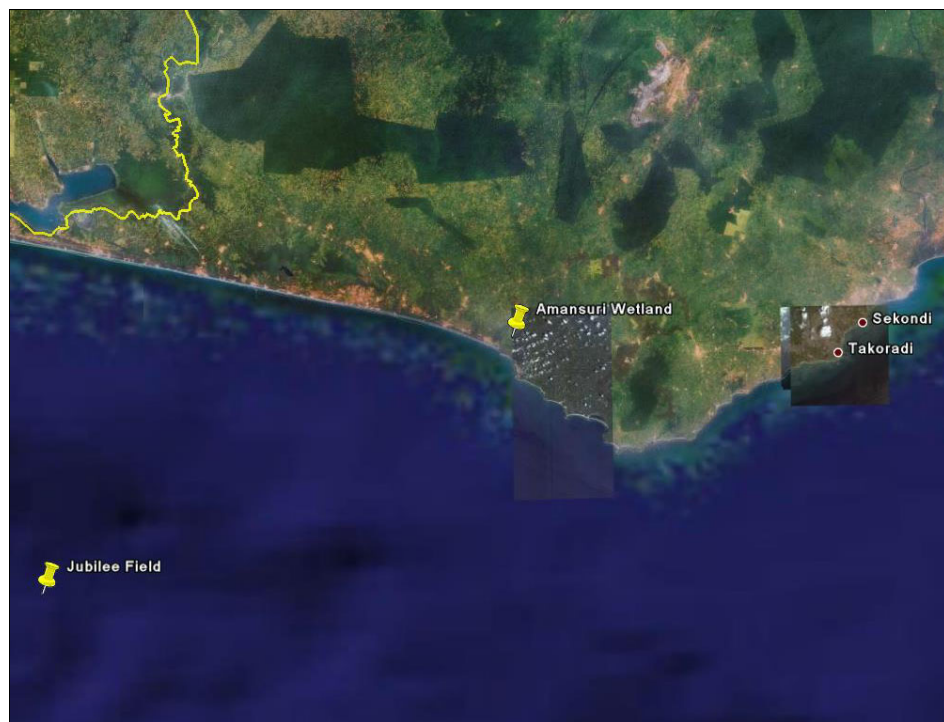


Figure 5.3. Location of the Amansuri wetland, an Important Bird Area, in relation to the Jubilee Field and the onshore base at Takoradi.

Effects on Fishing and Shipping Activities

Support vessels would normally be expected to follow the most direct route between the project area and onshore support base, weather conditions permitting. Due to the low level of support vessel traffic (e.g., one round trip per day), no impact on fishing or shipping is expected.

Mitigation

Helicopters engaged in support operations should avoid flying over the Amansuri wetland when traveling to or from the onshore support base. If avoidance is not feasible, a minimum altitude of 710 m should be maintained when flying over this area to minimise disturbance to wildlife. This is consistent with corporate policy for helicopter companies, which typically states that helicopters should maintain a minimum altitude of 305 m over unpopulated areas and coastlines, and 710 m over populated areas and sensitive areas including parks, wildlife areas, and recreational seashores (MMS, 2007b).

5.1.8 Structure Removal

During decommissioning, the FPSO and subsea facilities would be removed. Removal of subsea facilities and dragging of anchors during removal operations would physically disturb the seafloor and benthic communities. The impacts would be similar to those of installing the facilities.

Due to the use of an FPSO instead of a fixed platform, it is expected that there would be no need for explosives during decommissioning. Explosives are often used to sever the legs of conventional platforms (MMS, 2005) and are the main source of impacts during decommissioning, with the potential for killing or injuring fish, marine mammals, and sea turtles (Klima et al., 1988; Viada et al., 2008).

Mitigation

A decommissioning plan will be developed at the end of the project life and is expected to include any appropriate environmental safeguards. Based on the geohazards study by Gardline Surveys, there are no hard bottom communities or chemosynthetic communities in the project area, and therefore no impacts on these communities are expected during decommissioning.

5.2 SOCIOECONOMIC IMPACTS OF ROUTINE ACTIVITIES

This section evaluates potential impacts of the development project on the socioeconomic environment. Impact factors include: (1) creation of employment opportunities; (2) opportunities for local enterprises; (3) economic impacts (e.g., from royalties, taxes, fees, etc.); (4) opportunities for community development; (5) population influx and increase in social pathologies; (6) housing demand; (7) increased strain on service provision; (8) increased traffic; (9) impacts on fishing; (10) onshore impacts of project infrastructure; and (11) health and safety impacts of normal operations. Impacts of accidental events are addressed separately in

Section 5.3.

5.2.1 Creation/Transfer of Employment Opportunities

The project will result in the creation or temporary transfer of job opportunities during three phases: development drilling, installation of production facilities, and routine production operations. Because some activities overlap among phases, the total number of jobs is likely to be less than the sum of the individual phases discussed below. A corresponding loss of job opportunities will occur when the project is decommissioned.

Table 5.3 indicates the number of job opportunities that are expected to be created or temporarily transferred to Ghana during development drilling. As this table illustrates, approximately 140 jobs will be directly transferred due to the operation of the two MODUs, with an expected local staffing complement of 10% for the *Eirik Raude*. Support operations will provide approximately 260 employment opportunities with a local staff complement of between 30% and 80%.

Table 5.3. Predicted direct employment impact of the project during development drilling.

Item	Duration (Months)	Number	Local Staffing (%)
MODU <i>Eirik Raude</i>	24	50	10
Anchor Handler #1	24	10	10
Work Boat #1	24	6	10
Work Boat #2	24	6	10
MODU <i>Blackford Dolphin</i>	8	50	0
Anchor Handler #2	8	10	0
Work Boat #1	8	6	0
Work Boat #2	8	6	0
Port Support – Marine	Continuous	40	80
Aviation Support	Continuous	20	30
Five major services companies to support drilling and completions phase	24	200	50
Total		404	

Installation, commissioning and start-up of the FPSO and subsea facilities will result in approximately 200 employment opportunities over the course of 3 months, with approximately 10% local staffing (refer to **Table 5.4**). In addition, support operations will continue to provide approximately 280 employment opportunities with a local staff complement of between 30% and 80%.

Table 5.4. Predicted direct employment impact of the project during installation of production facilities.

Item	Duration (Months)	Number	Local Staffing (%)
Port Support – Marine	Continuous	40	80
Aviation Support	Continuous	20	30
FPSO field installation spread, commissioning and start-up	3	200	10
In-country management and administrative support	Continuous	20	50
Five major services companies to support drilling and completions phase	24	200	50
Total		480	

During routine production operations, the FPSO and onshore support base are not likely to bring a multitude of employment opportunities. Approximately 156 employment opportunities with between 10% and 50% local staffing are expected (Table 5.5). In addition, marine and aviation support operations will continue to provide approximately 60 employment opportunities with a local staff complement of between 30% and 80%. This is a long-term impact, however, with the operations estimated to continue for 20 years. It is expected that the local employees will emanate from various areas of Ghana, including approximately 40% from Takoradi, 40% from Accra and approximately 20% as Ghanaian expatriates.

Table 5.5. Predicted direct employment impact of the project during routine production operations.

Item	Duration	Number	Local Staffing (%)
Port Support – Marine	Continuous	40	80
Aviation Support	Continuous	20	30
FPSO Production Phase	Continuous	120	20
FPSO Anchor Handler	Continuous	10	10
FPSO Work Boat	Continuous	6	10
In-country management and administrative support	Continuous	20	50
Total		216	

At the end of the project, the development infrastructure will be decommissioned. This is expected to lead to a reduction in employment, requiring that those employed on the project at the time (an estimated 216 workers) secure alternative employment. However, since it is likely that there will still be other exploration and oil extraction activities occurring in the area at the time the project is decommissioned, it is expected that these workers will be able to find alternative employment in the industry. This impact is therefore not anticipated to be highly significant.

Optimisation of Benefits/Mitigation

The following measures are recommended to optimise the benefits associated with employment creation:

- Establish a “labour and employment desk” as a contact point for local community members who wish to seek employment on the project. One of its tasks will be to create a skills register of the qualifications and work experience of local community members who apply at the desk for employment on the project. The relevant details of all applicants are to be recorded, regardless of whether or not they are successful in their applications. If future opportunities for employment arise in the operational phase of the project (either through maintenance activities or through Corporate Social Responsibility initiatives established by the Jubilee Joint Venture in the area), these persons may be invited to apply for suitable positions.
- Establish a monitoring system to ensure that the Contractor honours the specified employment policy.
- Use local staffing as far as possible.

The following measures are recommended to reduce impacts of decommissioning:

- The company should give advance warning of pending retrenchments, so that employees have the maximum time to seek alternative employment;
- Employees about to be retrenched should be offered professional counselling to deal with the effects of job loss to reduce the traumatic effect of dismissal.
- During the operational phase of the project, employees should be offered the opportunity to develop alternative skills that will increase their chances of finding employment outside the oil industry. Possible examples of such alternative skills include building and construction, plumbing, and information and computer technology skills. It is also recommended that employees be offered the opportunity to receive training in small business development and relevant skills to encourage job creation and financial independence;
- In accordance with labour law requirements, the company must provide severance payments and assist employees in obtaining social benefits; and
- Employees who are to be dismissed should be notified of vacancies at other Jubilee Joint Venture operations, so that they may apply for employment at these operations. Application for such vacancies must be forwarded within the stipulated period and will be considered with due regard to the skills required.

5.2.2 Opportunities for Local Enterprises

With the rapid expansion of Sekondi-Takoradi as a result of the oil extraction activities in the area, numerous opportunities for local enterprises to provide support services to the oil sector becomes available. MI Drilling Fluids will construct a support base at Sekondi-Takoradi to support the operations, and it is currently estimated that an additional 10 to 12 major service companies will be opening their offices as well in Sekondi-Takoradi. The Jubilee Joint Venture currently projects that half of these service companies rent existing space and the other half will build facilities, such as a mud plant, to support the development.

Opportunities for support and supply services would include the following areas:

Rig operation

- Drill bits supply
- Drilling fluids and materials
- Cementing and pumping
- Anchor handling
- Mud logging services
- Fuel
- Catering (food/fresh water)

Heavy equipment rentals

- Boat suppliers
- Helicopters
- Fixed wing services
- Trucking
- Tank rentals
- Cranes

Metal works

- Fabrication, welding and joinery
- Machinery
- Pipeyard
- Engineering

Business services

- Information and computer technology support
- Catering/restaurants
- Transportation/freights

- Travel
- Insurance
- Banking
- Accommodation
- Stationery and office supplies
- Construction
- Electrical services
- Chemicals

Consulting and resource services

- Safety engineers and trainers
- Environmental, health, and safety (EHS) services
- Petroleum engineers
- Project and development managers
- Electrical services
- Legal services
- Recruitment

Environmental

- Waste management
- Quality control
- Inspection services

Property

- Building services
- Security services
- Utilities
- Warehouse and storage

Other operators are also planning to drill outside the scope of the Jubilee Field Phase 1 development plan, which is currently the main driver of expansion activities.

Optimisation of Benefits

The following measures are recommended to maximise this positive impact:

- Develop a register of local support and services companies and the types of goods and services provided by them. This register may be linked to the skills register recommended above. The responsibility of developing and maintaining this register shall rest with the labour and employment desk mentioned above.
- Establish linkages with other institutions involved in skills development and business development, such as the community development programme of the Metropolitan Authority and nongovernmental organisations (NGOs) active in the area. The performance indicator of this measure shall be minutes of meetings conducted with representatives of these institutions.
- Where appropriate support and/or service companies do not exist, investigate the possibility of launching a training/skills development initiative under the auspices of the Corporate Social Responsibility (CSR) programme of the Jubilee Joint Venture to develop local entrepreneurial skills.

5.2.3 Economic Impacts

A substantial economic value is associated with drilling activities and future operations of the project in the Jubilee Field, although a large portion of this will go to ship conversions in China. At the time of this writing, the economic value of the project to the Ghanaian Government could total over 17.5% of the income generated by oil sales (per GNPC estimates).

Although exact figures related to expected procurement totals, capital expenditures, and operational expenditures are not currently available, this would entail a significant economic injection in the Ghanaian economy, despite a large portion of investment being allocated to ship conversions out of the country.

Decommissioning of the project will lead to a reduction in opportunities for businesses that supply the operation with goods and services and a reduction in financial benefits to the Government of Ghana through royalties, taxes, etc. These impacts will largely be ameliorated by the continued activity of other exploration and extraction operations in the area, and are therefore not expected to be significant.

Optimisation of Benefits/Mitigation

The following measures are recommended to maximise the positive impacts of the project:

- Ensure that contractual obligations are met in terms of royalties and taxes.

Although it not expected that decommissioning will severely affect the local economy, it is recommended that the following measures be implemented to further reduce this impact:

- All stakeholders should be given advance warning of when the operation will be terminated. Such notice should be given early enough to give companies supplying the project with goods and services sufficient time to seek alternative business opportunities; and
- During the operational phase of the project, local companies supplying the project with goods and services should be encouraged to also secure contracts with other industries and operations.

5.2.4 Opportunities for Community Development

At the time of this writing, the Jubilee Joint Venture is in the process of defining their CSR commitments. Potential communities that may be targeted include the coastal fishing communities.

Optimisation of Benefits

The following measures are recommended to maximise this positive impact:

- Liaise with local communities as to their needs and priorities;
- Liaise with other institutions and organisations (e.g., the Metropolitan Authority, NGOs, etc.) in the area in order to ascertain whether any CSR initiatives can be aligned with current initiatives; and

- Communicate the CSR initiatives clearly to relevant parties, such as the Metropolitan Authority, NGOs and villages.

5.2.5 Population Influx and Increase in Social Pathologies

The project could result in a population influx to the Sekondi-Takoradi area as a result of the sudden presence of a number of employees and other supporting services. It is also highly likely that many work seekers move into the project area in search of employment. The work seekers often are left unemployed, and may resort to criminal activities to sustain their livelihoods if they cannot find alternative employment opportunities. The increase in population numbers may lead to a higher risk of social pathologies entering communities, such as an increased risk in the spread of sexually transmitted diseases (STDs), alcohol abuse, potential conflict with locals, etc.

The possibility for conflict would increase if workers and jobseekers have the opportunity to interact with locals and prostitutes become active; if there is a real or perceived increase in crime in the area, and the workers are held responsible for these criminal acts; or if the perception exists that the workers are taking jobs that could have gone to locals.

These social pathologies could be exacerbated by an increased availability of cash in surrounding communities as a result of project-related economic benefits. This increase in disposable income may be utilised in socially unproductive means – including a higher potential for alcohol and other substance abuse and inappropriate sexual activity that generally harms women (and increases the risks of STDs). Money that is spent unwisely may not only fail to achieve the potential benefits of increased income, but may actually harm individuals and their families and be a source of negative social behaviours that may harm communities as a whole.

Mitigation

The following measures are recommended to combat the spread of STDs:

- Implement HIV/AIDS and alcohol abuse campaigns for employees.
- Align awareness campaigns with those of other organisations in the area.

The following measures are recommended to prevent conflict between employees and locals:

- The recruitment policy used to employ people on the project must be fair and transparent.
- This policy must be clearly communicated to local communities.
- Measures described below to control access to the onshore support base and movements of workers also apply in this regard.

The following measure is recommended to address crime:

- Consult with the local police to establish standard operating procedures for the control and/or removal of loiterers at the support base.

5.2.6 Housing Demand

During development drilling, MODU crews will be housed offshore, while onshore support will live locally in Sekondi-Takoradi. It is expected that onshore support employees will either be locals (therefore not requiring any housing) or expatriates, who will be housed in apartments. Based on the number of employees that will be housed onshore, it is not expected that the demand for housing will place significant strain on housing availability in Sekondi-Takoradi as a result of the Jubilee project itself. However, the five support companies may require local housing, which may result in some strain on housing and service provision in Sekondi-Takoradi.

Logistical support will be provided from existing facilities that are owned by Tullow and Kosmos at the port of Takoradi and the Naval Support Base at Sekondi. The air force base will also provide logistical support, but it is not expected that construction camps will be erected in the area.

During routine production operations, the onshore support base employees who are not locals will be accommodated in houses or apartments in Sekondi-Takoradi. The offshore workers will be housed offshore, and will be on a rotational assignment to ensure that they are either at their own homes or in transit when they are not working on the FPSO.

Mitigation

- Liaise with, metropolitan authorities to ensure adequate supply of housing, or alternatively, assist in providing temporary housing.

5.2.7 Increased Strain on Service Provision

As a result of the numerous service companies commencing operations in Takoradi, an increased strain on service provision in Takoradi is expected. As discussed in **Section 4.4.3.2**, the current service provision levels in Takoradi are being placed under severe strain. Onshore facilities will use local existing water, electricity, and sanitation facilities. The Jubilee Joint Venture is currently working with local industries to enhance waste treatment and disposal capabilities.

Although the presence of the onshore support base for the project is not expected to have a major impact on the service provision levels, other concomitant industrial developments that are also commencing will place a cumulative strain on the metropolitan authority to maintain electricity, water, and waste disposal services.

Mitigation

- The Sekondi-Takoradi Metropolitan Authority must be informed of the nature of services that will be required for service provisions well in advance of the anticipated timeframe.

5.2.8 Increased Traffic

The operational support for both MODUs that will originate out of the Port of Takoradi (vessel support) and the Ghana military airbase (flight support) will result in an increase in shipping and air traffic between Sekondi-Takoradi and the Jubilee Field.

While each MODU is onsite, a total of two work boats will make at least one round trip per day between the shorebase and the drilling rig. One helicopter is assumed to make four round trips per day during drilling. Once the FPSO has been installed and begins operations, a single work boat will visit the FPSO on a daily basis. In addition, two helicopter trips to the FPSO will be required daily. Tankers will be dispatched to the FPSO approximately every 10 days for offloading of the FPSO.

Details are not available on the number of ship movements in the Port of Takoradi but the additional ship movements from the project are not expected to be significant. The same applies to the Ghana Military Airbase regarding helicopter traffic. There may also be an increase in road traffic as a result of project-related activities.

Mitigation

- Ensure efficient and clear communication with port and airbase personnel to avoid unnecessary delays in shipping or airborne movements.

5.2.9 Impacts on Fishing

The presence of the two MODUs and the FPSO are not expected to impact fisheries. Drilling rigs act as temporary artificial reefs by providing shelter and attracting food for fish. Due to the distance from shore, and the lack of an offshore deepwater demersal fishing industry in Ghana, there would be no economic impact on fisheries (West African Pipeline Company, 2004). Additionally, there are no known bottom driftnet or trawling operations in the vicinity of the drill sites that would be adversely affected by the presence of the drilling rigs or FPSO.

For safety reasons, an exclusion zone will be maintained around offshore facilities; the radius is expected to be 500 m for the MODUs and 1,000 m for the FPSO. It is expected that commercial tuna fishers will be excluded from only a very small portion of their fishing grounds, as tuna are pelagic fish. The 500-m exclusion zone represents 0.785 km² or 0.0003% of Ghana's Exclusive Economic Zone (EEZ) and the 1,000-m exclusion zone represents 3.14 km² or 0.0013% of the EEZ. The exclusion zones represent a negligible fraction of the available fishing area. Furthermore, other reports (West African Pipeline Company, 2004) predict that, should the water depth at the proposed drillsites be in excess of 1,000 m, a suspended well head or any other obstruction or debris on the seafloor would not adversely affect the commercial deep-sea tuna fishery.

A variety of discharges are associated with offshore oil and gas operations (see **Sections 5.1.1 and 5.1.4**). These effluent discharges are required to comply with MARPOL standards and other effluent limits as detailed in **Table 2.3**. They are expected to have minor or negligible effects on water quality within a few tens to hundreds of meters around discharge locations and would not be expected to significantly affect commercial fishing.

Mitigation

- Establish clear communication channels to commercial deep-sea fishers as well as artisanal fishing villages to communicate any potential impacts that may arise from project activities.

- Implement community awareness campaign to educate fishers regarding the exclusion zone and potential risks associated with infringing on the zone.
- Comply with MARPOL discharge standards and project effluent limits.

5.2.10 Onshore Impacts of Project Infrastructure

Offshore facilities are not likely to be visible from shore. Offshore structures such as drilling rigs and platforms typically are visible from shore at distances of 5 to 16 km, with small structures (e.g., a single drilling rig) barely visible at 5 km from shore. On a clear night, lights on top of offshore structures could be visible to a distance of approximately 32 km (MMS, 2007b). The Jubilee Field is about 63 km from the nearest shoreline.

Oil will be offloaded from the FPSOs directly onto tankers in the Jubilee unit, therefore no pipelines, oil transport trucks, onshore refineries, etc. will be required. As a result, no significant impacts are expected in this regard. Since this impact is not rated as significant, no mitigation measures are recommended.

5.2.11 Health and Safety Impacts of Normal Operations

Some public health and safety risks are created during normal operations. Impacts that may arise in the event of an oil spill are discussed in the following section.

As noted previously, an exclusion zone will be maintained around offshore facilities; the radius is expected to be 500 m for the MODUs and 1,000 for the FPSO. Fishermen and other marine-based vessels are not allowed to travel within this buffer. Given that fishes are attracted to offshore drilling rigs and platforms (due to these floating structures acting as artificial reefs), fishermen may be tempted to approach closer than these distances, posing a potential safety hazard.

The movement of ships between the support base and the offshore project area during the construction phase will also pose a slight increase in marine traffic and will require proper permitting and diligence during performance of the drilling work to avoid any potential safety hazards such as collisions, or delays in shipping activities.

Safety risks on construction activities of the rigs also pose dangers to rig workers, including potential falls from heights, working with flammable materials, welding, etc.

