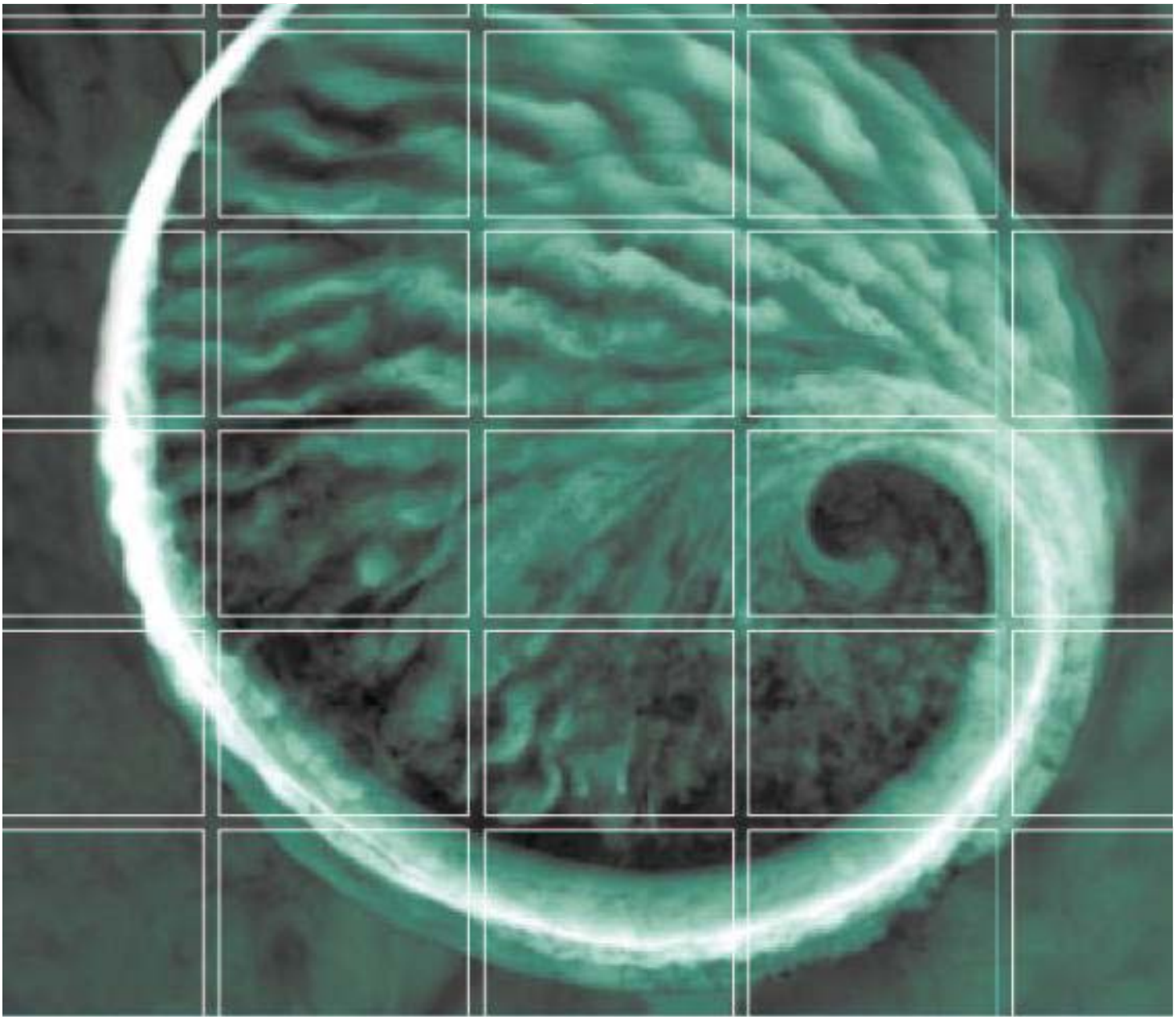

Supplemental Environmental Impact Assessment – Kizomba Satellites Project

Esso Exploration Angola Limited
Angola Block 15 Development

February 18, 2009

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List of Acronyms and Abbreviations