Mitigation

- Liaise with harbour police authorities regarding patrolling of the exclusion zone surrounding the rigs to prevent fishers from entering the exclusion zone.
- Implement education and awareness programmes in the coastal villages to inform the villagers of the potential dangers of fishing close to the drilling rigs and FPSO.
- Liaise with the harbour control officers to ensure adequate tracking and monitoring of shipping movements to and from the harbour.
- Ensure that workers wear Personal Protective Equipment (PPE) when working on site offshore.

5.3 ENVIRONMENTAL AND SOCIOECONOMIC IMPACTS OF ACCIDENTS

Potential accidents considered here include an oil spill (e.g., a crude oil spill resulting from a blowout, or a diesel fuel spill) and a hydrogen sulfide release.

5.3.1 Oil Spills

A crude oil spill is a rare event that could occur as a result of a blowout. A blowout is an uncontrolled flow of reservoir fluids into the wellbore, and sometimes catastrophically to the surface. A blowout may consist of saltwater, oil, gas, condensate, or a mixture of these. During drilling, all wells are equipped with a blowout preventer, a special assembly of high pressure valves fitted to the top of a well to prevent high-pressure oil or gas from escaping.

Worldwide statistics from offshore drilling provide a reasonable basis for evaluating spill risk. According to Holand (1997), the average blowout frequency for exploration drilling in the U.S. Gulf of Mexico is 0.00593 blowouts per well drilled, or 1 blowout per 169 exploration wells drilled. Similarly, the MMS Safety and Environmental Management Program blowout incident rate for 1996 to 1999 was approximately 5 blowouts per 1,000 well starts, or 1/200 (MMS, 2001). For the North Sea, the estimated frequency is 0.00630 blowouts per well drilled, or 1 blowout per 159 exploration wells (Holand, 1997).

Most blowouts do not result in oil spills. For example, of the 151 well blowouts reported in the Gulf of Mexico from 1971 to 1995, only 18 (i.e., 12%) resulted in oil spills. The total volume released from all of these spills was 1,000 bbl of crude oil and condensate (MMS, 2001). Between 1964 and 1999, almost all offshore spills (94%) from drilling and production-related operations on the U.S. outer continental shelf were less than or equal to 1 bbl in size (Anderson and LaBelle, 2000). Generally, the historical data indicate that a blowout occurring and resulting in a large oil spill of any size is very unlikely.

A diesel fuel spill is an accident that could occur during any phase of offshore hydrocarbon activities. Potential sources would include vessel collisions or groundings, tank ruptures, or a hose break during at-sea refuelling operations. A large spill, such as one resulting from a diesel tank rupture, would be an extremely rare event. The probability has not been estimated, but historical data for a highly active region (the Gulf of Mexico) include no such incidents between 1981 and 1999 (Anderson and LaBelle, 2000; MMS, 2007b). Historical data indicate that most diesel spills are <1 bbl, and for spills greater than this, the median size is 5 bbl (MMS, 2000).

Environmental Impacts

The environmental effects of an oil spill could vary substantially depending on the size of the spill, its chemical characteristics, the oceanographic and meteorological conditions at the time, and the effectiveness of spill response measures. At minimum, the spill would affect water quality by producing an oil slick on the sea surface and increasing hydrocarbon concentrations due to dissolved components and small oil droplets.

Impacts on Air Quality

A diesel fuel or crude oil spill would affect air quality in the vicinity of the oil slick by introducing volatile organic compounds through evaporation. The emissions would not last long due to rapid volatilization of hydrocarbons. Evaporation is greatest within the first 24 hours. The extent and persistence of impacts would depend on the meteorological and oceanographic conditions at the time.

Impacts on Water Quality and Water Column Biota

A diesel fuel or crude oil spill in offshore waters would produce a slick on the water and temporarily increase hydrocarbon concentrations. While most crude oil components are not soluble in water and have densities less than seawater, diesel fuel contains lighter hydrocarbon fractions that dissolve in seawater. Therefore, while spilled oil and spilled diesel fuel tend to float and undergo weathering at the sea surface (National Research Council, 1985), the dissolution of diesel fuel into the water column will be greater.

A crude oil or diesel fuel spill could affect water column biota including phytoplankton, zooplankton, and fishes. While adult and juvenile fishes may actively avoid a large oil spill, the planktonic eggs and larvae would be unable to avoid contact. Eggs and larvae of fishes will die if exposed to certain toxic fractions of spilled oil. Many fishes inhabiting coastal waters have planktonic eggs and larvae. Impacts would be potentially greater if local scale currents retained planktonic larval assemblages (and the floating oil slick) within the same water mass. However, due to the wide dispersal of early life history stages of fishes in the surface waters of the region, a spill is not expected to have significant impacts at the population level.

Impacts on Benthic Communities

A blowout resulting in a crude oil spill could affect benthic communities within a few hundred meters of the drillsite. While some oil could initially adhere to surface sediments surrounding the drillsite, resulting in smothering and/or toxicity to benthic organisms, most of the oil is assumed to rise rapidly through the water column. The physical impacts of a subsurface blowout are also a consideration. MMS (2007b) estimates that a severe subsurface blowout could resuspend and disperse sediments within a 300-m radius. While coarse sediments (sands) would probably settle at a rapid rate within 400 m from the blowout site, fine sediments (silts and clays) could be resuspended for more than 30 days and dispersed over a much wider area. The affected area would be recolonized by benthic organisms over a period of months to years.

A diesel fuel spill at the surface would have no effect on benthic communities. Spilled diesel will float on the ocean surface, undergoing evaporation and dissolution.

Impacts on Marine Mammals

Spilled oil may affect marine mammals through various pathways: direct contact, inhalation of oil or related volatile distillates, ingestion of oil (directly, or indirectly through the consumption of oiled prey species), and (for mysticetes) impairment of feeding by fouling of baleen (Geraci and St. Aubin, 1990). Marine mammals surfacing within or near an oil spill may inhale petroleum vapors. Ingested oil, particularly the lighter fractions, can be toxic to marine mammals. Ingested oil can remain within the gastrointestinal tract and be absorbed into the bloodstream and thus irritate and/or destroy epithelial cells in the stomach and intestine. Certain constituents of oil, such

as aromatic hydrocarbons and polycyclic aromatic hydrocarbons (PAHs), include some well-known carcinogens. These substances, however, do not show significant biomagnification in food chains and are readily metabolized by many organisms. Spilled oil may also foul the baleen fibers of mysticete whales, thereby impairing food-gathering efficiency or resulting in the ingestion of oil or oil contaminated prey (Geraci and St. Aubin, 1990).

Impacts on Sea Turtles

Spilled oil may affect sea turtles through various pathways: direct contact, inhalation of oil or related volatile distillates, ingestion of oil (directly, or indirectly through the consumption of oiled prey species), and ingestion of floating tar (Geraci and St. Aubin, 1990). Several aspects of sea turtle biology and behaviour place them at risk, including lack of avoidance behaviour, indiscriminate feeding in convergence zones, and inhalation of large volumes of air before dives (Milton et al., 2003). Studies have shown that direct contact of oil with sensitive tissues such as eyes and other mucous membranes produce irritation and inflammation. Oil can adhere to turtle skin or shells. Turtles surfacing within or near an oil spill may inhale petroleum vapors. Ingested oil, particularly the lighter fractions, can be toxic to sea turtles. Hatchling and juvenile turtles feed opportunistically at or near the surface in oceanic waters, and are especially sensitive to spilled oil and oil residues such as floating tar (Lutcavage et al., 1997). Tar found in the mouths of turtles may have been selectively eaten or ingested accidentally while feeding on organisms or vegetation bound by tar (Geraci and St. Aubin, 1990).

Any of the five species of sea turtles could be affected by a diesel fuel or crude oil spill in offshore waters. The area affected would be relatively small relative to the available ocean habitat, and the duration presumably would be a few days, based on the anticipated weathering characteristics and spill response capabilities. It is possible that individual turtles may come into contact with these sources of spilled oil, and some individuals may not recover from such exposure.

About 70% of Ghana's coastline is suitable for turtle nesting, and 80 km of the coast is densely nested (Carr and Campbell, 1995). However, the Jubilee Field is about 63 km from the nearest shoreline. Spill trajectory in relation to coastal habitats will be important considerations in responding to any spill in the project area.

Impacts on Marine and Coastal Birds

Spilled oil (including crude oil or diesel) may affect birds through various pathways. Direct contact with oil may result in the fouling or matting of feathers with subsequent limitation or loss of flight capability, or insulating or water repellent capabilities; irritation or inflammation of skin or sensitive tissues such as eyes and other mucous membranes; or toxic effects from ingested oil or the inhalation of oil or related volatile distillates.

Although seabirds could come into contact with a spill in offshore waters, the total area of a slick is expected to be small relative to the available marine habitat. The risk would be greater if oil moved into intertidal areas where seabirds and shorebirds may be foraging. In a worst case, it is possible that birds along oiled shorelines could be exposed to oil and require cleaning and/or treatment.

Impacts on Coastal Habitats

The impacts of an oil spill on coastal habitats could vary substantially depending on the size of the spill, its chemical characteristics, the oceanographic and meteorological conditions at the time, and the effectiveness of spill response measures. While a large crude oil spill could persist long enough to reach the coastline, it is unlikely that a small diesel fuel spill would affect coastal water quality or coastal habitats, as the Jubilee Field is about 63 km from the nearest shoreline.

A variety of coastal habitats are found along the Ghana shoreline. The Environmental Sensitivity Atlas of the Coastal Areas of Ghana (Armah et al., 2004) identifies and ranks 14 ecosystems according to their spill sensitivity. Open lagoons and estuarine wetlands that are important for birds and mangroves are rated as having very high sensitivity. The high sensitivity designation applies to sandy beaches with turtle nesting; rocky flats with abundant crevices; intertidal rocks with algae exposed at low tide; open coastal lagoon/estuaries; and semi-closed lagoons that are important for birds. The remaining coastal areas as well as open coastal waters are more robust against oil spill impacts and are rated as having medium or low sensitivity.

Most of the Ghanaian coastline (67%) consists of low or medium sensitivity habitats (Table 5.6). About 30% of the coast is high sensitivity, and 3% is rated as having very high sensitivity.

Table 5.6. Oil spill sensitivity ranking of the coast of Ghana (From: Armah et al., 2004).

Sensitivity	Extent of Coastline (km)	Percent of Coastline
Very high	19	3
High	176	30
Medium	52	9
Low	338	58
Total	585	100

The fate and potential effects of oil spills reaching the various coastal habitats of Ghana is discussed further by Armah et al. (2004).

Socioeconomic Impacts

In the event of an accidental spillage of oil, numerous activities and areas may be affected. These include fisheries in open waters, fishery landing sites, beach seine fishery, lagoon fishing, salt production sites, tourist areas, recreational areas, industrial plants and coastal farming. These are elaborated below.

Impacts on Fisheries in Open Waters

With the occasional exception of tuna purse seiners, it is unlikely that fishing vessels will be in the vicinity of the drilling rigs or FPSO. The exclusion zone around the MODUs and FPSO would only exclude tuna fishers from a very small portion of their fishing grounds (Anchor Environmental Consultants CC, 2008).

In the event of an accidental oil spill, the oil plume is likely to spread and drift to various areas due to long shore currents within hours to days. This will severely impede fishing activities in open waters that has been contaminated with oil due to ships and fishing gear being covered in oil, and the catch may be spoiled. This will

force fishing activities in this area to temporarily halt or relocate to other fishing grounds nearby that has not been contaminated by oil (Armah et al., 2004).

Given that this impact is temporary in nature (the oil spills will drift away within a few hours or days), and that alternative fishing grounds free of oil should be readily available, this impact is expected to be low.

Impacts on Fishery Landing Sites for Vessels and Canoes

Although the majority of the artisanal fishing effort is conducted well inshore of the proposed drilling location, unlikely but possible incidents (e.g., a large oil spill, which could reach the coast due to the prevailing onshore winds), could severely impact the livelihoods of these fishers. The number of people involved in these artisanal fisheries means that potential impacts on these fisheries in the unlikely event of an oil spill must be considered (Anchor Environmental Consultants CC, 2008).

Oil spills would most likely result in the oil drifting up on beaches and landing sites for vessels and canoes. The impacts of stranded oil on the landing sites will make operations impossible, or at least hamper operations significantly. This implies that fishers will have to move their activities to other landing sites until the beach is cleaned or the oil degrades – a process that may last weeks to several months. During this time the fishers and their dependants who process the fish, will face difficulty in transporting landed fish and other working routines (Armah et al., 2004).

Impacts on Beach Seine Fishing

The occurrence of beach seine fishing in western Ghana is highly prevalent in coastal villages, with approximately half of the 304 landing sites using approximately 800 beach seine nets (see **Section 4.4.1.4**). Therefore, beach seine fishing constitutes a major source of income for coastal villages.

It is expected that an oil spill that drifts along the coast or washes up on shore will make the operation of beach seine fishing impossible. The nets may be damaged or the catch will be spoiled, forcing the fishermen to stop fishing with this method until the beach is cleaned or the oil is degraded (which may last any period between weeks to a number of months). The severity of the impact is dependent on the number of villagers in a village, and the number of beach seine nets located at the village.

Impacts on Lagoon Fishing and/or Aquaculture Plants

A number of open lagoons are located in the coastal stretch between Effasu and Takoradi. In the case of an oil spill, the artisanal fisheries in open lagoons that are connected to the sea have the potential to be impacted by the spill. The usual methods in lagoon fishing include cast nets, set-nets, hook and line, and various forms of traps – all of which could be affected in the event of an oil spill (Armah et al., 2004).

The coastal lagoon fishery will be severely impacted since all methods of fishing will be restricted and lagoon fishing holds significant socioeconomic value to the coastal villages (Armah et al., 2004).

Impacts on Salt Production Utilising Marine Waters

As was mentioned in **Section 4.4.1**, it is estimated that salt production occurs in approximately 14 coastal lagoons along the Ghanaian coast. The salt production

industry is important to the national economy and provides employment opportunities to coastal villages.

Should an oil spill occur and oil drift ashore near the sites where salt production occurs, the salt would be affected by the deposits of oil in the pans, or salt production would have to be discontinued by closing the pans until the oil is removed. The extent of the impact is highly dependent on the mode of operation for the salt producer (e.g., timing of water intakes, the location of water intakes in the lagoon, etc.), and therefore the impact of an oil spill should be assessed on an individual basis. However, in general, the impact is considered to be quite high in the event of an oil spill since salt production is an important industry along the coast in terms of providing employment and income to villages (Armah et al., 2004).

Impacts on Tourism Sites and Facilities

The coastal area of Ghana provides numerous tourism opportunities and holds potential for growth into a strong economic sector for the nation. The various tourism sites that may be impacted in the event of an oil spill would include hotels and other minor resorts or campsites located on the waterfront, recreational facilities (such as restaurants) located at the coastal areas and historical monuments located in the vicinity of the coastal areas (Armah et al., 2004)

In the event of an oil spill stranding in front of these tourism sites and facilities, the access and/or utilisation of the shore for coastal amenities (such as relaxation, water sports, recreational fishing etc.) will be diminished or rendered impossible. These may lead to dissatisfaction of tourists, and rumours may lead to cancellation of hotel bookings in other areas along the coast that are not affected by oil spills. The experience of visiting historical monuments for tourists will be impacted detrimentally should an oil spill be located on the beach by the historical monument.

Impacts on Major Ports

Ghana has two major ports for cargo and merchant vessels – Tema and Takoradi. Both ports are important import and export gates for trade in Ghana. Takoradi is the onshore support base for the Jubilee project, with Sekondi being a naval base located next to the port of Takoradi (Armah et al., 2004).

In the event of an oil spill in or near the harbour, normal ship traffic and calls will be disrupted. Ships can be oiled in the waterline, and oil in the water intakes for cooling the engine may create operational problems for vessels (Armah et al., 2004). Furthermore, risk of ignition of floating oil may prevent sailing, loading, and unloading operations. Delayed oil spill combat equipment such as booms may also influence shipping operations (Armah et al., 2004). Effective and rapid response techniques should be given thoughtful consideration in order to minimise the impact from the combat.

The delays in shipping operations may result in direct losses to the economy, and claims from ship owners and firms that rely on harbour operations may also be lodged. Workers in the harbour may also experience temporary unemployment. The impact of such a spill is therefore high as the harbour is crucial for import/export commodities to Ghana.

Impacts on Industrial Plants Relying on Marine Water Intakes

The Takoradi Thermal Plant lies on the coast by Sekondi-Takoradi, and relies on marine water for cooling purposes. Other industries located on the coast in the study area are not expected to rely on marine water (Armah et al., 2004). In the even of an oil spill, the normal operation of the industrial plant may be influenced and temporary closure of the plant may occur. This may result in the loss of energy supply to areas in and around Sekondi-Takoradi (and potentially to the national grid as well), with concomitant economic impacts on other industries that cannot operate.

The impact of an oil spill on industrial plants is therefore considered high.

Impacts on Coastal Farming

The major farming activity along the coast of Western Ghana is coconut farming (Armah et al., 2004). An oil spill that reaches the shore is not expected to have a significant impact on coconut cropping or harvesting activities.

Mitigation

The Jubilee Joint Venture is developing an Oil Spill Response Plan that will be implemented as part of this project. As a member of Oil Spill Response Limited (OSRL), the Jubilee Joint Venture will have access to Tier III equipment housed in Southampton and Tier II response equipment and supplies pre-staged in west and central Africa. Ghana also has limited in-country oil spill response capabilities. Oil and gas operators in Ghana also intend to establish a mutual aid agreement to give each other access to dispersant, boom, and equipment; at present, the shore-based location for these materials will be Takoradi.

In addition to the Oil Spill Response Plan, the project includes numerous preventive measures as described in **Section 3.6.2** to reduce the risk of spillage and minimise the potential for significant impacts. Also, under MARPOL, ships (including drilling rigs) are required to have in place a Shipboard Oil Pollution Emergency Plan (SOPEP). The SOPEP will contain the necessary reporting procedures and actions required to control discharge, and the steps necessary to initiate an external response for any spills.

The following additional mitigation measures are recommended with respect to oil spills:

- Establish a Compensation Determination Committee that will manage all compensation claims related to the Jubilee Joint Venture in the event of an oil spill.
- Establish effective communication channels to potentially affected groups including commercial deep-sea fishers, artisanal fishers, harbour control authorities, tourism sites, salt producers, and the Takoradi Thermal Plant to ensure rapid response to the event of an oil spill.
- Ensure that the Oil Spill Response Plan provides the capability to respond rapidly to oil spills in the harbour area and the Thermal Plant area.

5.3.2 Hydrogen Sulfide Releases

A release of hydrogen sulfide (H₂S) is an accident that can occur during oil and gas activities. Although no H₂S is expected to be encountered during this project, H₂S detection equipment will be in place to ensure employee health and safety. Potential impacts are addressed briefly below.

Environmental, health, and safety concerns associated with an H₂S release include irritation, injury, lethality to personnel and wildlife, and equipment and pipeline corrosion. However, the risk is highly localized. Normally, dispersion mechanisms in the atmosphere (wind, etc.) cause natural gas leaks and associated H₂S to disperse quickly. According to MMS (2007b), for a very large facility (throughput on the order of 100 MMcfd of produced natural gas) with high concentrations (on the order of 20,000 ppm) and very calm winds (speed of <1 m/sec), H₂S levels reduce to 20 ppm at several kilometers from the source; H₂S levels are reduced to 500 ppm at 1 km. Most “sour gas” facilities have H₂S concentrations below 500 ppm, which then reduces to 20 ppm within the dimensions of a typical platform (or considerably less).

An accidental H₂S release could have localized effects on air quality and human health. The extent of the risk would depend on the size and H₂S concentration of the release and ambient meteorological conditions. The risk of significant water column effects is low because H₂S is highly soluble in water and is oxidized over a period of hours (MMS, 2007b).

Mitigation

No H₂S is expected to be encountered during the project. However, the Jubilee Joint Venture is developing a Hydrogen Sulfide Program to protect employees from exposure to the harmful health effects of H₂S gas in the event of an accidental release. H₂S detection equipment will be in place to ensure employee health and safety. No additional mitigation is recommended.

5.4 CUMULATIVE IMPACTS

Cumulative effects are those resulting from the incremental effects of the proposed action when added to other past, present, and reasonably foreseeable future actions, regardless of who undertakes them. Cumulative effects can result from individually minor, but collectively significant, actions taking place over time.

5.4.1 Contributing Sources of Cumulative Impacts

The following activities are expected to produce environmental and socioeconomic impacts in the region during the lifetime of this project:

- **Coastal pollution** – As noted in **Section 4.2.4**, pollution from human activities is a significant problem in Ghana’s coastal waters. According to the United Nations Environment Programme (UNEP, 1999), the principal land-based sources of pollution in Ghana are human, domestic, municipal, mining, manufacturing, and agricultural discharges, which are often untreated and unregulated. Pollutants entering coastal waters from these activities include organic matter and nutrients from sewage, trace metals and hydrocarbons from industrial and municipal wastes, and persistent organic pollutants from synthetic pesticides and industrial discharges. Nutrient enrichment (eutrophication) due to sewage discharges is another important problem along the coast. Nixon et al. (2007) reported concentrations of ammonia and phosphate in Korle Lagoon, near Accra, that may be the highest yet reported for an estuarine system. They found a strong correlation between population density and dissolved inorganic nitrogen concentrations among the wide range of systems studied.

- **Fishing and overfishing** – in particular with trawlers but also with many other methods, in shallow waters. As noted in **Sections 4.3.2** and **4.4.6**, Ghana’s fishery resources have been subjected to increasing exploitation, resulting in a “boom and bust” pattern with huge variations in the abundance of some targeted species.
- **Current and future oil exploration activities in the area** – The oil sector is an emerging sector in the Ghanaian economy, with major oilfields being discovered in 2007. As a result, numerous other oil operators are also planning to drill outside of the Jubilee Field area. The socioeconomic impacts of these activities (in terms of stimulating local economic growth, population influx into the area, etc.) are expected to increase as a result of the proposed development. As other oil extraction operations are initiated in the area, these are expected to give further impetus to the socioeconomic changes described above. As mentioned elsewhere in this report, it is currently estimated that 10 to 12 major service companies will be opening their offices in Sekondi-Takoradi. While these will mainly serve the Jubilee project, it is expected that a significant portion of the expansion in the oil sector in Sekondi-Takoradi will be as a result of other projects not related to this project.
- **Expansion of Sekondi-Takoradi as a result of other developments** – Takoradi is one of two major ports in Ghana, and has recently undergone significant expansion. The city’s growth, as well as its concomitant socioeconomic impacts, cannot be ascribed solely to the emerging oil industry, but is also the result of activity in other economic sectors. As mentioned earlier, the port also serves as gateway for Sahelian transit cargo and as a cruise destination. Because of the city’s growth, existing infrastructure and services are already under pressure. It is expected that this pressure will be exacerbated when the Jubilee project and other oil exploration and extraction projects become operational.

5.4.2 Cumulative Environmental Impacts

The following sections discuss the potential for cumulative environmental impacts to occur as a result of the project in combination with other activities in the region.

Effluent Discharges

Most routine effluents from this project are expected to be dispersed rapidly in offshore waters near the drilling rigs and FPSO. Due to the distance from shore, there should be no significant cumulative or synergistic effect with coastal pollution sources in Ghana.

Drilling discharges (especially cuttings) have the potential to persist in seafloor sediments around wellsites. Over time as multiple wells are drilled from various development projects, there may be a cumulative impact on sediments and benthic communities. However, the overall regional impact would be negligible due to the small proportion of total seafloor area affected.

Marine Debris

Armah et al. (2004) note the widespread presence of marine debris along the Ghanaian coastline, mostly from local sources. Historically, the offshore oil and gas industry has been a source of marine debris in some areas due to material accidentally lost overboard. However, due to the MARPOL requirements prohibiting disposal of trash and debris in the ocean, as implemented through Waste Management Plans on the

drilling rigs and FPSO, the project is not expected to result in an increase in marine debris along the coast.

The MMS (2007b) reports that over the last several years, oil companies have employed trash and debris reduction and improved handling practices to reduce the amount of offshore trash that could potentially be lost into the marine environment. Improved trash management practices, such as substituting paper and ceramic cups and dishes for those made of styrofoam, recycling offshore trash, and transporting and storing supplies and materials in bulk containers when feasible, are commonplace and have resulted in a marked decline in accidental loss of trash and debris.

Air Pollutant Emissions

Air pollutant emissions from this project are expected to be dispersed rapidly in the atmosphere near the drilling rigs and FPSO. Due to the distance from shore and from other development activities in the offshore environment, there should be no significant cumulative or synergistic effect.

Increased Vessel Traffic from Support Operations

Vessel traffic from this project and other offshore developments in the region will increase the overall level of underwater noise affecting marine mammals and turtles. In addition all vessel traffic carries a small risk of vessel strikes on these animals. The increased traffic would result in an incremental increase in these impacts.

Increased Risk of Spills

As noted in **Section 5.3.1**, the probability of this project being responsible for a significant oil spill is remote. However, as more oil operations are established off the coast, the risk of such accidents will increase proportionally. In addition to the Oil Spill Response Plans developed by individual operators, the risk can be mitigated through cooperation and coordination among operators. As noted in **Section 3.6**, oil and gas operators in Ghana intend to establish a mutual aid agreement to give each other access to dispersants, booms, and other spill equipment. Because of Ghana's limited national response capabilities, the equipment and expertise being developed by offshore operators should offset the increased risk of spills and increase the local capability to respond to spills from other sources along the coast.

5.4.3 Cumulative Socioeconomic Impacts

The following sections describe the cumulative socioeconomic impacts that are expected to arise when the effects of the proposed Jubilee project are added to these developments.

Local Economic Growth

The economic growth that is currently evident, especially in the Sekondi-Takoradi area (as a result of the expanding oil industry as well as development in other sectors), will be further stimulated by the project. In addition, other oil ventures will further expand the tax base and financial benefits accruing to the Government of Ghana. This cumulative impact is expected to be beneficial in terms of creating further employment opportunities and creating opportunities for local businesses.

Population Influx and Social Pathologies

While the cumulative impacts of local economic growth in the area are expected to be largely positive, it may also have negative side-effects. For instance, as more oil exploration activities commence, this may give rise to widespread expectations among communities surrounding the Sekondi-Takoradi area that large numbers of employment opportunities will be created. This, in turn, could cause a significant influx of job-seekers into the city. If these expectations are not realised, it is also possible that conflicts could erupt between people competing for the limited jobs that are available. The population influx and economic growth could also stimulate an increase in criminal activity in the city.

Pressure on Infrastructure and Services

As mentioned above, infrastructure and services in Sekondi-Takoradi are already under pressure. This effect would be further exacerbated by the combined effect of this project and other economic developments in the area.

Increase in Traffic

As discussed earlier, the impact of the project on traffic (road, sea, and air) is not expected to be significant. However, the combined effect of this project and other developments (in the oil industry and in other sectors) may well give rise to a measurable increase in traffic. In addition to placing pressure on existing road and port infrastructure, this will also increase the risk of accidents.

Impacts on Fishing Activities

A similar situation applies in the case of fishing. As mentioned elsewhere in this report, the impact of the project on fishing during normal operations is not expected to be significant. However, as more oil exploration and extractions operations are established off the coast of Ghana, their cumulative effect may affect both commercial and artisanal fishing. Such effects could involve a partial disruption of commercial fishing traffic, and the risk that operational discharges may impact on marine life.

Increased Risk of Spills

As mentioned earlier, accidental spillage of oil could affect numerous activities, including commercial fishing in open waters, fishery landing sites, beach seine fishery, lagoon fishing, salt production, tourism and recreational, industrial plants, and coastal coconut and oil palm farming. The probability of this project being responsible for such an incident is remote. However, as more oil operations are established off the coast, the risk of such accidents will increase proportionally. As noted previously, because of Ghana's limited national response capabilities, the equipment and expertise being developed by offshore operators should offset the increased risk of spills and increase the local capability to respond to spills from other sources along the coast.

5.5 IMPACT RATINGS AND SUMMARY

This section summarizes the environmental and socioeconomic impacts discussed in the preceding sections. The consequence of potential impacts was evaluated, taking into account the nature of the impact including extent and duration. Each impact was rated as follows, using the definitions given in **Table 5.7**:

- Beneficial;
- Negligible;
- Minor;
- Moderate; or
- Severe.

Table 5.7. Definitions of impact consequence.

Consequence	Definition
Beneficial	• Likely to cause some enhancement to the environment or socioeconomic benefits
Negligible	• No changes, or small adverse changes unlikely to be noticed or measurable against background conditions
Minor	• Adverse changes that can be monitored and/or noticed, but are within the scope of existing variability and do not meet any of the “severe” or “moderate” impact definitions
Moderate	One or more of the following: • Localized, occasional violations of air or water quality standards or guidelines • Localized contamination of sediments • Localized damage to sensitive habitats such as hard bottom areas, chemosynthetic communities, mangroves, or wetlands • A few deaths or injuries of protected species, occasional, temporary disruption of their critical activities (e.g., breeding, nesting, nursing), and/or localized damage to their critical habitat • Localized, short-term interference with fishing activities, recreation, or tourism • Localized damage to or contamination of beaches, parks, tourism areas, or other recreational resources • Localized, short-term adverse impacts on the economy or socioeconomic conditions
Severe	One or more of the following: • Extensive, continual violation of air or water quality standards or guidelines • Extensive, persistent contamination of sediments • Extensive damage to sensitive habitats such as hard bottom areas, chemosynthetic communities, mangroves, or wetlands • Extensive damage to nonsensitive habitats to the extent that ecosystem function and ecological relationships would be altered • Numerous deaths or injuries of a protected species, continual disruption of their critical activities (e.g., breeding, nesting, nursing), and/or destruction of their critical habitat • Extensive, continual interference with fishing activities, recreation, or tourism • Extensive, persistent damage to or contamination of important cultural, historical, or religious sites or tourism areas • Extensive, persistent adverse impacts on the economy or socioeconomic conditions • A threat to public health or public safety • Substantial public controversy or social unrest

Because the impact analysis includes both routine, planned activities, and accidental events, the probability of impact occurrence also was rated, using the following categories:

- Likely – can reasonably be expected to occur one or more times during the project. Impacts of most routine project activities are in this category;
- Occasional – not planned or expected, but could occur at some time during the project;
- Rare – highly unlikely; exceptional conditions may allow the event to occur during the project;
- Remote – extremely unlikely event; has occurred before in the industry but highly unlikely to occur during the project.

To summarize the overall significance of each impact, impact consequence and probability were combined using a risk matrix as shown in **Table 5.8**. The result is an overall impact significance rating that ranges from Negligible to High. Impacts rated as High or Medium in significance are priorities for mitigation. Mitigation was also considered for some less significant impacts to further reduce the probability or consequence of impacts.

Table 5.8. Matrix combining impact consequence and probability to determine overall impact significance. Impact consequence categories are defined in **Table 5.7** and impact probability categories are defined in the text. Each combination of consequence and probability is assigned an overall significance ranging from Negligible to High.

LEGEND		Decreasing Impact Consequence ←				
		Beneficial	Negligible	Minor	Moderate	Severe
Decreasing Probability ↓	Likely	Beneficial	Negligible	Low	Medium	High
	Occasional	Beneficial	Negligible	Low	Medium	High
	Rare	Beneficial	Negligible	Negligible	Low	High
	Remote	Beneficial	Negligible	Negligible	Low	Medium

Table 5.9 summarizes the environmental and socioeconomic impacts evaluated in this chapter. The table rates each impact with respect to consequence and probability, as well as overall significance. Where appropriate, mitigation measures are indicated, along with the residual impact significance taking the mitigation into account.

Table 5.9. Summary of potential impacts and mitigation for the Jubilee Field, Phase 1 development.

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
ENVIRONMENTAL IMPACTS OF ROUTINE ACTIVITIES						
Drilling discharges	- Water column turbidity and transient impacts on plankton and nekton - Burial, smothering, and anoxia effects on benthic communities, mainly within about 500 m of wellsites	Likely	- Negligible (water quality, plankton, nekton) - Minor (soft bottom benthos)	Negligible to Low	- Compliance with project effluent guidelines including use of low-toxicity drilling fluids, no free oil, limits on mercury and cadmium concentrations in stock barite, and limits on drilling fluid retention on cuttings - Use of a cuttings dryer to minimise retention on cuttings	Negligible to Low
Seafloor disturbance	Physical damage to benthic communities due to placement of structures and/or anchors	Likely	Minor (soft bottom benthos)	Low	None recommended	Low
Presence of structures (including noise and lights)	- Platforms are likely to attract pelagic fish and plankton - Fouling community on offshore structures may result in localized benthic enrichment - Underwater noise may affect behaviour of marine mammals and turtles	Likely	- Beneficial (pelagic fishes) - Negligible to Minor (plankton, benthos, marine mammals, turtles, and birds)	Beneficial to Low	None recommended	Beneficial to Low
Operational effluent discharges	Minor impacts on water quality near offshore facilities, similar to existing ship traffic in region	Likely	Minor (water quality, plankton)	Low	- Compliance with MARPOL - Compliance with project effluent guidelines including oil and grease content	Low
Marine debris	- Risk of death or injury to marine mammals, turtles, or birds due to ingestion of or entanglement with accidentally discarded debris - Water quality impacts; cluttering of seafloor and shorelines	Rare	- Minor (water quality, plankton, nekton, benthic communities) - Minor to Moderate (marine mammals, turtles, and birds)	Negligible to Low	- Compliance with MARPOL prohibitions on dumping trash and debris in the ocean - Development of Waste Management Plans to minimise the chance of accidentally losing items overboard - Site clearance survey conducted to ensure that any debris from drilling activities is removed from the seafloor around the wellsites	Negligible

Table 5.9. (Continued).

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
Air pollutant emissions	Minor impacts on air quality, similar to other vessel and aircraft traffic in region	Likely	Minor	Low	- Compliance with MARPOL Annex VI emissions limits for ships and IFC guidelines for small combustion sources - Routine inspection and maintenance of engines, generators, and other equipment to minimise excess noise and air emissions - Use low-sulfur diesel fuel if available	Low
Support activities	- Helicopters flying over Important Bird Areas (IBAs) could disturb protected coastal bird populations - Potential for support vessel striking a marine mammal or sea turtle - Minor behavioural disturbance of marine mammals, turtles, and birds	Likely	- Minor to Moderate (bird populations in IBAs) - Minor (marine mammals, turtles, and other birds)	Low to Medium	Helicopter pilots advised to avoid flying over the Amansuri wetland IBA. If avoidance is not feasible, a minimum altitude of 710 m should be maintained when flying over this area to minimise disturbance to wildlife	Low
Structure removal	Physical impacts to benthic communities, similar to those during installation	Likely	Minor (soft bottom benthos)	Low	Development of a Decommissioning Plan that includes appropriate environmental safeguards in accordance with international best practice	Low
SOCIOECONOMIC IMPACTS OF ROUTINE ACTIVITIES						
Creation/transfer of employment opportunities (development drilling, facility installation, and routine production operations) ¹	- Development drilling – 404 employment opportunities over approximately 2 years - Facility installation – 480 employment opportunities over approximately 2 years - Routine production operations – 216 employment opportunities over approximately 20 years 10% to 80% local staff	Likely	Beneficial (residents in Sekondi-Takoradi)	Beneficial	- Establish “labour and employment desk” as contact point for local community members - Create skills register of local community members (qualifications, work experience) - Establish monitoring system to ensure contractors honour specified employment policy - Use local staffing as far as possible	Beneficial
Loss of employment opportunities (decommissioning)	Upon decommissioning, employees will have to secure alternative employment	Likely	Moderate (Sekondi-Takoradi and the Jubilee Field)	Medium	- Notify employees of pending retrenchments - Assist employees in securing alternative employment	Low

Table 5.9. (Continued).

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
Opportunities for local enterprises and multiplier effects	- Numerous service companies will open in Sekondi-Takordi, which will allow other businesses to provide services - Although a large portion of the project's expenditures will be allocated to ship conversions, this will have great spin-off benefits for the economy as a whole	Likely	Beneficial (enterprises in Sekondi-Takoradi)	Beneficial	- Develop register of local support and services companies - Establish linkages with other institutions involved in all skills development and business development - Investigate possibility to launch training/skills development initiative	Beneficial
Economic impacts – Production	GNPC estimates that more than 17.5% of income generated from selling oil will accrue to the Ghanaian government	Likely	Beneficial (Ghanaian government)	Beneficial	Ensure that contractual obligations are met in terms of royalties and taxes	Beneficial
–Decommissioning	- Reduced opportunities for local suppliers - Reduced financial benefits for the Government	Likely	Moderate (Sekondi-Takoradi)	Medium	- Give advance warning of decommissioning - Encourage suppliers to secure other contracts prior to decommissioning	Low
Opportunities for community development	Policies and programs are presently being defined by the Jubilee Joint Venture	Likely	Beneficial (Sekondi-Takoradi, Effasu and other coastal villages)	Beneficial	- Liaise with local communities regarding their needs and priorities - Liaise with other institutions and organisations (Metropolitan Authority, NGOs, etc.) to align CSR initiatives - Communicate community CSR initiatives clearly to relevant parties	Beneficial

Table 5.9. (Continued).

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
Population influx and increase in social pathologies	Population influx into project area and increases in availability of cash may lead to increases in social pathologies (STDs, alcoholism, substance abuse)	Likely	Minor (Residents in Sekondi-Takoradi)	Low	- Measures to combat spread of STDs: - Implement HIV/AIDS and alcohol abuse programmes for employees - Align awareness campaigns with those of other organisations in area - Measures to prevent conflict between employees and locals: - Recruitment policy must be fair and transparent - Communicate the policy to local communities - Measures to control access to onshore support base and movements of employees - Measures to address crime: - Consult with local police to establish standard operating procedure for control and/or removal of loiterers at support base	Negligible
Housing demand	- Employees will require housing in Sekondi-Takoradi - Offshore workers will be housed offshore on a rotational basis	Likely	Minor (Sekondi-Takoradi)	Low	Liaise with Metropolitan Authorities to ensure adequate supply of housing	Negligible
Increased strain on service provisions	Onshore support base will require electricity, water, and waste disposal services	Likely	Minor (Sekondi-Takoradi)	Low	Inform Metropolitan Authorities well in advance of the anticipated timeframe the nature of services that will be required for service provisions	Low
Increase in traffic	Port at Takoradi will experience increase in ship movements, and the military base will experience increase in helicopter movements	Likely	Negligible (Port in Sekondi-Takoradi)	Negligible	Ensure efficient communication with port and airbase control officers to avoid unnecessary delays in shipping or airborne movements	Negligible

Table 5.9. (Continued).

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
Impacts on fishing	- Exclusion zone for the MODUs and FPSO may disrupt fishing activities in the vicinity - Operational discharges may affect fishing activities, but the likelihood of this event is low	Occasional	Minor (Jubilee Field)	Low	- Establish clear communication channels with commercial deep-sea fishers and artisanal fishing villages - Inform port authorities and commercial fishing operations in advance of location and schedule of project activities - Treat human wastes according to MARPOL standards prior to discharge	Negligible
Onshore impacts of project infrastructure	Offshore infrastructure not likely to be visible onshore; no pipelines, oil transport trucks, refineries, etc. are expected	Remote	Negligible (Effasu and other coastal villages)	Negligible	None required	Negligible
Health and safety impacts of normal operations	- Exclusion zone may be breached by fishers in fishing activities - Increased risk for ship collisions due to more shipping movements - Construction risks to rig workers	Occasional	Moderate (artisanal and commercial fishers, rig workers)	Medium	- Liaise with harbour police authorities regarding patrolling of exclusion zone - Implement education and awareness programs in the coastal villages to inform villagers of potential dangers of fishing close to oil rigs - Liaise with harbour control officers to ensure adequate tracking and monitoring of shipping movements between the oil rigs and the harbour - Ensure that workers wear personal protective equipment	Low

Table 5.9. (Continued).

Impact Factor	Impact Description	Probability	Consequence	Significance without Mitigation	Mitigation	Residual Impact Significance
IMPACTS OF ACCIDENTS						
Oil spill (e.g., crude oil from a blowout, or a diesel fuel spill) – Environmental	- Depending on spill size and conditions, effects could include violation of water quality standards; contamination of sediments; death or injury of marine mammals, turtles, and birds; and contamination of coastal habitats - Physical effects on soft bottom benthos around wellsites in the event of a subsea blowout	Rare to Remote	Moderate to Severe	Low to Medium	- Oil Spill Response Plan - MARPOL requires Shipboard Oil Pollution Emergency Plan and Oil Record Book	Low
– Socioeconomic	- Commercial and artisanal fishing including beach seining and lagoon fishing may be shut down temporarily during clean-up operations - Tourism sites may experience decline in visitors due to dissatisfaction of tourists - Possible temporary shutdown of cooling water intake at the Takoradi Thermal Power Plant, which may result in the loss of power to Sekondi-Takoradi and possibly other areas in Ghana - Vessels and gear in ports may be damaged and normal port operations may be influenced until clean-up completed	Rare to Remote	Minor (commercial fishers) Severe (fish landing sites, beach seining sites, lagoon fishing sites along the coast between Effasu and Sekondi-Takoradi) Moderate (tourism sites between Effasu and Sekondi-Takoradi) Moderate (Port of Sekondi-Takoradi) Severe (Takoradi Thermal Power Plant)	Negligible to High	- Establish Compensation Determination Committee that will manage all compensation claims - Establish effective communication channels with potentially affected groups including commercial deep-sea fishers, artisanal fishers, harbour control authorities, tourism sites, salt producers, and the Takoradi Thermal Plant to ensure rapid response in the event of an oil spill - Ensure that Oil Spill Response Plan provides the capability to combat oil spills in the harbour area and the Thermal Plant area	Low
H ₂ S release	Violation of air quality standards; potential death or injury of humans on offshore facilities	Remote	Moderate	Low	- MODUs and FPSO equipped with H₂S detection equipment - Hydrogen Sulfide Program to protect employees in the event of an H₂S release	Low

CSR = Corporate Social Responsibility; FPSO = floating production, storage, and offloading (vessel); GNPC = Ghana National Petroleum Corporation; IFC = International Finance Corporation; MARPOL 1973/1978 = International Convention for the Prevention of Pollution from Ships; MODU = mobile offshore drilling unit; NGO = nongovernmental organisation; and STD = sexually transmitted disease.

¹ Because some activities overlap among phases, the total number of jobs is likely to be less than the sum of the individual phases.

6.0 Mitigation

Table 6.1 presents a brief overview of the key management and mitigation measures included in the Jubilee Field, Phase 1 Development Plan. Many project activities are already subject to Environmental, Health, and Safety (EHS) procedures and systems developed by the Jubilee Joint Venture. Additional mitigation measures to avoid, reduce, or minimise impacts have been cited in the impact analysis in **Chapter 5**. A detailed summary of mitigation and monitoring activities is presented in the Action, Contingency, and Mitigation Plan (ACMP).

Table 6.1. Overview of key management and mitigation measures.