AB	Angola Block
ACGIH	American Conference on Governmental Hygienists
AnLNG	Angola LNG
API	American Petroleum Institute
AQG	Air Quality Guidelines
bbl	Barrel, equivalent to 42 U.S. gallons or approximately 163 liters
BC	Benguela Current
BOP	Blow out preventer
BWS	Block-wide Study
CALM	Catenary Anchor Leg Mooring
CH_4	Methane
cm	Centimeter
CO	Carbon monoxide
CO_2	Carbon dioxide
DDCV	Deep Draft Caisson Vessel
EEAL	Esso Exploration Angola (Block 15) Ltd
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EUR	Estimated ultimate recovery
FPSO	Floating, Production, Storage and Offloading
GI	Gas injection
HP	High pressure
hr	Hour
HYDROSAN	Hydrographic Office of the South African Navy
IIM	Marine Fisheries Institute
IMO	International Maritime Organization
Kbpd or Kbd	1000s of barrels per day
kg	Kilogram
L	Liter
LNG	Liquefied Natural Gas
m	Meter
m^2	Square meter
m^3	Cubic meter
mm	millimeter

MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, Consolidated Edition 1997
MB	Million barrels
MBO	Million barrels of oil
MD	Measured depth
MDBML	Measured depth below mud line
MinPet	Angola Ministry of Petroleum
mg	Milligrams
MMS	Minerals Management Service
MODU	Mobile Offshore Drilling Unit
MPFM	Multiphase flow meter
Mscf	Million standard cubic feet
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
MW	MegaWatt
NAF	Non-aqueous fluid
NAVAREA	Navigation Area
NIOSH	National Institute for Occupational Safety and Health
NMVOC	Non-methane volatile organic compounds
NO_2	Nitrogen dioxides
NOx	Nitrogen oxides
NW	Northwest
OCD	Offshore coastal dispersion
ODMP	Operational Discharge Management Plan
OOC	Offshore Operators Committee
OSCP	Oil Spill Contingency Plan
OSHA	Occupational Safety and Health Administration
OSRP	Oil Spill Response Plan
PIP	Pipe-in-pipe
PIT	Pressure integrity test
PM	Particulate matter
POP	Persistent Organic Pollutants
ppg	Pounds per US gallon
ppm	Parts per million
ROC	Retention on cuttings
ROV	Remotely operated vehicle
SE	Southeast
SEC	South Equatorial Current

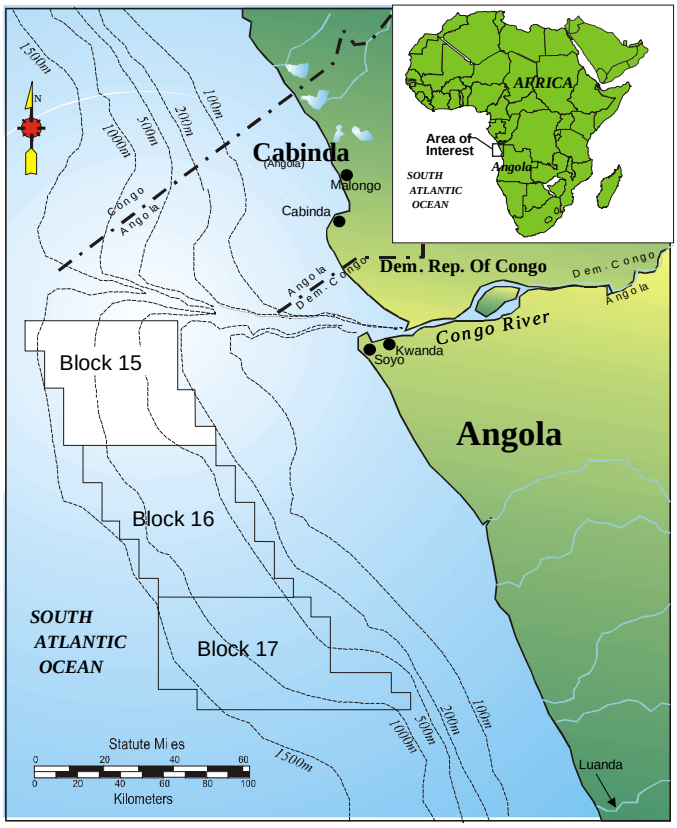
SHR	Single hybrid riser
SO_2	Sulfur dioxide
SS	Stainless Steel
SURF	Subsea umbilicals, risers and flowlines
SW	Southwest
SWHP	Surface wellhead platform
TLP	Tension leg platform
TUTA	Topside umbilical termination assembly
TVD	True vertical depth
ug	Microgram
UKHO	United Kingdom Hydrographic Office
UN	United Nations
US	United States
USCG	United States Coast Guard
w/w	Wet weight
WBM	Water-based mud
WHO	World Health Organization
WI	Water injection
WOF	Workover fluid