Impact Source	Key Management and Mitigation Measures
Effluents and wastes	• Comply with MARPOL requirements, including those for sewage, food waste, deck drainage, and garbage • Comply with project effluent guidelines for drilling fluids and cuttings, including use of low-toxicity drilling fluids, limits on mercury and cadmium concentrations in stock barite, and limits on drilling fluid retention on cuttings • Use a cuttings dryer to minimise drilling fluid retention on cuttings • Comply with project effluent guidelines for operational effluent discharges such as produced water, including limits on oil and grease content • Implement Waste Management Plans to minimise the chance of accidentally losing items overboard • Conduct a site clearance survey to ensure that any debris from drilling activities is removed from the seafloor around the wellsites
Air pollutant and noise emissions	• Comply with MARPOL Annex VI requirements for air pollutant emissions from ships and International Finance Corporation guidelines for air pollutant emissions for small combustion sources • Conduct routine inspection and maintenance of engines, generators, and other equipment to minimise excess noise and air emissions • Use low-sulfur diesel fuel if available
Support activities	• Advise helicopter pilots to avoid flying over Amansuri wetland Important Bird Area • Ensure efficient communication with port and airbase control officers to avoid unnecessary delays in shipping or airborne movements
Employment, support services, community development, and housing demand	• Establish a “labour and employment desk” for local community members • Create skills register of local community members • Establish monitoring system to ensure that contractors honour specified employment policy • Use local staffing as far as possible • Inform Metropolitan Authorities well in advance of the anticipated timeframe and nature of services that will be required • Develop register of local support and services companies • Establish linkages with other institutions involved in all skills development and business development • Investigate possibility to launch training/skills development initiative • Liaise with local communities as to their needs and priorities • Liaise with other institutions and organisations to align Corporate Social Responsibility (CSR) initiatives • Communicate CSR initiatives clearly to relevant parties

Table 6.1. (Continued).

Impact Source	Key Management and Mitigation Measures
	• Implement measures to combat spread of sexually transmitted diseases • Implement measures to prevent conflict between employees and locals • Implement measures to address crime • Liaise with Metropolitan Authorities to ensure adequate housing supply • Ensure that contractual obligations are met in terms of royalties and taxes
Interactions with the fishing community	• Establish clear communication channels to commercial deep-sea fishers and artisanal fishing villages • Inform port authorities and commercial fishing operations in advance of location and schedule of project activities • Liaise with harbour police authorities regarding patrolling of exclusion zone • Implement education and awareness programs in the coastal villages to inform villagers of potential dangers of fishing close to oil rigs • Liaise with harbour control officers to ensure adequate tracking and monitoring of shipping movements between the offshore facilities and the harbour
Decommissioning	• Prior to decommissioning, prepare a decommissioning plan that includes appropriate environmental safeguards in accordance with international best practice • Give advance warning of decommissioning to employees and local communities • Assist employees in securing alternative employment • Encourage suppliers to secure other contracts prior to decommissioning
Accidents	• Prepare and implement an Oil Spill Response Plan that provides the capability to combat oil spills both offshore and along the coast, including the harbour area and the Takoradi Thermal Plant area • Comply with MARPOL requirements for Shipboard Oil Pollution Emergency Plan and Oil Record Book • Establish Compensation Determination Committee to manage compensation claims • Establish effective communication channels to potentially affected groups to ensure rapid response to the event of an oil spill • Equip offshore facilities with hydrogen sulfide detection equipment • Implement a Hydrogen Sulfide Program to protect employees • Ensure that workers wear personal protective equipment

MARPOL 1973/1978 = International Convention for the Prevention of Pollution from Ships.

7.0 Analysis of Alternatives

This chapter summarizes the alternatives considered for the Jubilee Field, Phase 1 development. The only formal alternative to the proposed development is the “no project alternative.” However, numerous technical and operational alternatives were considered in preparing the Phase 1 Development Plan.

7.1 Technical and Operational Alternatives Considered

7.1.1 Project Location

The Jubilee Field, Phase 1 development location was defined based on the results of exploratory and appraisal drilling to date, as well as geophysical data from seismic surveys. Analysis of the results of the two discovery wells, Mahogany 1 and Hyedua 1, indicates that the wells encountered an accumulation of hydrocarbons that extends across the boundary between the West Cape Three Points Block and the Deepwater Tano Contract Area. Article 8.20 of the Petroleum Agreements contemplates unitization of a field across block boundaries. In recognition of this and with the objective of optimized development of the accumulation, the parties defined the Phase 1 Unit Area and have executed a Unitization and Unit Operating Agreement that will govern operations within the Unit Area. In consultation with the Ghana National Petroleum Corporation (GNPC), the accumulation was named Jubilee Field. The ongoing appraisal program will ultimately define the full extent of the Jubilee Field.

7.1.2 Development Approach

As part of the Development Plan for Jubilee Field, Phase 1 development, the Jubilee Joint Venture evaluated the technical, operational, and economic factors associated with various development approaches.

A search of potential analog fields was undertaken. Petroleum industry databases were reviewed for analog fields to compare with the Jubilee Field. The initial search was limited to offshore fields, located in Africa, Europe, and North and South America, which were discovered after 1980 with greater than 100 MMbo reserves. Using these criteria, 275 fields were identified and screened for similarities to the Jubilee Field. The key conclusions are that (1) most large field developments in West Africa have used one or more FPSOs, and (2) these developments have typically followed a phased approach.

The Jubilee Field, Phase 1 development is the first phase of a staged development plan consisting of 17 wells drilled and completed over a three-year period. This phased approach provides for early oil production and more importantly, significantly reduced development risk through improved understanding of reservoir behaviour during the early production phase and incorporation of lessons learned into subsequent phases of development.

The Phase 1 development will be implemented using field proven, subsea production and control systems that will be tied back to a turret moored FPSO. Several factors have led to a subsea solution for the Phase 1 development including remote location,

water depth, depth of the reservoir below the mud line and aerial extent of the Jubilee Field.

The Jubilee Field is remote from major oil refining centres, therefore, oil storage is required in the field area. The most cost effective and field proven means of providing the required storage is via a permanently moored tanker (i.e., an FPSO). Oil can then be lifted in parcels by other trading tankers for transportation to market. In order to provide sufficient storage capacity margin given the field production rates contemplated in Phase 1, it was decided that the permanently moored tanker should be a Very Large Crude Carrier (VLCC) with storage of 1.5 to 2.2 MMbo.

Conversion of an existing tanker into an FPSO was selected as the preferred development option. A permanently moored tanker offers a large, load-bearing deck space and provides a relatively stable platform. Conversion to an FPSO combines the oil storage and production facilities on a single vessel, providing a cost-effective hub for deepwater development operations. This development solution has been employed extensively in offshore West Africa with great success. A further advantage of an FPSO conversion versus other development schemes (e.g., building a new FPSO or using deepwater compliant or floating structures) is that the work can be accomplished in a significantly shorter time frame, reducing the time to first oil, a primary development driver.

7.1.3 Drilling Program

The Jubilee Joint Venture evaluated alternatives for the number, type, location, and depth of wells to be drilled for the Phase 1 development. The Phase 1 plan includes 17 wells consisting of 9 oil production wells, 3 gas injection wells, and 5 water injection wells. The actual number and location of the Phase 1 development wells will be refined based on results of the initial drilling program and further evaluation of geophysical data.

Data from previously drilled exploration and appraisal wells indicate that at least four separate oil pools are present in the Jubilee Field. The drilling program focuses on two of these reservoirs (Upper Mahogany 3 and Lower Mahogany 2) that represent the most significant hydrocarbon accumulations appraised in the Jubilee Field to date.

Although the Phase 1 wells are planned with hole angles of generally less than 55 degrees, the potential application of horizontal and high angle wells during the Phase 1 development will continue to be considered. However, the most likely application would be implemented during future phases of development. The drilling risks for Phase 1 development are relatively low and have been mitigated by taking a conservative approach on well design. The directional plans require primarily low-to-moderate hole angles. The drilling fluids are proven in this area for providing very stable wellbores. **Appendix C** includes an analysis of alternatives for drilling fluid selection.

7.1.4 Gas Utilization

Reservoir modelling indicates that oil recovery from Phase 1 would be maximised by utilization of associated gas for reinjection into the reservoir. Therefore, the Phase 1 Development Plan is based on oil production alone, with the future ability to export gas in subsequent phases. The Phase 1 Development Plan assumes that all gas (after

fuel use on the FPSO) will be re-injected into the formation for future recovery and use. The functional design of the FPSO is based on having sufficient on-board compression capacity to be able to re-inject 100% of associated gas volumes.

Three gas injection wells are planned in the Phase 1 development. The optimum location for gas injection wells is in the highest structural position where sufficient gas injection can be established to support reservoir pressure and enhance ultimate recovery. In addition, gas injection wells are ideally located as far as possible from oil production wells to avoid premature gas breakthrough and gas cycling between gas injection and oil production wells. Three alternate locations for gas injection wells have been identified within the project area. Selection of the preferred location will be based on results of the planned Mahogany 3 appraisal well and further interpretation of geophysical data.

The Jubilee Joint Venture is evaluating a number of options to bring the gas to market during subsequent phases. However, gas export activities are not part of the Phase 1 project and would be evaluated separately in future EIAs if such activities are proposed.

7.1.5 Shore Base

During the project, offshore service vessels will provide support from an onshore base at the Port of Takoradi. Takoradi was selected because it is the nearest Ghanaian port that can meet the requirements for a support base. These requirements typically include:

- dock space to serve as a loading/offloading point for equipment and machinery supporting offshore operations;
- facilities for dispatching personnel and equipment;
- temporary storage for materials and equipment; and
- availability of a 24-hour dispatcher.

Takoradi is the oldest port in Ghana and has recently expanded. MI Drilling Fluids, an offshore service company, is building a base there, and several other major service companies are expected to open offices there as a result of this project and activities planned by other operators.

The other main port in Ghana is Tema. It was not considered for a support base because it is much farther from the development area (about 350 km compared with 132 km for Takoradi).

Helicopter support will originate from the Ghanaian Air Force Base at Takoradi. This facility has been utilised during prior oil and gas exploratory programs conducted offshore Ghana (e.g., Anadarko's exploratory program on West Cape Three Points Block, 2006-2007).

7.2 No Project Alternative

Under the “no project” alternative, the Jubilee Field, Phase 1 development would not be conducted. This alternative would avoid all of the environmental and socioeconomic impacts that are described in **Chapter 5.0**. However, it would not meet the objectives of the Jubilee Joint Venture or the Ghanaian government with respect to environmentally responsible development of the nation’s petroleum resources.

Key national objectives according to the Ghana National Petroleum Act, 1983 are to “(a) promote the exploration and the orderly and planned development of the petroleum resources of the Republic; and (b) ensure that the Republic obtains the greatest possible benefits from the development of its petroleum resources.” The “no project” alternative is inconsistent with these objectives because it would prevent orderly development of large accumulations of oil discovered in 2007 in the area. Furthermore, the “no project” alternative would prevent the Jubilee Joint Venture parties from meeting their obligations under the Petroleum Agreements for the Deepwater Tano Contract Area and West Cape Three Points Block.

The Impact Assessment (**Chapter 5.0**) has evaluated the environmental and socioeconomic impacts of the Jubilee Field, Phase 1 development. The project will be conducted according to international practices and comply with Ghanaian laws and regulations and applicable international standards and guidelines. The impacts of routine activities, such as seafloor disturbance, effluent discharges, air pollutant emissions, and vessel traffic, are minor or negligible in consequence. Taking into account the planned mitigation and monitoring measures, the project is not expected to cause significant impacts on the environment of Ghana.

7.3 Conclusion

In developing the proposed action, the Jubilee Joint Venture evaluated alternatives including the project location, development approach, drilling program, gas utilization, and onshore support base. The Development Plan as proposed is the alternative that meets the goal of developing and producing commercial hydrocarbon accumulations from the Jubilee Field rapidly and economically while ensuring protection of the environment.

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Appendices

Appendix A

Mobile Offshore Drilling Unit Specifications

Blackford Dolphin

GENERAL

Name: Blackford Dolphin

Flag: Singapore

Owner: Fred. Olsen Energy ASA

Manager: Dolphin Drilling Ltd.

Year Built: 1974. Major Deepwater Upgrade 2006/2007

Builder: Aker Nylands Verksted AS, Oslo, Norway (1974), Keppel Verolme (2006/2007)

Design: Aker H3

Classification: DNV + 1A1, R, Column Stabilised Drilling Unit, HELDK-SH, CRANE and Drill

MAIN DIMENSIONS

Length: 108,3 m (355,3 ft)

Breadth: 84.1 m (276 ft)

Height: 36,57 m (120 ft), Main Deck elevation above baseline

OPERATING PARAMETERS

Water Depth: 7000 ft Maximum (Outfitted for 6000 ft)

Maximum Drilling Depth: 30000 ft (9144 m)

Transit Speed: 4,5 knots (towed)

Survival Conditions: Hs 16,8 m (Hmax 32 m), Max wind 100 knots, Current velocity 2,0 knots

Drilling Conditions: Hs 8,4 m, Max wind 100 knots

CAPACITIES

Variable Deck Load: 4500 mt (9,920,802 lbs)

Liquid Mud: 5000 bbls (596 m3)

Bulk Mud/Cement: 8 x 2170 ft3

DRILLING EQUIPMENT

Derrick: 1500 kips (750 st) Static Hookload Capacity, 40 ft x 35 ft x 160 ft

Drawworks: NOV SSGD – 4600 with 4 AC Motors

Rotary: NOV D-605, 60 ½" opening

Topdrive: NOV (Hydralift) HPS 750-E-AC-KT with 750 st Load Capacity

Riser Tensioners: 6 x NOV DWRT-200-50 Dual Wireline Tensioners, Max capacity 2,400,000 lbs

Motion Compensators: Crown Mounted Compensator, 1500 kips static / 800 kips (363 mt) compensating load

Mud Pumps: 3 x NOV 14-P220 with 2200 hp each

MACHINERY

Main Power: 4 x Caterpillar Model 3612, 3800 KW, 5096 Hp Max continuous power

Emergency Power: 1 x Caterpillar 1800 KW

Propulsion: In-line propulsion system (Propulsion assist mode only)



SUBSEA SYSTEMS

BOP: 18 ¾" Hydril 15k (2 + 3 Cavity)

Control System: ABB / Vetco Multiplex system

Diverter: Hydril FS 1500 psi

Choke and Kill: 3 1/16" RB Pipetech 15k H2S (including Mud Gas Separator)

MOORING

Winches: 8 x NOV BLM W325 AC Single Wildcat, Electric, 293 mt rated pull

Wire/Chain: Wire / Chain combination

Anchors: 8 off

CRANAGE

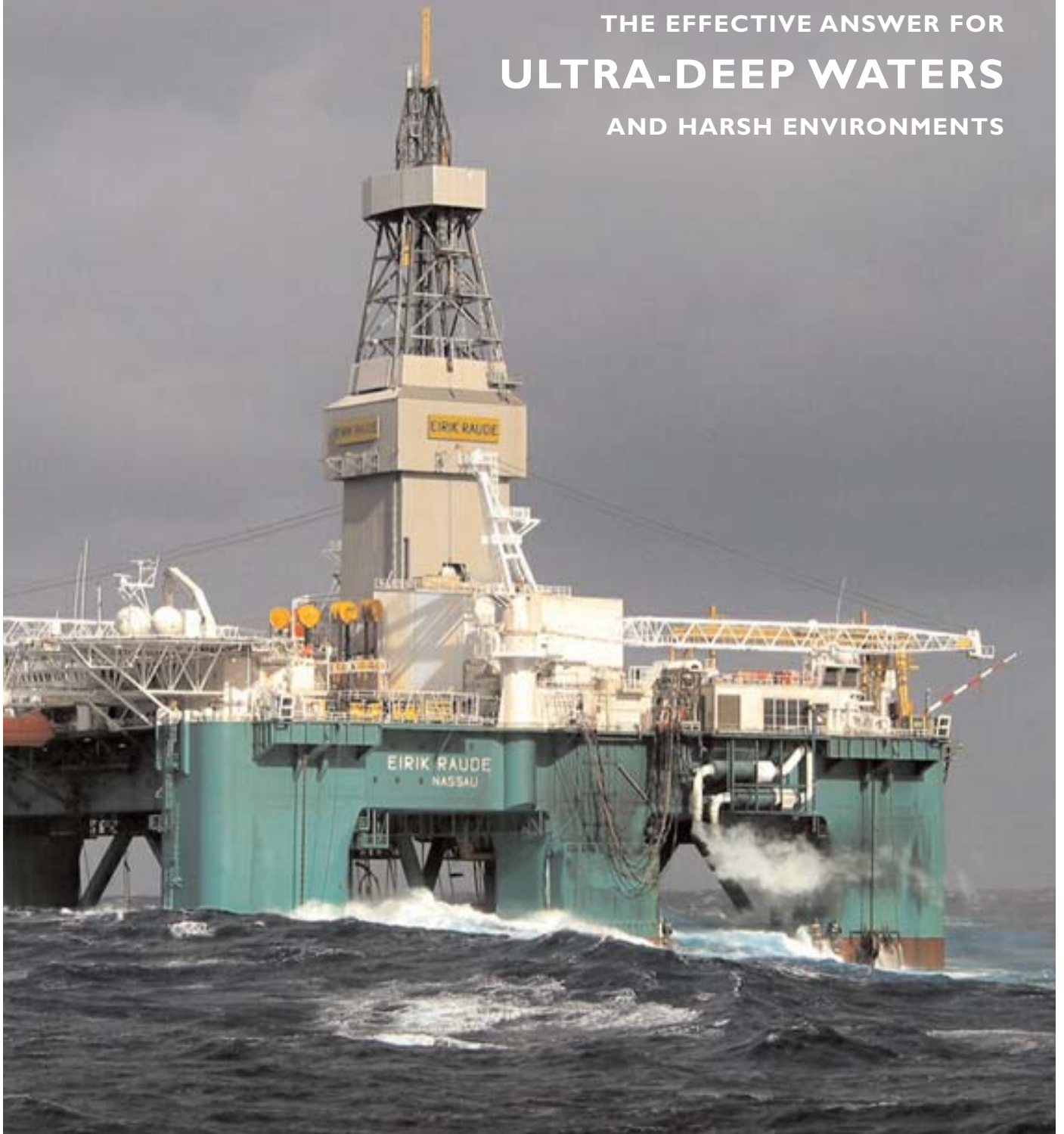
2 x 85 mt @ 16,7 m Knuckle Boom Cranes

ACCOMMODATION

130 (120 in 2-man cabins)



THE EFFECTIVE ANSWER FOR
ULTRA-DEEP WATERS
AND HARSH ENVIRONMENTS



**GENERAL**

Year Completed: 2002

Builder: Dalian New Shipyard, China – baredeck; Outfitting: Friede Goldman Offshore, Irving Shipyard

Design: Trosvik Bingo 9000, 6 columns, DP Class 3

Classification: DnV + IAI Column Stabilised Drilling Unit, DYNPOS AUTRO, POSMOOR ATA, HELDK SH, CRANE, EO, F-AM, DRILL (N)

MAIN DIMENSIONS

Length: 391.68ft (119.38m) overall; 257.55ft main deck

Width: 278.88ft (85.50m) overall; 218.38ft main deck

Pontoons: 2 x 344.49ft x 52.49ft x 40.19ft deep

Moonpool: 22.9ft x 47.50ft

Air Gap: 44.29ft (13.50m) operating

DRAFT AND DISPLACEMENT

Operating Draft: 77.9ft (23.75m)

Transit Draft: 39.4ft (12m)

Survival Draft: 68.9ft (21m)

Operating Displacement: 52,552 tons (53,393mt)

Transit Displacement: 37,640 tons (38,243mt)

MACHINERY

Main Power: 6 x Wärtsilä Vasa 18V32 diesel engines, rated 7,500kW each, 10,200hp; 6 x ABB ASG 900 XUB generators, rated 7,300kW, 9,125kVA each

Power Distribution: ABB

Emergency Power: ABB/Wärtsilä 2 Main engines dedicated to Emergency power

Propulsion: 6 x KaMeWa Aquamaster UUC 700 I fixed pitch variable speed thrusters, rated 5,500kW each, 157rpm, 13.45ft diameter.

OPERATING PARAMETERS

Water Depth: From 70 to 400 meters in moored configuration, and to 3000 meters DP. 10,000ft (3,000m)

Transit speed: 7 knots

DRILLING EQUIPMENT

Derrick: Hydralift 170 x 40 x 40ft; 2,000,000 lbs, setback: 1,330,000 lbs

Motion Compensators: Hydralift Crown 1000-25 active/passive Crown Mounted Compensator, rating 2,000,000 lbs, compensating: 1,000,000 lbs; 25ft stroke

Drawworks: Continental Emsco Electrohoist IV, 4,000hp

Rotary: Varco BJ RSTT 60.5", 984.2 tons

Top Drive: Hydralift HPS 1000 2E ac electric drive, 2,000,000 lbs; Speed: 0-280rpm; Max torque: 67,000ft-lbs

Travelling Block: Hydralift

Handling: Hydralift Hydra-Racker; Hydralift Back-up arm, Raised back-up system; Hydralift Iron Roughneck;

Fwd pipe rack: Hydralift Pipe Catwalk machine, Hydralift knuckle boom pipehandling crane; Aft riser rack:

Hydralift Riser Catwalk machine, Hydralift Riser Gantry crane

Riser Tensioners: 8 x Hydralift double, 200,000 lbs each; 3,200,000 lbs

Cementing: BJ Services, Third Party free installation unit

Mud Pumps: 3 x Continental Emsco FC-2200, 2,200hp, 7,500psi



CAPACITIES

Variable Deck Load: 6467 M.tons Operating; 6467 M.tons Survival; 4415 M.tons Transit.

These are examples and depend upon load case and distribution.

Tubulars in Pipe Rack: 600t

Liquid Mud: 10,419 bbls (1,657m³)

Bulk Mud/Cement: 4 x 87.6m³ for each product

Drillwater: 12,329 bbls (1,960m³)

Potable Water: 3,950 bbls (628m³)

Fuel Oil: 29,131 bbls (4,631m³)

Base Oil: 2,516 bbls (406 m³)

Brine: 4,283 bbls (680 m³)

SUBSEA SYSTEMS

BOP: Cameron 18 3/4 15,000psi, H2S service. Guidelineless re-entry system. Wellhead connector cage and frame is designed for use in two modes: 72" diameter funnel for use on regular wellheads; with funnel removed allowing BOP to be run "pin down" for use with GRA guide base. Wellhead connector: Vetco Super HD H4 18 3/4 15,000 psi. Lower cavity: Cameron double BOP 18 3/4 15,000psi; variable and fixed rams. Upper cavity: Cameron double BOP 18 3/4 15,000psi; 1 x variable or fixed ram and 1 x shear blind ram. Lower annular: Cameron type D 18 3/4 10,000psi with mandrel; LMRP connector: Cameron collet connector 18 3/4 15,000psi; Upper annular: Cameron type D 18 3/4 10,000psi; Oilstates Flexjoint: with Vetco Riser adapter 18 3/4 5,000psi. BOP operating fluid- return system.

TV System: BOP/LMRP mounted

Positioning: Kongsberg Simrad SDPM32 system

Riser Details: ABB Vetco MR-10-GS dog riser, 21" OD x 7/8" wall, rating 3,000,000 lbs; 2 x 4 1/2 ID choke and kill lines; 1 x 4" ID booster line; 2 x 2 1/2 hydraulic conduits; 1 x 1" ID glycol line

Diverter: ABB Vetco KFDS-CSO-500, 59 1/2 ID; 2 x 16" flow outlets

Choke and Kill: Cameron triple outlet double master target valve 3 1/16" 15,000psi choke line; Cameron double outlet double master target valve 3 1/16" 15,000psi kill line

BOP Handling: Hydralift BOP and X-mas tree transporter; 285.4 tons (290mt); Gantry crane for BOP service and

Xmas tree handling: Hydralift, 2 x 49.2 tons, lift height: 52.5ft

Drillpipe: 5 1/2 S-135 with HT55 tool joints

Drillcollars: 9 1/2 8 1/4, 6 3/4

MOORING

Winches: 8 x Ulstein Brattvag single drum windlasses

Wire/Chain: 84 mm Chain, 4 x 1000 meter lengths

Anchors: 8 x Stevpris 15 ton, high holding power anchors.

CRANAGE: 2 x Hydralift WOMCVC 3447, 73.8 tons at 54ft, 49.2 tons at 82ft, 14.8 tons at 180ft

HELIDECK: S61 / EH 101 Helicopter

ACCOMMODATION: 120 berths + hospital

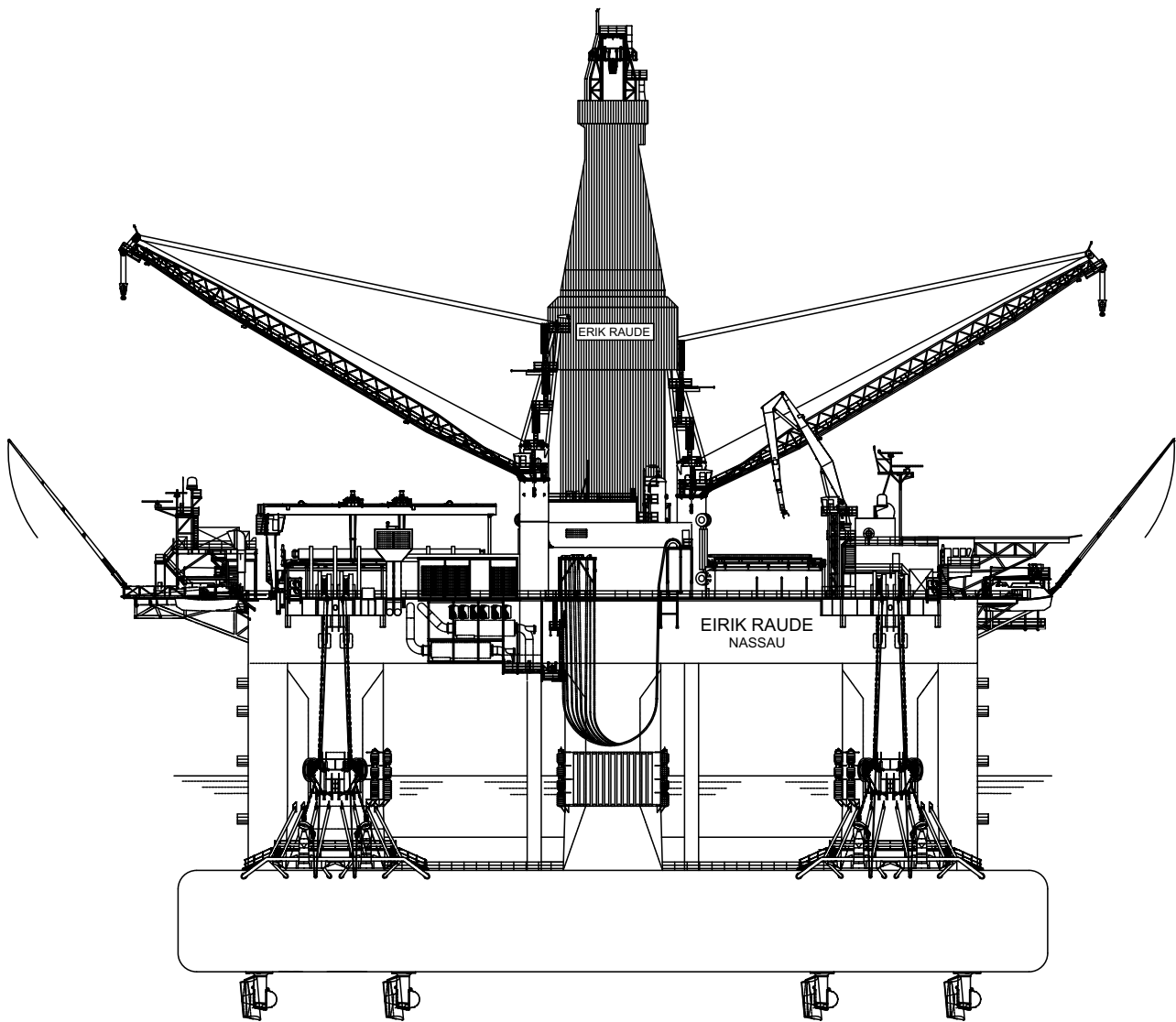
ADDITIONAL DATA

Lifesaving equipment: 4 x 60-men lifeboats; 1 x pickup boat; 8 life rafts tot. cap. 240 men.

The unit is equipped with Kongsberg Simrad Integrated Automation System consisting of:

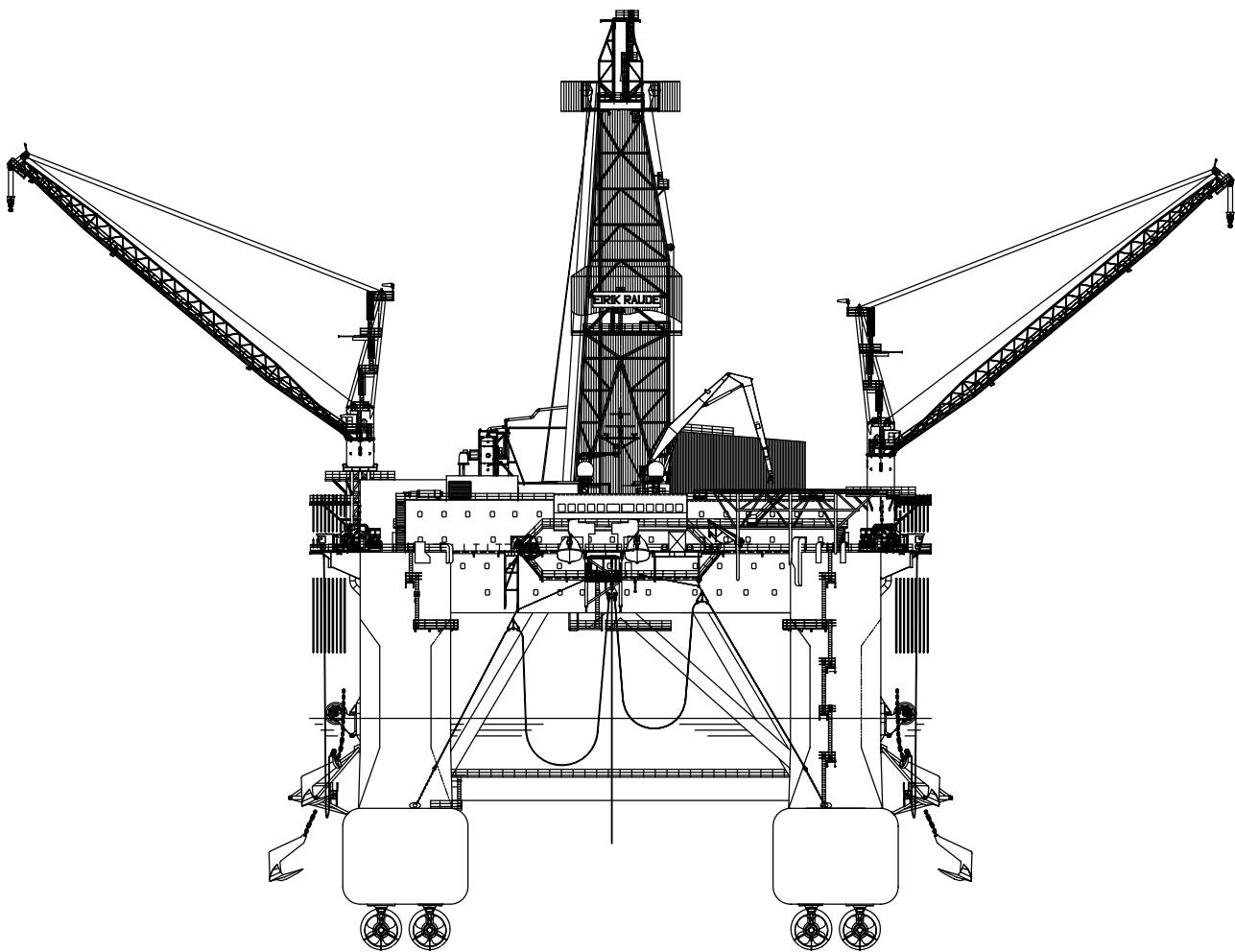
Dynamic Positioning (SDP), Thruster Control (STC), Vessel Control monitoring and automation (SVC) systems.

Fully winterised. Zero discharge drainage system, suitable for use in the Norwegian Barents Sea. Winterized.

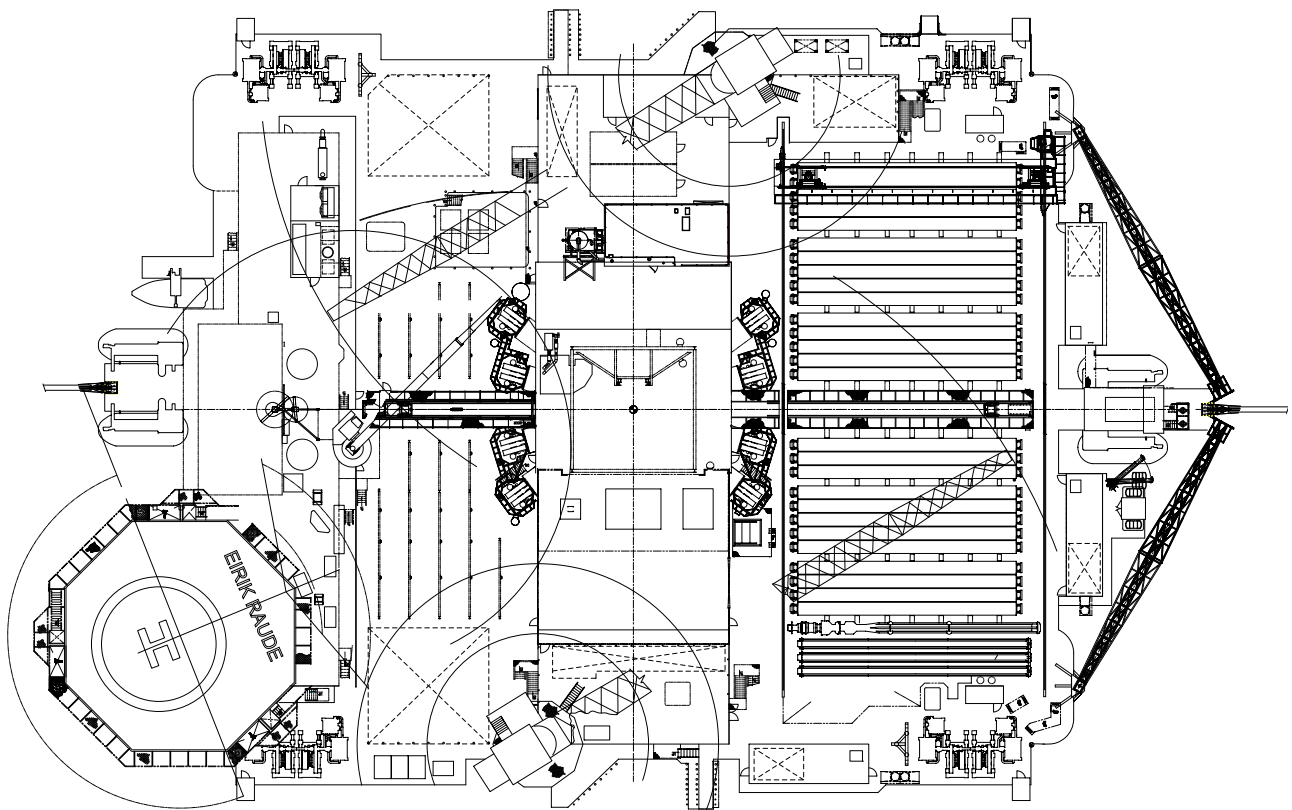


MAIN DIMENSIONS

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 Width: 278.88ft (85.50m) overall; 218.38ft main deck
 Pontoons: 2 x 344.49ft x 52.49ft x 40.19ft deep
 Moonpool: 22.9ft x 47.50ft
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The drilling units *Leiv Eiriksson* and *Eirik Raude* are 5th generation harsh environment, dynamically positioned semi-submersibles, capable of operating in water depths up to 3000 meters. The dynamic positioning capability is to Class 3. In addition *Eirik Raude* is capable of being moored in water depths of 70 meters to 500 meters. Both units are designed with zero discharge capability and have low emission power generation systems.

Leiv Eiriksson has worked principally offshore West Africa, but will be mobilising to the North Sea area in 2007. *Eirik Raude* has operated in a variety of harsh environments including the Canadian east coast, west of the UK, the Barents Sea and the Norwegian Sea. It will be moving to Canada and the US Gulf of Mexico during the period 2006 to 2008.



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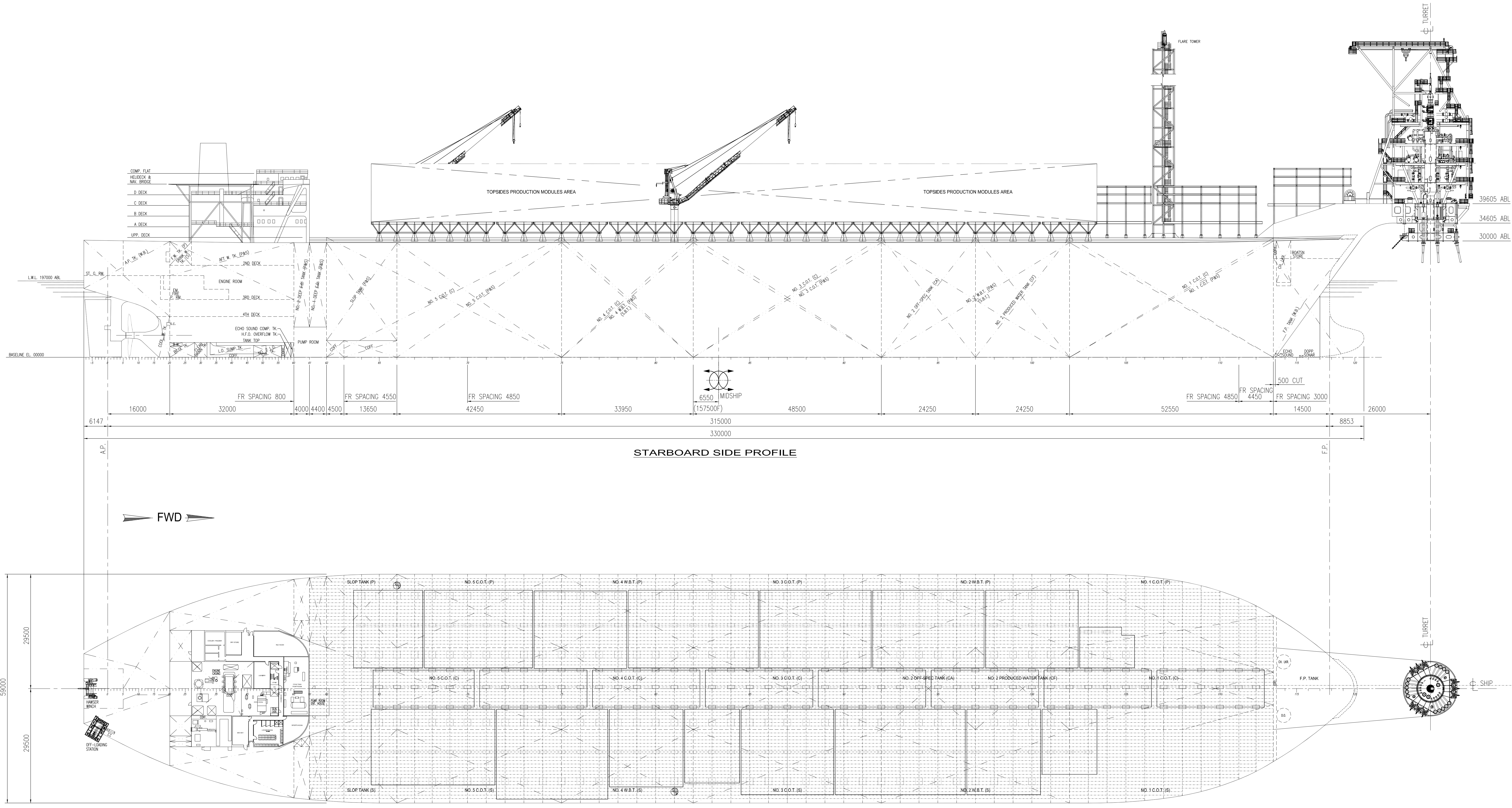
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E-mail: oras@ocean-rig.com

www.ocean-rig.com

Appendix B

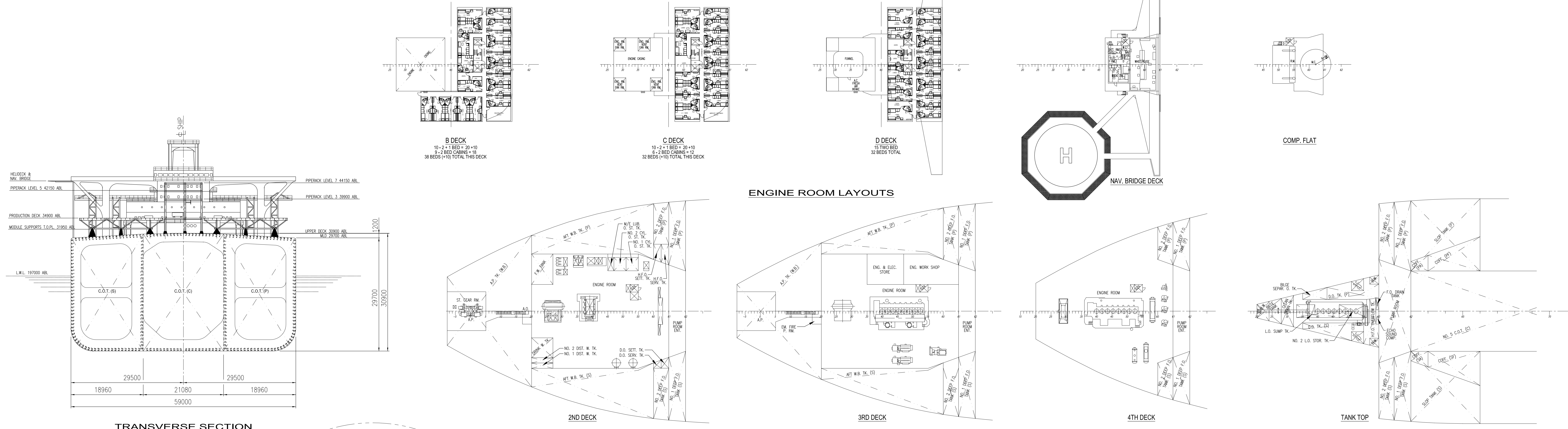
Floating Production, Storage, and Offloading Vessel Schematics



STARBOARD SIDE PROFILE

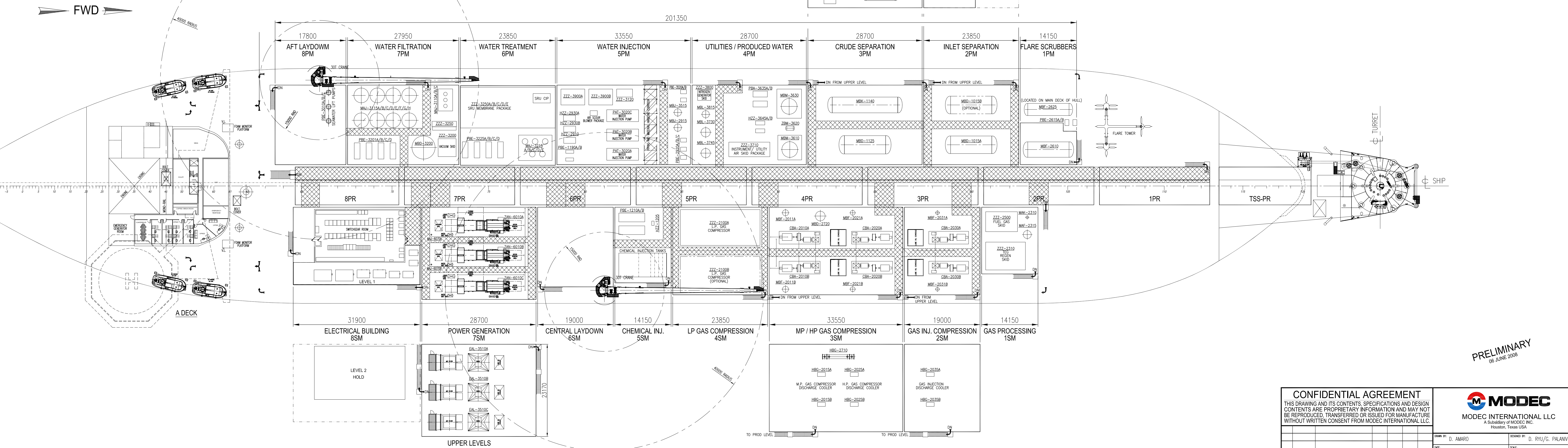


STOOL SUPPORTS AND TANK LOCATION PLAN



ENGINE ROOM LAYOUTS

TRANSVERSE SECTION (LOOKING AFT)



PRODUCTION FACILITIES (TOPSIDES) PLAN

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MODEC
MODEC INTERNATIONAL LLC
A subsidiary of MODEC OILFIELD SERVICES LTD.