1.0 INTRODUCTION

1.1 BACKGROUND

The Environmental Impact Assessment (EIA) prepared by Esso Exploration Angola (Block 15) Limited (EEAL) for development in Angola Block 15 was approved by the Angolan Ministry of Petroleum (MinPet) on November 15, 2001. This EIA (hereafter referred to as the "Block 15 EIA") describes the baseline environment, the potential impacts to the environment of developments within Block 15, potential socioeconomic impacts, regulations, and EEAL's environmental management plan (EMP) for Block 15 development activities. The location of Block 15 relative to the Angolan Coast is shown in Figure 1-1.

FIGURE 1-1: Block 15 Location



The Block 15 EIA describes plans for installation and operation of the Kizomba A, Kizomba B and Xikomba oilfield developments. Additional developments were considered in the Block 15 EIA, in order to estimate the total cumulative impact on the environment of further developments in Block 15. These were intended to be representative in scale and detail of likely future developments, and were referred to as 'Kizomba C' and 'Project Y'.

Since approval of the Block 15 EIA, EEAL has submitted and MinPet has approved supplements to the Block 15 Development EIA for two further projects.

The first of these projects is a small subsea tieback to Kizomba A to develop the Marimba North reservoir. The second project involved the conversion of two vessels to floating production, storage and offloading vessels (FPSOs), and installation of additional wells to develop three more reservoirs, and is called Kizomba C.

EEAL is now planning to implement a further phase of Block 15 development activities, referred to as the Kizomba Satellites Project (hereafter, "Kizomba Satellites"), to bring remaining undeveloped Block 15 Development Areas on stream. This Supplemental EIA provides a complete project description and discussion of potential impacts for construction and operation of the Clochas and Mavacola Development Areas. A further EIA Supplement will be prepared and submitted as required for other possible Satellite Development Areas, which may include Mbulumbumba, Vicango, Reco-Reco, Kakocha, Tchihumba and Bavuca.

For components of the Kizomba Satellites development which do not differ from the Block 15 EIA assumptions, the associated potential environmental and socioeconomic impacts have already been addressed in the Block 15 EIA. This Supplemental EIA therefore focuses on discussion of potential impacts from the significant features of the current Kizomba Satellites design that are expected to differ from the impacts already addressed in the Block 15 EIA. As in the case of the Block 15 EIA, the scope of the assessment includes offshore development activities, as well as onshore activities supporting the construction and operation of Kizomba Satellites. In addition, this Supplemental EIA provides information on Angolan regulations that have come into effect since the Block 15 EIA was issued in 2001.

The Block 15 EIA includes a comprehensive characterization of the baseline environment for Block 15.[1] The Kizomba Satellites project involves drilling wells and laying seabed flowlines entirely within Block 15. Accordingly, the baseline characterization included in the Block 15 EIA is applicable to and sufficient for the purpose of this Supplemental EIA.

The Supplemental EIA for the Kizomba Satellites Project was conducted jointly by Environmental Resources Management (ERM) and Sociedade Angolana de Projectos, Lda (SOAPRO). SOAPRO has submitted an application to the Ministry of Environment for a Certificate of Registration as an Angolan Environmental Consultant.

This document was prepared in English and translated into Continental Portuguese. In case of ambiguity, the English edition more precisely details the authors' original intent.

[1] Environmental Impact Assessment Development Activities for Angola Block 15 Chapter 6.