PRINCIPAL PARTICULARS
LENGTH (O.A.) 330.00M
LENGTH (B.P.) 315.00M
BREADTH (MID) 50.00M
DEPTH (MID) 28.70M
DESIGN DRAFT (MID) 19.72M

PRELIMINARY
08-JUNE-2008

TULLOW GHANA LIMITED
FPSO - JUBILEE FIELD UNIT

OVERALL GENERAL ARRANGEMENT

0245-MI20-0001-0100



TRANSVERSE SECTION

*1 : 100% FULL *2 : 90% FULL

*1 : OVERFLOW LEVEL *2 : 95% OF OVERFLOW LEVEL

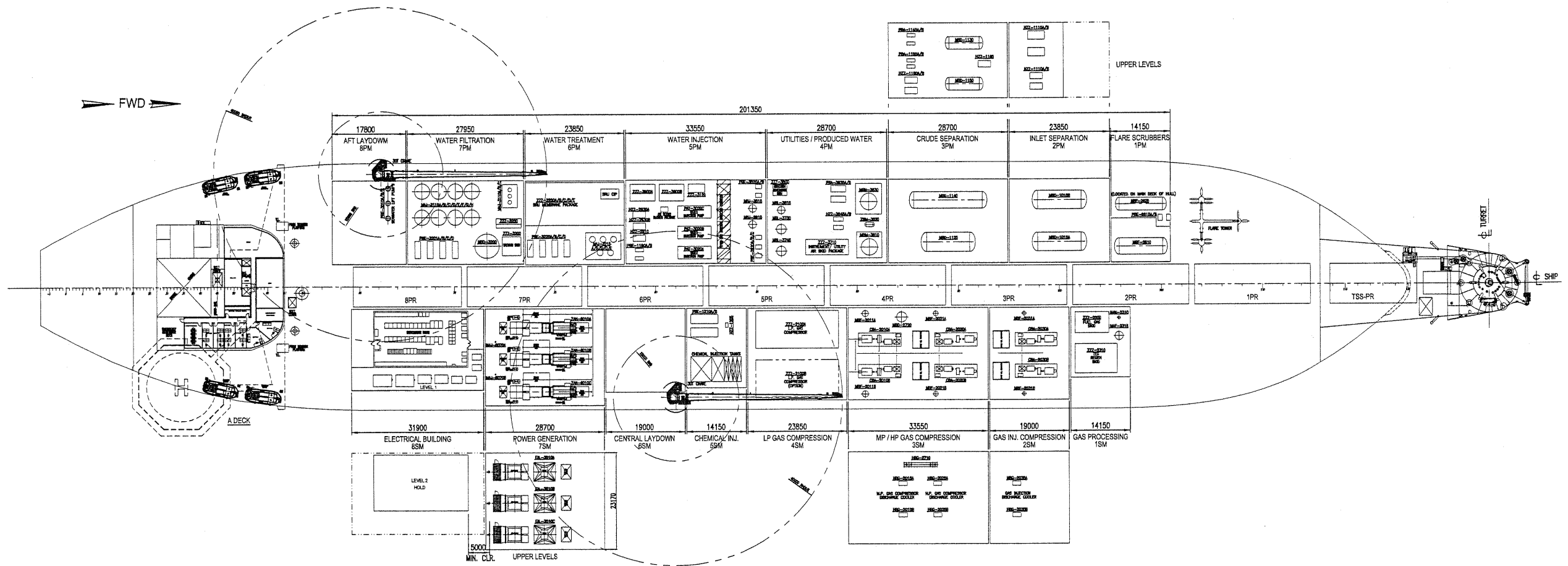
*1 : OVERFLOW LEVEL *2 : 95% OF OVERFLOW LEVEL

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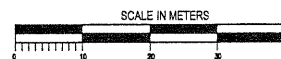
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REV.



TOPSIDES MODULE & EQUIPMENT LAYOUT PLAN



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FOR PROPOSAL
06 JUN 2008

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REV	DATE	REVISION DESCRIPTION	ORIG	CHKD	LDE	EM	DRAWN BY: D. AMARO DATE: 19 MAY 2008 SCALE: 1:500	DESIGNED BY: D. RYU DATE: 19 MAY 2008 SCALE: 1:500	REF: B

Appendix C

Alternatives Analysis: Drilling Fluids and Cuttings

Appendix C

Alternative Analysis: Drilling Fluids and Cuttings

This appendix discusses the selection of drilling fluids and options for disposal of drilling fluids and cuttings.

C.1 Drilling Fluid Selection

For its drilling programme, Jubilee Joint Venture plans to use both water-based fluids (WBFs) and an enhanced mineral oil-based fluid (EMOBF), Versaclean. WBFs, consisting of fresh or salt water, barite, clay, caustic soda, lignite, lignosulfonates, and/or water-soluble polymers, will be used in the upper sections of the well bore (i.e., during initial spudding and upper section drilling, down to approximately 500 m below the mudline). Versaclean, an EMOBF produced by MI-SWACO, will be used for mid- and lower sections of each well, from approximately 500 m below the mudline to the bottom of each hole.

Versaclean uses Escaid 120 as its base oil at a 75:25 oil:water ratio. Escaid 120 is a highly refined mineral oil that has low aromatic content and low toxicity. The EMOBF will be recovered and returned to the vendor for recycling; it will not be discharged except for small amounts adhering to cuttings. Escaid 120 is categorised as Group C under the Offshore Chemical Notification Scheme (OCNS). The OCNS is used to regulate chemical use and discharge by the UK and Netherlands offshore petroleum industries, and also is widely used internationally. The OCNS is based on OSPAR Decision 2000/2 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals. This system awards the offshore chemical a letter grouping between A and E, with A being the greatest potential environmental hazard and E being the least.

The selection of Versaclean was based on a thorough evaluation of alternatives to meet the objectives of the drilling programme. The Versaclean system is versatile and provides many benefits including fast rate of penetration, excellent lubricity and inhibition, hydrate inhibition, easy maintenance, and can also be reused again and again as long as proper focus is given to maintaining good solids control. The Versaclean system can be formulated and engineered to meet a wide range of applications and requirements. It is widely used in West Africa including all of the previous wells drilled in the West Cape Three Points Block and the Deepwater Tano Contract Area. Versaclean is essentially the only non-aqueous drilling fluid that is readily available in the area.

The International Association of Oil & Gas Producers (OGP, 2003) recognizes three categories of non-aqueous drilling fluids (NADFs):

- **Group I (high aromatic content)** – These were the first NADFs used and include diesel and conventional mineral oil based fluids. They are refined from crude oil and are a nonspecific collection of hydrocarbon compounds including paraffins, olefins and aromatics, and polycyclic aromatic hydrocarbons (PAHs). Group I NADFs are defined by having PAH levels greater than 0.35%.

- **Group II (medium aromatic content)** – These fluids, usually referred to as low toxicity mineral oil-based fluids, were developed as a second step in addressing the concerns over the potential toxicity of diesel-based fluids. Group II NADFs are also developed from refining crude oil, but the distillation process is controlled to the extent that total aromatic hydrocarbon concentrations (between 0.5% and 5%) are less than those of Group I NABFs and PAH content is less than 0.35% but greater than 0.001%.
- **Group III (low to negligible aromatic content)** – These fluids are characterised by PAH content less than 0.001% and total aromatic content less than 0.5%. Group III includes synthetic based fluids, which are produced by chemical reactions of relatively pure compounds and can include synthetic hydrocarbons (olefins, paraffins, and esters). Base fluids derived from highly processed mineral oils using special refining and/or separation processes (paraffins, EMOBFs, etc.) are also included.

Under the OGP (2003) classification scheme, Versaclean is a Group III NADF and can be considered similar to synthetic-based fluids in terms of environmental characteristics. Versaclean was selected based on its ready availability in Ghana, its versatile performance characteristics for the drilling programme, and its favourable environmental qualities.

C.2 Drilling Fluid and Cuttings Disposal Options

During the drilling programme, WBFs and cuttings from both WBF and EMOBF systems will be discharged to the sea. Ocean discharge was selected as the preferred disposal option after considering the alternatives as identified by OGP (2003): (1) onshore disposal; (2) cuttings reinjection; and (3) offshore discharge.

C.2.1 Onshore Disposal

Under the onshore disposal option, cuttings are processed on the drilling rig, stored, and transported to shore for disposal. There are two components of onshore disposal that must be considered when evaluating this option (OGP, 2003). The first is marine transport (i.e., ship-to-shore which is common to all potential onshore disposal options) and the associated advantages and disadvantages. Second are the advantages and disadvantages associated with the selected onshore disposal option.

The onshore disposal option is not technically complicated, but it involves a substantial amount of equipment, effort and cost (OGP, 2003). The following steps typically are involved:

- Cuttings from the shale shakers are stored in storage containers (boxes, bags, or tanks);
- Storage containers are off-loaded by crane to a workboat or other vessel or cuttings may be pumped by vacuum into tanks on a workboat;
- A vessel transports the cuttings (and containers) to shore;
- Containers are offloaded from the boat to the dock at port;

- As trucks or other ground transport vehicles are available, cuttings (and containers) are loaded into the trucks;
- Trucks transport the cuttings to a land disposal or treatment facility;
- Equipment at the facility offloads the cuttings from the trucks, while other equipment may provide further treatment or manipulation (e.g., bulldozers, grinding and slurrification units);
- The treated cuttings may be placed in a landfill and buried, incinerated, spread on land, or injected into a suitably isolated injection zone;
- Empty containers are transported back to the port by truck and, ultimately, back to the rig by boat.

Onshore disposal involves a substantial amount of additional equipment relative to the offshore discharge option. On the rig or platform, incremental equipment requirements are primarily limited to storage containers such as cuttings boxes to hold the cuttings prior to and during transport. This option also involves increased use of existing rig equipment, such as the crane. If vacuum transfer equipment is used, less lifting will be required.

Once onshore, there are a number of options for treatment/disposal of cuttings. These typically include injection, land-spreading, land-farming, and landfill disposal. If necessary or optimal, cuttings may be treated prior to disposal biologically (by for example composting) or thermally (thermal desorption or incineration). Once treated, the cuttings can be land-filled, land-spread, or re-used for example in road construction (OGP, 2003).

Onshore disposal was considered unfavourable for this project for several reasons:

- Shipping cuttings to shore involves significant safety and environmental risks including the potential for serious injury due to the large number of crane lifts (Morris and Seaton, 2006; Kirkness and Garrick, 2008).
- The space and equipment requirements are substantial. In addition to the storage space requirements on the rig itself, these would include rental of one or more dedicated boats (or barges), use of port facilities, rental of trucks, and use of equipment at the disposal facility. If onshore injection is involved, grinding, slurrification, and pumps for injection would be required at the site.
- Transport operations would result in additional impacts due to increased vessel traffic, air pollutant emissions from vessel engines, and a risk of spillage during transport.
- Onshore treatment and disposal facilities for oily cuttings are not available in Ghana. Construction and operation of such facilities could result in additional environmental and social impacts.

C.2.2 Cuttings Reinjection

Cuttings reinjection is a process that involves grinding cuttings to a small size, slurring them to create a stable suspension, and injecting the cuttings and the associated NADFs into a subsurface geological formation (OGP, 2003; Alba et al., 2007). Cuttings may be injected into the annulus of a well being drilled, or into a dedicated or dual-use disposal well, i.e., one that will later be completed for production.

Offshore cuttings reinjection typically is used on rigs or platforms with surface wellheads. For this project, cuttings reinjection is not feasible because the wellheads will be subsea (i.e., on the seafloor) and there would be no access to the annulus. As noted by OGP (2003): “Since the technology for injecting through subsea wellheads from floating facilities and in deep water is not mature, the technique would not likely be applicable to fields in deep water developed exclusively with subsea wellheads at this time.”

C.2.3 Offshore Discharge

Under the offshore discharge option, cuttings from both WBF and EMOBF systems are discharged to the ocean from the drilling rig, after passing through the rig’s solids control equipment (including cuttings dryers). Spent WBFs are also discharged into the ocean. Except for small amounts adhering to cuttings, EMOBFs are recovered and returned to the vendor for recycling.

As noted by OGP (2003), the offshore discharge option is operationally simple and usually requires no additional equipment to that conventionally found on a drilling rig. Unlike the other disposal options, no temporary storage for cuttings is required. In most offshore operating areas around the world, discharge of WBF and WBF cuttings is routine practice except in highly sensitive areas. NADF cuttings are discharged offshore in a number of geographic locations subject to local regulations.

The principal disadvantages of ocean discharge are the environmental impacts due to cuttings accumulations on the seafloor, particularly to benthic communities in a small area around each wellsite. These impacts have been discussed in **Chapter 5** of the ESIA.

Two aspects of offshore discharge are discussed further below: (1) minimising retention on cuttings through the use of cuttings dryers; and (2) evaluation of the possibility of discharging through a caisson extending 15 m below the sea surface.

Minimising Retention on Cuttings

For the Jubilee drilling programme, during well intervals when the EMOBF is used, base fluid retention on cuttings (ROC) is expected to range from 6% to 8%. Moreover, because both drilling rigs will use a cuttings dryer, ROC significantly less than 6% to 8% may be achieved.¹

Shale shakers are the primary solids control devices for cuttings (OGP, 2003). The percentage of drilling fluid retained on cuttings from the shale shakers varies depending on the particle size, the formulation of the drilling fluid, the geologic characteristics of the formation being drilled, and other factors. The U.S.

¹ This paragraph was edited and updated March 2009.

Environmental Protection Agency (USEPA, 2000) estimated an average ROC of 9.3% for cuttings taken from primary shale shakers, 13.8% for cuttings from secondary shale shakers, and 9.0% for cuttings from other shale shakers. Annis (1997) evaluated 738 synthetic-based fluid (SBF) cuttings samples and reported that the average ROC was $12.0\% \pm 4.8\%$ with the processing technology available in the mid-1990's. Other authors state ROC ranges of 15% to 20% (Kirkness and Garrick, 2008) and 5% to 15% (Seaton and Hall, 2005).

Cuttings dryers are the most common methods for further reducing ROC. They are used routinely offshore in the U.S. Gulf of Mexico. A cuttings dryer is a high-speed centrifuge that is used to spin off excess fluid from cuttings. Melton et al. (2004) reported an example in which a cuttings dryer reduced ROC from 11.8% to 2.1%. In a study of 23 wells using another cuttings dryer, Cannon and Martin (2001) reported that average ROC was reduced from 11.47% to 3.99%. ROC for individual wells ranged from about 2% to 6%. Johnston et al. (2004) measured ROC for 72 wells drilled using SBFs in the Gulf of Mexico; with cuttings dryers, average ROC calculated over all SBF well intervals was 4.39%.

While cuttings dryers cannot achieve a 1% ROC level, they can significantly mitigate the environmental impacts of cuttings discharges. Getliff et al. (1997) reported that cuttings with low concentrations of adhering SBF have a lesser tendency to clump, and dispersion is greater as the cuttings settle through the water column. When cuttings containing <5% SBF were discharged from a platform in the North Sea, they dispersed in the water column and no cuttings pile accumulated on the bottom.

Discharge Depth (Shunting)

Discharge location is another factor in the fate and effects of drilling discharges. During the first well interval when the hole is being jetted into the seafloor, cuttings and "spud mud" will be released at the seafloor. These initial discharges will create a mound with a diameter of several meters to tens of meters. There are no practical alternatives for discharge location during this stage of drilling.

After the initial well interval, the marine riser is set allowing drilling fluids and cuttings to be returned to the drilling rig, where they are processed through solids control equipment prior to discharge. Cuttings and residual drilling fluid are mixed with sea water and discharged to the sea through a pipe that typically is located a few metres below the water surface.

For discharges from a drilling rig, the IFC (2007) guidelines recommend using a caisson extending at least 15 m below the sea surface (i.e., shunting). However, due to the water depth of the Jubilee wellsites, shunting would not be expected to achieve any significant environmental benefit. Due to the water depth of the Jubilee Field area (1,020 to 1,720 m), the discharges will be dispersed and diluted rapidly as they settle through the water column. A caisson extending 15 m below the sea surface would effectively change the water depth by only about 1%.

Attaching a shunt on a large, floating deepwater drilling rig also poses serious logistical and safety issues. Structural considerations would require very heavy walled pipe and there is a high likelihood that in heavy wind and wave conditions, the shunt could be damaged significantly by the wave forces. For this reason, the use of a 15-m caisson is considered unsuitable for this project.

C.3 Preferred Alternatives

- For its drilling programme, Jubilee Joint Venture plans to use both WBFs and an EMOBF, Versaclean. WBFs will be used in the upper sections of the well bore and Versaclean will be used for mid- and lower sections of each well. Versaclean was selected based on its ready availability in Ghana, its versatile performance characteristics for the drilling programme, and its favourable environmental qualities (low toxicity, low aromatic content).
- Ocean discharge at the sea surface is the preferred disposal option for WBFs and for cuttings from both WBF and EMOBF systems. Cuttings dryers will be used to minimise retention of EMOBF on cuttings.

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Appendix D

Air Emissions Calculations

Appendix D

Air Emissions Calculations

D.1 Calculation Methods and Results

Table D.1 lists estimated emissions of criteria pollutants and greenhouse gases for all phases of Phase 1 activities. The emissions were calculated using a spreadsheet developed by the Minerals Management Service (MMS, 2008) for oil and gas activities in the Gulf of Mexico. Emission factors for carbon dioxide (CO₂) and methane (CH₄) were added to the spreadsheet based on data from Wilson et al. (2007). To calculate CO₂ equivalence, CH₄ emissions were multiplied by a factor of 21 (MMS, 2007).

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Table D.1. Emissions calculations for all stages of Jubilee Field, Phase 1 development.

Operation	Equipment	Rating	Max Fuel	Act. Fuel	Run Time		Estimated Tons							
	Diesel Engines	hp	gal/h	gal/d										
	Natural Gas Engines	hp	scf/h	scf/d	h/d	days	PM	SO _x	NO _x	VOC	CO	CO ₂	CH ₄	CO ₂ Equivalent ^a
Drilling/Completion <i>Eirik Raude</i>	Prime Mover	10200	492.66	11823.84	24	1092	94.21	432.19	3238.48	97.15	706.58	154916.99	8.83	155102.47
	Prime Mover	10200	492.66	11823.84	24	1092	94.21	432.19	3238.48	97.15	706.58	154916.99	8.83	155102.47
	Prime Mover	10200	492.66	11823.84	24	1092	94.21	432.19	3238.48	97.15	706.58	154916.99	8.83	155102.47
	Prime Mover	10200	492.66	11823.84	24	1092	94.21	432.19	3238.48	97.15	706.58	154916.99	8.83	155102.47
	Vessels (work1)	8500	410.55	9853.20	24	1092	78.51	360.16	2698.73	80.96	588.81	129097.49	7.36	129252.05
	Vessel (work2)	8500	410.55	9853.20	24	1092	78.51	360.16	2698.73	80.96	588.81	129097.49	7.36	129252.05
	Vessel (AHTS)	10000	483	11592.00	24	1092	92.36	423.72	3174.98	95.25	692.72	151879.40	8.66	152061.24
	Total (E Raude)	Entire period - 1,092 d					626.22	2872.79	21526.35	645.79	4696.66	1029742.34	58.71	1030975.21
Drilling/Completion <i>Blackford Dolphin</i>	Prime Mover	5096	246.1368	5907.28	24	266	11.47	52.60	394.12	11.82	85.99	18853.30	1.07	18875.87
	Prime Mover	5096	246.1368	5907.28	24	266	11.47	52.60	394.12	11.82	85.99	18853.30	1.07	18875.87
	Prime Mover	5096	246.1368	5907.28	24	266	11.47	52.60	394.12	11.82	85.99	18853.30	1.07	18875.87
	Prime Mover	5096	246.1368	5907.28	24	266	11.47	52.60	394.12	11.82	85.99	18853.30	1.07	18875.87
	Vessel (work1)	8500	410.55	9853.20	24	266	19.12	87.73	657.38	19.72	143.43	31446.82	1.79	31484.47
	Vessel (work2)	8500	410.55	9853.20	24	266	19.12	87.73	657.38	19.72	143.43	31446.82	1.79	31484.47
	Vessel (AHTS)	10000	483	11592.00	24	266	22.50	103.21	773.39	23.20	168.74	36996.26	2.11	37040.56
	Total (B Dolphin)	Entire period - 266 d					106.61	489.06	3664.64	109.94	799.56	175303.10	9.99	175512.98
Flowline/Injector/ Umbilical Installation	Pipeline Lay Barge	20000	966	23184.00	24	90	15.22	69.84	523.35	15.70	114.19	25035.07	1.43	25065.04
	Umbilical Vessel diesel	16000	772.8	18547.20	24	90	12.18	55.87	418.68	12.56	91.35	20028.05	1.14	20052.03
	Support Vessel diesel	8500	410.55	9853.20	24	90	6.47	29.68	222.42	6.67	48.53	10639.90	0.61	10652.64
	Total	Entire period - 90 d					33.87	155.40	1164.45	34.93	254.06	55703.02	3.18	55769.71
FPSO Installation	Tug (tow vessel)	7000	338.1	8114.40	24	2	0.12	0.54	4.07	0.12	0.89	194.72	0.01	194.95
	Tug (tow vessel)	7000	338.1	8114.40	24	2	0.12	0.54	4.07	0.12	0.89	194.72	0.01	194.95
	Tug (tow vessel)	5600	270.48	6491.52	24	2	0.09	0.43	3.26	0.10	0.71	155.77	0.01	155.96
	Tug (tow vessel)	5600	270.48	6491.52	24	2	0.09	0.43	3.26	0.10	0.71	155.77	0.01	155.96
	Tug (tow vessel)	4200	202.86	4868.64	24	2	0.07	0.33	2.44	0.07	0.53	116.83	0.01	116.97
	Vessels (AH)	10000	483	11592.00	24	90	7.61	34.92	261.67	7.85	57.09	12517.53	0.71	12532.52
	Vessels (work)	8500	410.55	9853.20	24	90	6.47	29.68	222.42	6.67	48.53	10639.90	0.61	10652.64
	Total	Entire period - 2 d tow, 90 d install					14.58	66.89	501.19	15.04	109.35	23975.25	1.37	24003.95

Table D.1. (Continued).

Operation	Equipment	Rating	Max Fuel	Act. Fuel	Run Time		Estimated Tons							
	Diesel Engines	hp	gal/h	gal/d										
	Natural Gas Engines	hp	scf/h	scf/d	h/d	days	PM	SO _x	NO _x	VOC	CO	CO ₂	CH ₄	CO ₂ Equivalent ^a
Production <i>Ohdoh</i>	Recip. (dual fuel)	5500	265.65	6375.60	12	365	8.49	38.95	291.84	8.76	63.67	13960.53	0.80	13977.24
	Recip. (dual fuel)	5500	265.65	6375.60	12	365	8.49	38.95	291.84	8.76	63.67	13960.53	0.80	13977.24
	Recip. (dual fuel)	5500	265.65	6375.60	12	365	8.49	38.95	291.84	8.76	63.67	13960.53	0.80	13977.24
	Recip. (emerg)	5500	265.65	6375.60	12	5	0.12	0.53	4.00	0.12	0.87	191.24	0.01	191.47
	Recip. (crane)	572	27.6276	663.06	12	365	2.76	4.05	38.63	3.09	8.36	1833.02	0.10	1835.21
	Recip. (crane)	527	25.4541	610.90	12	365	2.54	3.73	35.59	2.85	7.70	1688.81	0.10	1690.83
	Recip. (shipbrd)	5500	265.65	6375.60	2	365	1.41	6.49	48.64	1.46	10.61	2326.75	0.13	2329.54
	Recip. (shipbrd)	5500	265.65	6375.60	2	365	1.41	6.49	48.64	1.46	10.61	2326.75	0.13	2329.54
	Recip. (tanker)	20000	966	23184.00	24	37	6.17	28.33	212.25	6.37	46.31	10153.11	0.58	10165.27
	Support Vessel diesel	8500	410.55	9853.20	24	365	26.24	120.38	902.05	27.06	196.81	43150.72	2.46	43202.38
	Tug diesel (tow vessel)	4200	202.86	4868.64	24	365	12.97	59.48	445.72	13.37	97.25	21321.53	1.22	21347.06
	Tug diesel (tow vessel)	4200	202.86	4868.64	24	365	12.97	59.48	445.72	13.37	97.25	21321.53	1.22	21347.06
	Turbine natural gas	5500	52382	1257168.00	12	365	--	0.07	34.49	0.27	22.02	4828.02	0.28	4833.80
	Turbine natural gas	5500	52382	1257168.00	12	365	--	0.07	34.49	0.27	22.02	4828.02	0.28	4833.80
	Turbine natural gas	5500	52382	1257168.00	12	365	--	0.07	34.49	0.27	22.02	4828.02	0.28	4833.80
Engines, Subtotal	Miscellaneous	bbl/d	scf/h	Count			92.07	406.01	3160.22	96.21	732.86	160679.09	9.16	160871.47
Fugitives, Subtotal	Tank-	150000			24	365	--	--	--	821.25	--	--	--	--
Total	Annual - production, offloading						92.07	406.01	3160.22	917.46	732.86	160679.09	9.16	160871.47

* To calculate CO₂ equivalence, CH₄ emissions were multiplied by 21 and added to the CO₂ emissions.

AHTS = anchor handling tug supply
 CH₄ = methane
 CO = carbon monoxide
 CO₂ = carbon dioxide
 FPSO = floating production, storage
 and offloading
 gal/d = gallons per day
 gal/h = gallons per hour
 hp = horsepower

NO_x = nitrogen oxides
 PM = particulate matter
 scf/d = standard cubic feet per day
 scf/h = standard cubic feet per hour
 SO_x = sulfur oxides
 VOC = volatile organic compounds

Appendix E

Endangered or Critically Endangered Marine Mammals and Turtles

Appendix E

Endangered or Critically Endangered Marine Mammals and Turtles

This appendix discusses marine mammals and turtles that may occur in the Jubilee Field Development area offshore Ghana and that are categorized by the International Union for Conservation of Nature and Natural Resources (IUCN) Red List (2008) as critically endangered or endangered (**Table E.1**).

The IUCN Red List does not identify or designate critical habitat for listed species. According to International Finance Corporation (IFC) Performance Standard 6, critical habitat includes areas with high biodiversity value, including (i) habitat required for the survival of critically endangered or endangered species; (ii) areas having special significance for endemic or restricted-range species; (iii) sites that are critical for the survival of migratory species; (iv) areas supporting globally significant concentrations or numbers of individuals of congregatory species; (v) areas with unique assemblages of species or which are associated with key evolutionary processes or (vi) provide key ecosystem services; and (vii) areas having biodiversity of significant social, economic or cultural importance to local communities. Items (i) and (iii) are of particular relevance with respect to marine mammals and turtles.

Table E.1. Endangered or critically endangered marine mammals and turtles potentially occurring offshore Ghana.

Common Name	Scientific Name	IUCN Status	Potential Occurrence	
MARINE MAMMALS			Offshore	Coastal
Blue whale	<i>Balaenoptera musculus</i>	Endangered	X	---
Fin whale	<i>Balaenoptera physalus</i>	Endangered	X	---
Sei whale	<i>Balaenoptera borealis</i>	Endangered	?	---
SEA TURTLES			Presence	Nesting
Green turtle	<i>Chelonia mydas</i>	Endangered	X	X
Hawksbill turtle	<i>Eretmochelys imbricata</i>	Critically Endangered	X	---
Leatherback turtle	<i>Dermochelys coriacea</i>	Critically Endangered	X	X
Loggerhead turtle	<i>Caretta caretta</i>	Endangered	X	---
Olive ridley turtle	<i>Lepidochelys olivacea</i>	Endangered	X	X

IUCN = International Union for Conservation of Nature and Natural Resources.

E.1 Marine Mammals

There are no critically endangered marine mammals occurring in or offshore Ghana. Three endangered species may be present: blue whale, sei whale, and fin whale. Of these, only the blue whale is specifically listed by the IUCN (2008) as occurring offshore Ghana; the other two are included because they are known from the eastern-central Atlantic and therefore could occur in the area. The following discussion of IUCN-listed endangered marine mammals has been compiled from several sources, including Jefferson et al. (1993, 1997, 2008), Van Waerebeek et al. (2003), and the North Atlantic Marine Mammal Commission (NAMMCO, 2005), among others.

E.1.1 Blue Whale (*Balaenoptera musculus*)

Life History: Blue whales are known to live for 80 to 90 years. Calves are born in winter on tropical or subtropical breeding grounds. Specific breeding and calving areas remain unknown.

Distribution: Blue whales tend to be open-ocean animals, but come close to shore to feed, and possibly to breed, in some areas. Blue whales can be seen from the equator to the pack ice edges in both hemispheres, with most poleward intrusions in both hemispheres in summer and movements towards the middle latitudes and tropics for breeding in winter; blue whales tend to avoid most equatorial waters. Breeding waters are not well defined. Jefferson et al. (2008) identify both primary and secondary ranges for the blue whale, as well as areas of overlap with pygmy blue whales (**Figure E.1**). Some blue whales are resident, while others are migratory.

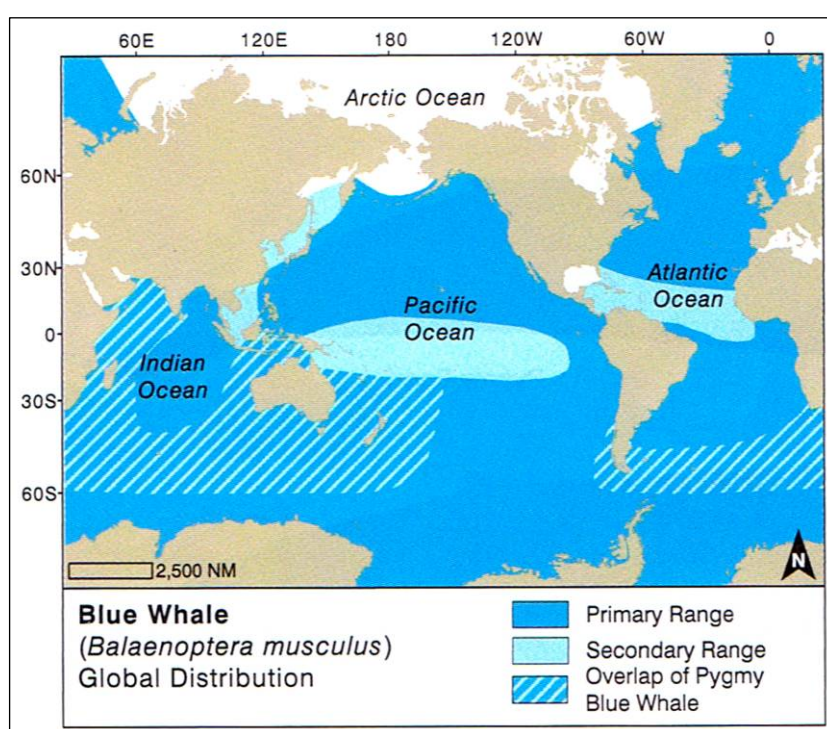


Figure E.1. Blue whale worldwide distribution (From: Jefferson et al., 2008).

Biology and Behaviour: Blue whales are usually sighted alone or in pairs. However, Jefferson et al. (2008) noted that scattered aggregations of a dozen or more may develop on prime feeding grounds. Although shorter dives are most common, dives of up to 30 min, generally interspersed with series of shorter surfacings (at 15 to 20 sec intervals), have been recorded. Fluking-up is not uncommon, although not all blue whales are “flukers.” In spite of their size, some blue whales have been observed breaching.

Multiple euphausiid species (krill) form the major part of the blue whale’s diet. When observed feeding, blue whales can be observed lunging, often on their sides or upside-down, through great clouds of krill.

Population Size and Regional Presence: Worldwide, the population of blue whales is estimated to range between 8,000 and 9,000 individuals.

Preferred Habitat: The primary range of this species includes mid- and higher latitudes of both hemispheres.

Migratory Routes: Migratory routes of blue whales are not well defined, aside from a tendency to move towards the middle latitudes and tropics for breeding in winter and higher latitudes in summer for feeding; blue whales tend to avoid most equatorial waters.

Important Oceanographic or Benthic Features and Critical Habitat: Important oceanographic or benthic features are unknown; this species prefers deep water.

Presence of Critical Habitat and Important Oceanographic or Benthic Features

Offshore Ghana: Ghana offshore waters may include either the primary or secondary range of this species. Critical habitat has not been designated for this species, nor have preferred breeding, calving, or feeding grounds been identified beyond the preferences noted previously. While it is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana, this region's location along the boundary between primary and secondary range for blue whales and its preference to avoid most tropical waters strongly suggests that neither critical habitat nor important features are present in the vicinity of the Jubilee Field.

E.1.2 Fin Whale (*Balaenoptera physalus*)

Life History: Sexual maturity in fin whales is reached at ages of 6 to 10 years in males and 7 to 12 years in females. Gestation lasts 11 to 12 months. Fin whales have a life expectancy of 80 to 90 years. Calving does not appear to occur in distinct nearshore areas as is the case with several other baleen whale species (i.e., humpbacks, gray whales).

Distribution: Fin whales are cosmopolitan, inhabiting primarily oceanic waters of both hemispheres. According to Jefferson et al. (2008), fin whales have been sighted in nearshore waters, most commonly where deep water approaches the coast. NAMMCO (2005) notes that this species is largely pelagic and is rarely seen in nearshore waters. It is suggested that nearshore occurrence is possible when deep water features (e.g., canyons) are found in close proximity to the coast. Waters offshore Ghana are within the secondary range for this species.

Fin whales can be seen in tropical, temperate, and polar zones of all oceans, with their primary range north of approximately 25°N (latitude) and south of approximately 25°S (latitude), as reflected in **Figure E.2** (Jefferson et al., 2008). Fin whales are migratory, and tend to exhibit seasonal movements between lower latitudes for winter breeding and higher latitudes for summer feeding. Some taxonomists classify fin whales from the northern and southern hemispheres as two subspecies – *B.p. physalus* and *B.p. quoyi*, respectively. There is generally considered to be at least three distinct worldwide populations, occupying the southern hemisphere, North Atlantic, and North Pacific. These populations do not mix across the equator and are further subdivided genetically.

Biology and Behaviour: Fin whales are among the fastest of the great whales, capable of attaining a speed of 37 km/h. Fin whales rarely raise their flukes on a dive, but have been observed occasionally breaching. Fin whales tend to be slightly more social than other rorquals, gathering in pods of two to seven whales or more; fin whales may be observed in large, multi-species feeding aggregations along with other baleen whales (e.g., humpbacks, minke) and dolphins (e.g., Atlantic white-sided dolphins). Young are born on breeding grounds in tropical and subtropical areas in mid-winter.

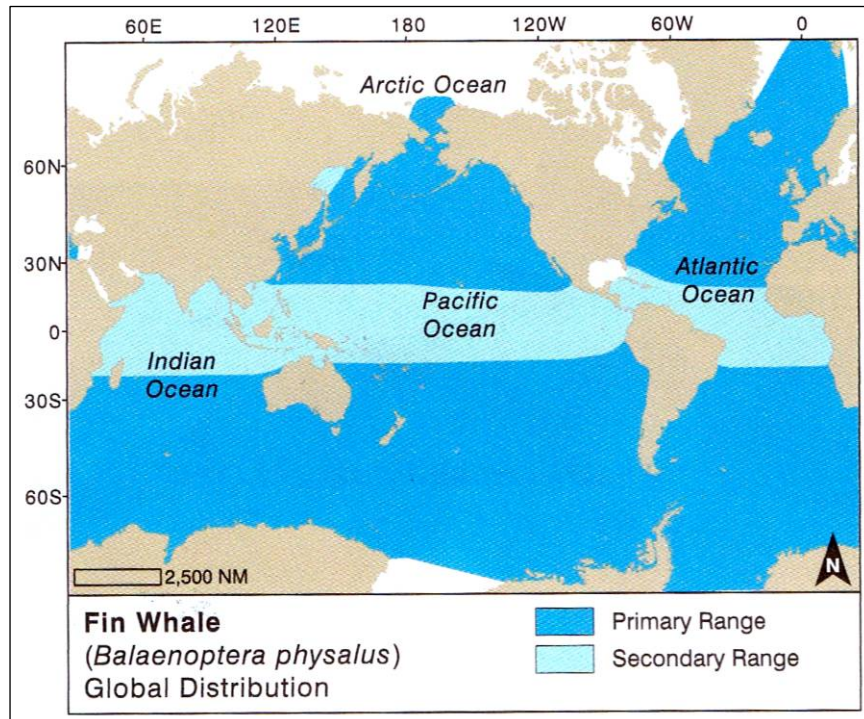


Figure E.2. Fin whale worldwide distribution (From: Jefferson et al., 2008).

Fin whales feed on small invertebrates (i.e., euphausiids, copepods), schooling fishes (e.g., capelin, herring, mackerel, sandlance, blue whiting), and squid. They are active lunge feeders. Areas of upwelling and interfaces between mixed and stratified waters may be an important feature of fin whale feeding habitat (Natural Heritage Trust, 2005).

Population Size and Regional Presence: Worldwide, the population of fin whales is estimated to be at least 140,000 individuals.

Preferred Habitat: The primary range of this species includes mid- and higher latitudes of both hemispheres, above 25°N and below 25°S. Areas of upwelling and interfaces between mixed and stratified waters may be an important feature of fin whale feeding habitat (Natural Heritage Trust, 2005).

Migratory Routes: Migratory routes of fin whales are not well defined, aside from a preference for waters north of 25°N latitude and south of 25°S latitude.

Important Oceanographic or Benthic Features and Critical Habitat: Important oceanographic or benthic features are unknown; this species prefers deep water.

Presence of Critical Habitat and Important Oceanographic or Benthic Features

Offshore Ghana: Ghana offshore waters include only the secondary range of this species. Critical habitat has not been designated for this species, nor have preferred breeding, calving, or feeding grounds been identified beyond the preferences noted previously. While it is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana, this region's location within only the secondary range for fin whales suggests that neither are present in the vicinity of the Jubilee Field.

E.1.3 Sei Whale (*Balaenoptera borealis*)

Life History: Sei whales are believed to live to an age of 50 years or more. Calving occurs in mid-winter within low latitude waters. Gestation lasts 10 to 12 months, with weaning of newborns lasting 6 to 9 months.

Distribution: Sei whales are open ocean whales, not often seen near the coast. Regional studies indicate that this species prefers deep water (i.e., waters over the continental slope). They occur from the tropics to polar zones in both hemispheres and in all of the world's major oceans, but are more restricted to mid-latitude temperate zones than are other rorquals; in general, the primary range for this species is from about 30°N (latitude) northward and 30°S (latitude) southward, as reflected in **Figure E.3** (Jefferson et al. 2008).

Mizroch et al. (1984) reported that in the North Pacific, sei whales winter in waters from 20°N to 23°N latitude, and summer from 35°N to 40°N, with a few individuals found at 50°N (Masaki, 1976). In the Antarctic, the summer distribution (inferred from catch statistics) is mainly from 40°S to 50°S, and the winter distribution is as yet unknown.

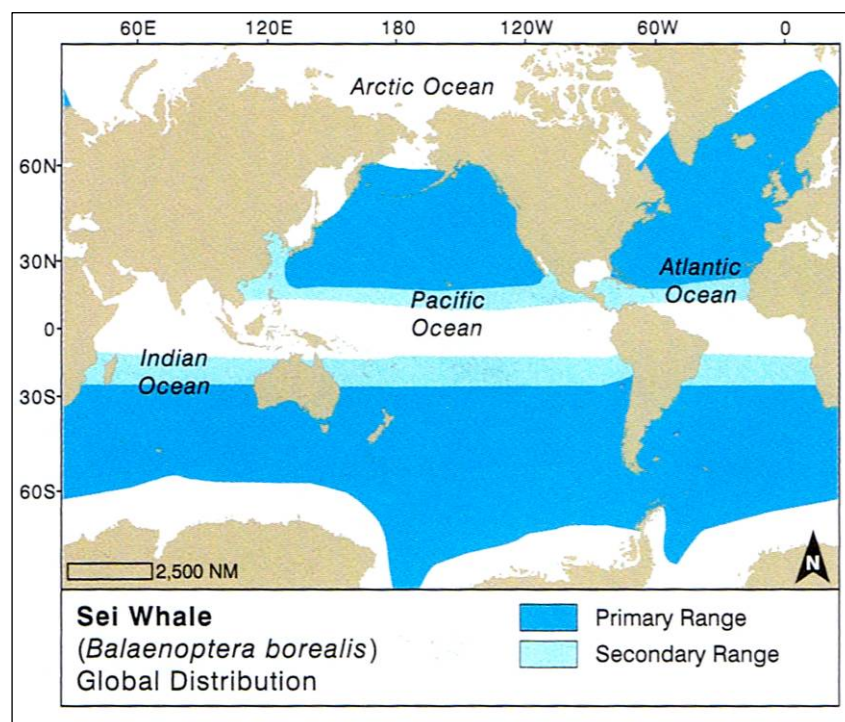


Figure E.3. Sei whale worldwide distribution (From: Jefferson et al., 2008).

In the North Atlantic, the northern (summer) limit of sei whale distribution is thought to be 72°N, although little is known of southern (winter) distribution (Jonsgård 1966). There is also evidence of differential migration by reproductive class, with pregnant females leading waves of migration both into and out of the feeding grounds (Matthews, 1938; Gambell, 1968). Pregnant females also tend to be found in higher latitudes (Masaki, 1976).

Waters offshore Ghana are not within either the primary or secondary range for this species. While sei whales undergo seasonal migrations, their movements are not as lengthy as other large whale species. Species distribution for sei whales is considered unpredictable, with regular, multi-year sightings in an area typically followed by an absence of individuals in subsequent years.

Biology and Behaviour: Sei whales are usually sighted in groups of two to five individuals, although little is known about their social behavior and interactions. When feeding, sei whales typically dive and surface in a predictable fashion. They rarely lift their flukes during diving and often remain just below the ocean surface between breaths, making this species more difficult to sight.

Sei whales feed on copepods and other small prey by skimming the ocean surface. Their feeding preferences have been characterized as being more flexible than other baleen whales (Jefferson et al., 2008).

Population Size and Regional Presence: Worldwide, the population of sei whales is estimated to be at least 80,000 individuals.

Preferred Habitat: The primary range of this species includes mid- and higher latitudes of both hemispheres, above 30°N and below 30°S.

Migratory Routes: Migratory routes of sei whales are not well defined, aside from a preference for waters north of 30°N latitude and south of 30°S latitude.

Important Oceanographic or Benthic Features and Critical Habitat: Important oceanographic or benthic features are unknown; this species prefers deep water. Sei whales are distributed far out to sea in temperate regions of the world and do not appear to be associated with coastal features (Forney et al., 2000).

Presence of Critical Habitat and Important Oceanographic or Benthic Features

Offshore Ghana: Ghana offshore waters do not include either the primary or secondary range of this species. Critical habitat has not been designated for this species, nor have preferred breeding, calving, or feeding grounds been identified beyond the preferences noted previously. While it is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana, this region's location outside of the primary and secondary range for sei whales strongly suggests that neither are present in the vicinity of the Jubilee Field.

E.1.4 Marine Mammals – Critical Habitat Summary

Neither the project area nor the adjacent coast of Ghana includes any habitat required for the survival of the three endangered marine mammals that may occur in the area (blue whale, fin whale, and sei whale). Summary information regarding these endangered species is provided in **Table E.2**.

Table E.2. Critical habitat summary for endangered marine mammals potentially present in Ghana.

Species	Presence in Ghana Waters	Critical Habitat
Blue whale (Endangered)	<i>Possible</i> (includes primary or secondary range of this species)	None designated for this species; no indication preferred habitat is present
Fin whale (Endangered)	<i>Possible</i> (includes secondary range of this species)	None designated for this species, nor have preferred breeding, calving, or feeding grounds been identified. The region's location outside the primary range for fin whales strongly suggests that there is no critical habitat in or near the project area
Sei whale (Endangered)	<i>Not expected</i> (neither primary or secondary range within Ghana waters)	None designated for this species, nor have preferred breeding, calving, or feeding grounds been identified. The region's location outside the primary and secondary range for sei whales strongly suggests that there is no critical habitat in or near the project area

E.2 Sea Turtles

Five species of sea turtles have been recorded from Ghana (Carr and Campbell, 1995; Beyer and Benefo-Twum, 2006). The hawksbill and leatherback turtles are critically endangered and the green, loggerhead, and olive ridley turtles are endangered (IUCN, 2008). The olive ridley turtle is the most abundant species in Ghana (Carr and Campbell, 1995).

There are historical reports of all five species nesting along the coast, but recent studies show only the green, leatherback, and olive ridleys currently nest there (Beyer and Benefo-Twum, 2006; HLAMI Association for Turtle Conservation and Hope, 2008).

E.2.1 Green Turtle (*Chelonia mydas*)

Life History: Green turtles exhibit slow growth rates, due primarily to their largely herbivorous diet. Age to maturity for green turtles appears to be the longest of any sea turtle species, estimated to require 20 to 40 years or more (Limpus and Chaloupka, 1997; Zug et al., 2002).

Distribution: Green turtles have a circumglobal distribution, occurring throughout tropical and subtropical waters; they may also be present in temperate waters. Movements within the marine environment are not completely understood; green turtles are believed to inhabit coastal waters of more than 140 countries (Groombridge and Luxmoore, 1989). Nesting occurs in more than 80 countries worldwide. Ghana nesting sites are listed among the lesser green turtle nesting sites worldwide (NMFS and USFWS, 2007a).

Green turtles appear to prefer waters that usually remain around 17° to 20° C. Green turtles may be found beyond their normal distribution during periodic warm water spells. Green turtles often return to the same foraging areas following subsequent nesting migrations (Godley et al., 2002; Broderick et al., 2006). It is also evident that some green turtles remain in open ocean habitat for extended periods, perhaps never recruiting to coastal foraging sites (Pelletier et al., 2003). While offshore, and occasionally in coastal waters, green turtles are not obligate herbivores, consuming a variety of invertebrate species (e.g., jellyfish, sponges, sea pens, pelagic prey).

NMFS and USFWS (2007a) summarized 46 worldwide nesting sites of importance, citing two locations in the eastern Atlantic along the western coast of Africa – Bijagos Archipelago (Guinea-Bissau) and Bioko Island (Equatorial Guinea).

Biology and Behaviour: Based on the behavior of post-hatchlings and juvenile green turtles raised in captivity, it is presumed that green turtles found in pelagic habitats live and feed at or near the ocean surface, and that their dives do not normally exceed several meters in depth (NMFS and USFWS, 1998). The maximum recorded dive depth for an adult green turtle was 110 m (Berkson, 1967, in Lutcavage and Lutz, 1997), while subadults routinely dive 20 m for 9 to 23 minutes, with a maximum recorded dive of 66 minutes (Brill et al., 1995 as cited in Lutcavage and Lutz, 1997).

Population Size and Regional Presence: A total of 108,761 to 150,521 females nest each year at the 46 nesting sites summarized by NMFS and USFWS (2007a). Abundance estimates (i.e., ranges) of nesting green turtles at Bijagos Archipelago (Guinea-Bissau) and Bioko Island (Equatorial Guinea) were 6,299 to 8,273 and 1,255 to 1,681 individuals, respectively.

Preferred Habitat: Green turtles spend the majority of their lives in coastal foraging grounds, including both open coastline and protected bays and lagoons. In addition, oceanic habitats are used by oceanic-stage juveniles, migrating adults, and (occasionally) by resident foragers.

Migratory Routes: Green turtles are highly mobile and undertake complex movements through geographically disparate habitats during their life (Musick and Limpus, 1997; Plotkin, 2003). The periodic migration between nesting sites and foraging areas by adults is a prominent feature of their life history. Female green turtles are philopatric to specific nesting beaches – they return to the same beach in subsequent nesting seasons (Carr et al., 1978); genetic analyses also indicate that these beaches are also their natal beaches (Meylan et al., 1990).

Important Oceanographic or Benthic Features and Critical Habitat (foraging, breeding, juvenile habitats): As noted previously, green turtles spend time in coastal foraging grounds, including both open coastline and protected bays and lagoons, and oceanic habitats. Nesting occurs at natal beaches.

Presence of Critical Habitat and Important Oceanographic or Benthic Features

Offshore Ghana: Ghana offshore and nearshore waters are within the cosmopolitan distribution of green turtles. Ghana nesting beaches are identified among the group of lesser nesting sites worldwide. It is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana. The importance of the Gulf of Guinea, in general, to sea turtle species, is discussed by Formia et al. (2003, 2007) and Fretey (2001).

E.2.2 Hawksbill Turtle (*Eretmochelys imbricata*)

Life History: Hawksbill turtles exhibit differential age to maturity. In the Caribbean, hawksbill turtles reach maturity in approximately 20 years, but require 30 to 35 years to reach maturity in the Indo-Pacific.

Distribution: Hawksbill turtles are found in tropical and subtropical seas worldwide. Formerly very abundant, this species has declined in most areas and stands at only a fraction of its historical abundance.

Biology and Behaviour: Hawksbill turtles nest on insular and mainland sandy beaches throughout the tropics and subtropics. Upon hatching, hawksbill turtles are thought to enter an oceanic phase, living in open ocean waters greater than 200 m water depth. Long distance travel may be via surface gyres, with eventual recruitment to neritic foraging habitat (i.e., at or near the ocean floor). Hawksbill turtles may associate with the same feeding location for years or may migrate from one feeding area to another. Adult hawksbills are highly mobile, traveling hundreds to thousands of kilometers between nesting beaches and foraging areas.

Diet of hawksbill turtles in the oceanic stage is thought to be a combination of plant and animal material. Post-oceanic hawksbills may occupy a range of habitats, including coral reefs or other hard bottom habitats, seagrass beds, algal beds, mangrove bays and creeks, or mud flats (NMFS and USFWS, 2007b).

Population Size and Regional Presence: A total of 3,072 to 5,602 females nest each year at the 33 nesting sites located in the Atlantic Ocean; between 8,000 and 10,000 females nest annually at nesting sites in the Indian Ocean (NMFS and USFWS, 2007b). Abundance estimates (i.e., ranges) of nesting hawksbill turtles at Bioko (Equatorial Guinea) and Sao Tomé and Príncipe were 7 and 14 to 27 individuals, respectively.

Preferred Habitat: Hawksbill turtles nest on insular and mainland sandy beaches throughout the tropics and subtropics; only two major nesting sites are present in west Africa. Hawksbill turtles utilize open ocean waters greater than 200 m water depth, and utilize surface gyres for long distance transport.

Migratory Routes: Hawksbill turtles are highly migratory and use a wide range of broadly separated localities and habitats during their lifetime (Musick and Limpus, 1997; Plotkin, 2003). Early juvenile hawksbills have been found in association with *Sargassum* in both the Atlantic and Pacific oceans; newly hatched hawksbills have also been observed associated with floating weed in the Caribbean and Indian Ocean.

Important Oceanographic or Benthic Features and Critical Habitat (foraging, breeding, juvenile habitats): Hawksbill turtles utilize open ocean waters greater than 200 m water depth, and utilize surface gyres for long distance transport.

Presence of Critical Habitat and Important Oceanographic or Benthic Features Offshore Ghana: Ghana offshore and nearshore waters are within the cosmopolitan distribution of hawksbill turtles. No nesting beaches for hawksbill turtles were identified in Ghana. It is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana. The importance of the Gulf of Guinea, in

general, to sea turtle species, is discussed by Formia et al. (2003, 2007) and Fretey (2001).

E.2.3 Leatherback Turtle (*Dermochelys coriacea*)

Life History: Studies characterizing their abundance, life history and ecology, and pelagic distribution are exceedingly difficult due to their circumglobal distribution. Age to maturity for leatherbacks is 29 years for individuals in the western North Atlantic.

Distribution: Leatherback turtles have the most extensive range of any living reptile and have been reported circumglobally from 71°N to 47°S latitude in the pelagic Pacific and in all other major pelagic ocean habitats (NMFS and USFWS, 2007c). Leatherbacks have the widest distribution of all sea turtles, nesting on beaches in the tropics and subtropics and foraging into higher latitude subpolar waters. In the Atlantic Ocean, leatherbacks are found as far north as the North Sea, Barents Sea, Newfoundland, and Labrador, and as far south as the Cape of Good Hope (South Africa). Eckert (2002) noted that juvenile leatherbacks are generally found in water warmer than 26°C. Genetic analyses of worldwide nesting assemblages support the natal homing hypothesis (i.e., leatherbacks return to nest at natal beaches); researchers note that the relative precision in natal homing observed in other sea turtles species is lacking in leatherbacks, allowing for colonization of new or depleted nesting beaches (Dutton et al., 1999).

Biology and Behaviour: Leatherback turtles lead a completely pelagic existence, foraging widely in temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Males are rarely observed near nesting areas, and it has been proposed that mating most likely takes place outside of the tropical waters, before females move to their nesting beaches (Eckert and Eckert, 1988).

Nesting in west Africa has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Islands of Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola (Fretey et al., 2007). A nesting population has also been documented on the island of Bioko (Equatorial Guinea). The most important nesting beach for leatherbacks in the eastern Atlantic is located in Gabon, where 6,000 to more than 8,000 nesting females were observed in 1999 through 2001 (Billes et al., 2003).

Surface feeding by leatherbacks has been reported, but foraging may also occur at depth. Maximum dive depths for post-nesting female leatherbacks have been recorded at 475 m and >1,000 m, with routine dives recorded at between 50 and 84 m. The maximum dive length recorded for such female leatherback turtles was 37.4 minutes, while routine dives ranged from 4 to 14.5 minutes (Lutcavage and Lutz, 1997). Leatherback turtles also appear to spend almost the entire portion of each dive traveling to and from maximum depth, suggesting that maximum exploitation of the water column is of paramount importance to the leatherback (Eckert et al., 1989).

Population Size and Regional Presence: Pritchard (1982) estimated a worldwide population of 115,000 female leatherbacks, of which 60 percent nested along Mexico's

Pacific coast. The most recent population size estimate for the North Atlantic ranges from 34,000 to 94,000 adult leatherbacks (Turtle Expert Working Group, 2007).

Preferred Habitat: Leatherback turtles lead a completely pelagic existence, foraging widely in tropical, subtropical, and temperate waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. In the Gulf of Guinea, a potential developmental habitat may have been identified in the waters of Sao Tome and Principe (NMFS and USFWS, 2007c).

Migratory Routes: Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas in the open ocean, along continental margins, and in archipelagic waters (Morreale et al., 1994; Eckert, 1998, 1999a). In a single year, a leatherback may swim more than 10,000 km (Eckert, 1998). It appears that young leatherback turtles (carapace length <100 cm) reside only in waters warmer than 26° C (Eckert, 1999b; Eckert, 2002). Satellite telemetry studies indicate that adult leatherback turtles follow bathymetric contours over their long pelagic migrations and typically feed on cnidarians (i.e., jellyfish, siphonophores) and tunicates (i.e., pyrosomes, salps), and their commensals, parasites, and prey (NMFS and USFWS, 2007c).

Important Oceanographic or Benthic Features and Critical Habitat (foraging, breeding, juvenile habitats): Researchers have suggested a linkage between leatherback turtle abundance and oceanographic features, specifically the hydrographic retention of zooplankton and subsequent concentration of scyphomedusan prey in coastal areas during relaxation of upwelling-favorable winds (Benson et al., 2003).

Presence of Critical Habitat and Important Oceanographic or Benthic Features

Offshore Ghana: Ghana offshore and nearshore waters are within the cosmopolitan distribution of leatherback turtles. No nesting beaches for hawksbill turtles were identified in Ghana. It is not known if critical habitat or important oceanographic or benthic features exist offshore Ghana. The importance of the Gulf of Guinea, in general, to sea turtle species, is discussed by Formia et al. (2003, 2007) and Fretey (2001).

E.2.4 Loggerhead Turtle (*Caretta caretta*)

Life History: Age to maturity for loggerhead turtles ranges between 30 and 35 years.

Distribution: Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics (NMFS and USFWS, 2007e). In the eastern Atlantic, the Cape Verde Islands support the only known loggerhead nesting assemblage in the region; it is of intermediate size (Fretey, 2001).

Biology and Behaviour: During the first several years of life, loggerheads forage in open ocean pelagic habitats. Both juvenile and subadult loggerheads feed on pelagic crustaceans, mollusks, fish, and algae. Studies of loggerhead diving behavior indicate varying mean depths and surface intervals, depending on whether they were located in shallow coastal areas (short surface intervals) or in deeper, offshore areas (longer surface intervals). The maximum recorded dive depth for a post-nesting female was 211 to 233 m, while mean dive depths for both a post-nesting female and a subadult

were 9 to 22 m. Routine dive times for a post-nesting female were between 15 and 30 minutes, and ranged between 19 and 30 minutes for a subadult (Sakamoto et al., 1990 in Lutcavage and Lutz, 1997).

Population Size and Regional Presence: The latest population estimates for loggerhead turtles is 44,560 nesting females.

Preferred Habitat: Loggerheads prefer to feed in coastal bays and estuaries, as well as in the shallow water along the continental shelves of the Atlantic, Pacific, and Indian Oceans. Preferred habitat of *Caretta caretta* changes throughout the life cycle. Adult females go ashore to lay eggs, preferring steeply sloped, high energy beaches. When hatchlings emerge from the nest, they head for the ocean. Young juveniles are typically found among drifting *Sargassum* mats in warm ocean currents. Older juveniles and adults are most often found in coastal waters and tend to prefer rock or mud substrate instead of sand seafloor. Loggerheads may also be found near coral reefs and within salt marshes, brackish lagoons, and river mouths.

Migratory Routes: Following their emergence from nests laid on sandy beaches, sea turtles begin a complex life history which takes them to differing habitats, moving between oceanic, neritic, and terrestrial habitats.

Important Oceanographic or Benthic Features and Critical Habitat (foraging, breeding, juvenile habitats): Older juveniles and adults are most often found in coastal waters and tend to prefer rock or mud substrate instead of sand seafloor. Loggerheads may also be found near coral reefs and within salt marshes, brackish lagoons, and river mouths. Adult females prefer steeply sloped, high energy beaches for egg laying.

Presence of Critical Habitat and Important Oceanographic or Benthic Features Offshore Ghana: In the absence of specific oceanographic or benthic features, or critical habitat of importance to loggerheads, there are no known critical habitats or important oceanographic or benthic features present offshore Ghana. The importance of the Gulf of Guinea, in general, to sea turtle species, is discussed by Formia et al. (2003, 2007) and Fretey (2001).

E.2.5 Olive Ridley Turtle (*Lepidochelys olivacea*)

Life History: Age to maturity for olive ridley turtles ranges between 10 and 18 years, with a median age of sexual maturity of 13 years.

Distribution: Olive ridley turtles occur throughout the world, primarily in tropical and sub-tropical waters. The species is divided into three main populations, with distributions in the Pacific Ocean, Indian Ocean, and Atlantic Ocean. They are not known to move between or among ocean basins. Like leatherback turtles, most olive ridley turtles lead a primarily pelagic existence (Plotkin et al., 1993). While olive ridleys generally have a tropical to subtropical range, individuals do occasionally venture north in cooler water. Surprisingly little is known of their oceanic distribution and critical foraging areas. They appear to occupy a series of foraging areas geographically distributed over a very broad range within their oceanic habitat (Plotkin et al., 1994). They are also known to move freely between oceanic environments (>200 m water depth) to neritic zones (<200 m water depth).

Biology and Behaviour: Olive ridleys feed on tunicates, salps, crustaceans, other invertebrates and small fish. Montenegro et al. (1986), as cited in NMFS and USFWS (1998), found a wide variety of prey in olive ridleys from the eastern Pacific. Adult males fed primarily on fishes (57%), salps (38%), crustaceans (2%) and molluscs (2%), while adult females fed primarily on salps (58%), and a lesser degree on fishes (13%), molluscs (11%), algae (6%), crustaceans (6%), bryozoans, sea squirts, sipunculid worms and fish eggs (all individually less than 1%).

Olive ridleys have been caught in trawls at depths of 80 to 110 m (NMFS and USFWS, 1998), and a post-nesting female reportedly dove to a maximum depth of 290 m. The average dive length for an adult female and adult male is reported to be 54.3 and 28.5 minutes, respectively (Plotkin et al., 1994; Lutcavage and Lutz, 1997). Several of the most common prey of olive ridley turtles (salps, pyrosomes) occur sub-surface and migrate within the water column as part of the deep scattering layer. As a result, olive ridley turtles tend to dive deeper, spending 20% of the time at the surface and 40% of their time at depths greater than 40 m. On 25% of the recorded dive days, olive ridley turtles dove to depths greater than 150 m at least once. Daily dives of 200 m have been observed, and one dive was recorded at 254 m. The dive habitat of the tagged olive ridley turtles had a deep thermocline at 100 m and minimal horizontal surface temperature fronts (Polovina et al., 2003).

Population Size and Regional Presence: Olive ridleys are common throughout the eastern Atlantic. Highest densities have been recorded in the Gulf of Guinea between Côte d'Ivoire and Gabon. Nesting beaches in the eastern Atlantic Ocean have been noted for The Gambia, Guinea-Bissau, Sierra Leone, Côte d'Ivoire, Ghana, Togo, Benin, Boiko, Sao Tome, Corisco, Mbanye, Hoco Islands, Cameroon, Equatorial Guinea, Gabon, Congo, Angola, and Liberia. NMFS and USFWS (2007d) report widespread, low density olive ridley nesting along many west African beaches from Gambia south to Angola.

Preferred Habitat: Olive ridley turtles occur throughout the world, primarily in tropical and sub-tropical waters. They are found in both oceanic (>200 m water depth) and neritic environments (<200 m water depth).

Migratory Routes: Satellite monitoring of post nesting movements of olive ridley turtles showed migration routes traversing thousands of kilometers over deep (>1,000 m) oceanic water, distributed over a very broad range, suggesting that olive ridleys are nomadic and exploit multiple feeding areas, rather than migrate to one specific foraging area (NMFS and USFWS, 1998).

Important Oceanographic or Benthic Features and Critical Habitat (foraging, breeding, juvenile habitats): There are no indications that olive ridleys prefer specific oceanographic or benthic features. No critical habitat has been identified for this species.

Presence of Critical Habitat and Important Oceanographic or Benthic Features Offshore Ghana: In the absence of specific oceanographic or benthic features, or critical habitat of importance to olive ridleys, there are no known critical habitats or important oceanographic or benthic features present offshore Ghana. The importance of the Gulf of Guinea, in general, to sea turtle species, is discussed by Formia et al. (2003, 2007) and Fretey (2001)

E.2.6 Sea Turtles – Critical Habitat Summary

About 70% of Ghana's coastline is suitable for turtle nesting, and 80 km of the coast is densely nested (Carr and Campbell, 1995). Nesting beaches along the coast of Ghana would constitute critical habitat according to IFC Performance Standard 6, because these are habitats required for the survival of critically endangered or endangered species and are sites that are critical for the survival of migratory species. The critical habitat designation would apply for three sea turtle species known to currently nest on Ghana beaches (green, leatherback, and olive ridley turtles) (**Table E.3**). These species also nest widely in the Gulf of Guinea region and circumglobally.

Table E.3. Critical habitat summary for sea turtles potentially present in Ghana.

Species	Presence in Ghana Waters	Critical Habitat
Green turtle	<i>Likely</i>	Known to nest on Ghana beaches, which would constitute critical habitat
Hawksbill turtle	<i>Possible</i> (within the range of this species)	There are historical reports of nesting in Ghana, but not recently
Leatherback turtle	<i>Likely</i>	Known to nest on Ghana beaches, which would constitute critical habitat
Loggerhead turtle	<i>Possible</i> (within the range of this species)	There are historical reports of nesting in Ghana, but not recently
Olive ridley turtle	<i>Likely</i> (the most abundant turtle in Ghana waters)	Known to nest on Ghana beaches, which would constitute critical habitat

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