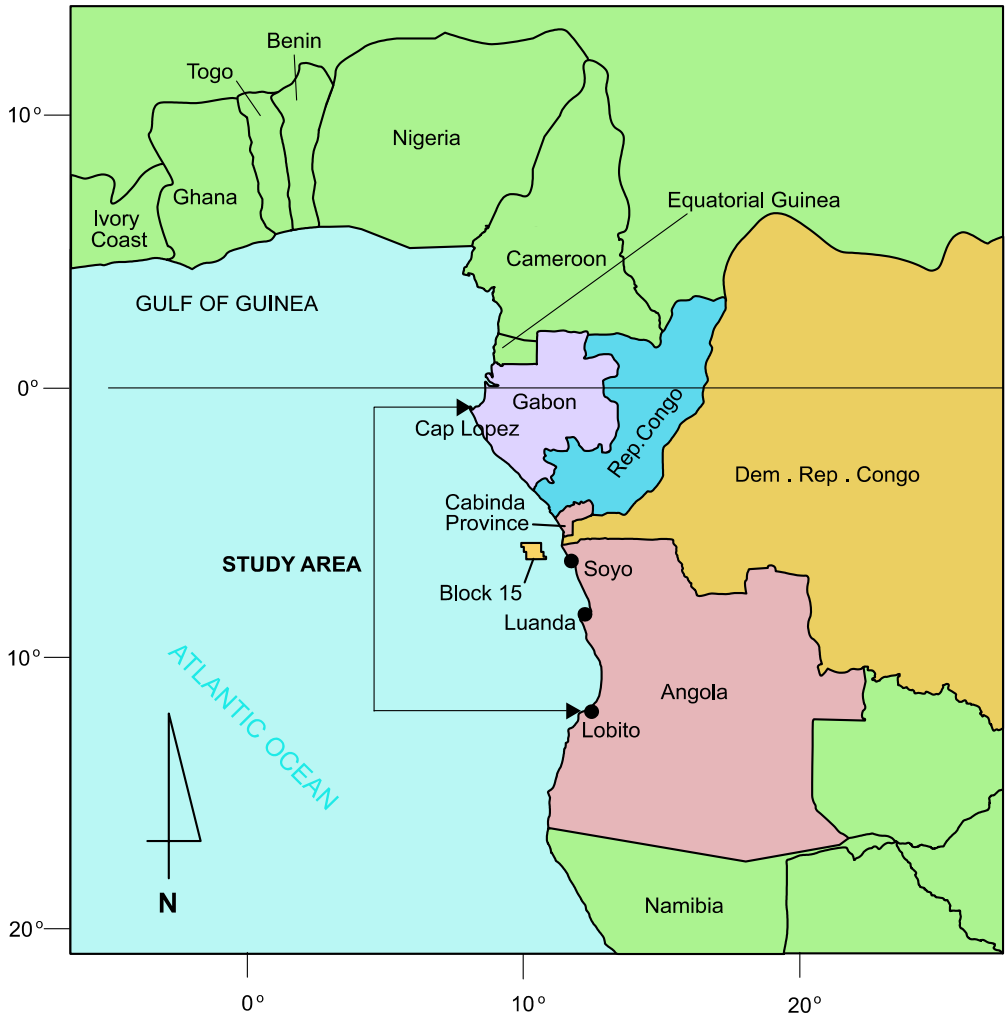
1.2 OVERVIEW OF BLOCK 15 EIA

This section includes a summary overview of the information presented in the Block 15 EIA.

1.2.1 Environmental Baseline

Block 15 occupies approximately 4,277 km² of ocean, and is situated approximately 145 km west of Soyo near the mouth of the Congo River. Water depths in the block range from 250 m to 1,700 m. The broad Study Area for the environmental baseline covered in the Block 15 EIA is shown in Figure 1-2.

FIGURE 1-2: Block 15 EIA Study Area



The study area extends from Lobito, Angola in the south to Cap Lopez, Gabon, in the north and seawards to the limit of the Exclusive Economic Zone (EEZ). The baseline environmental description in the Block 15 EIA runs to 89 pages, includes 33 figures, and references both outside and in-house studies carried out

to provide the information. The description details the physical environment of the study area, offshore and nearshore habitats and communities, the commercial environment in regard to fishing and shipping activities, provides baseline sediment chemistry, and identifies and characterizes primary components of the ecosystem. A general description follows.

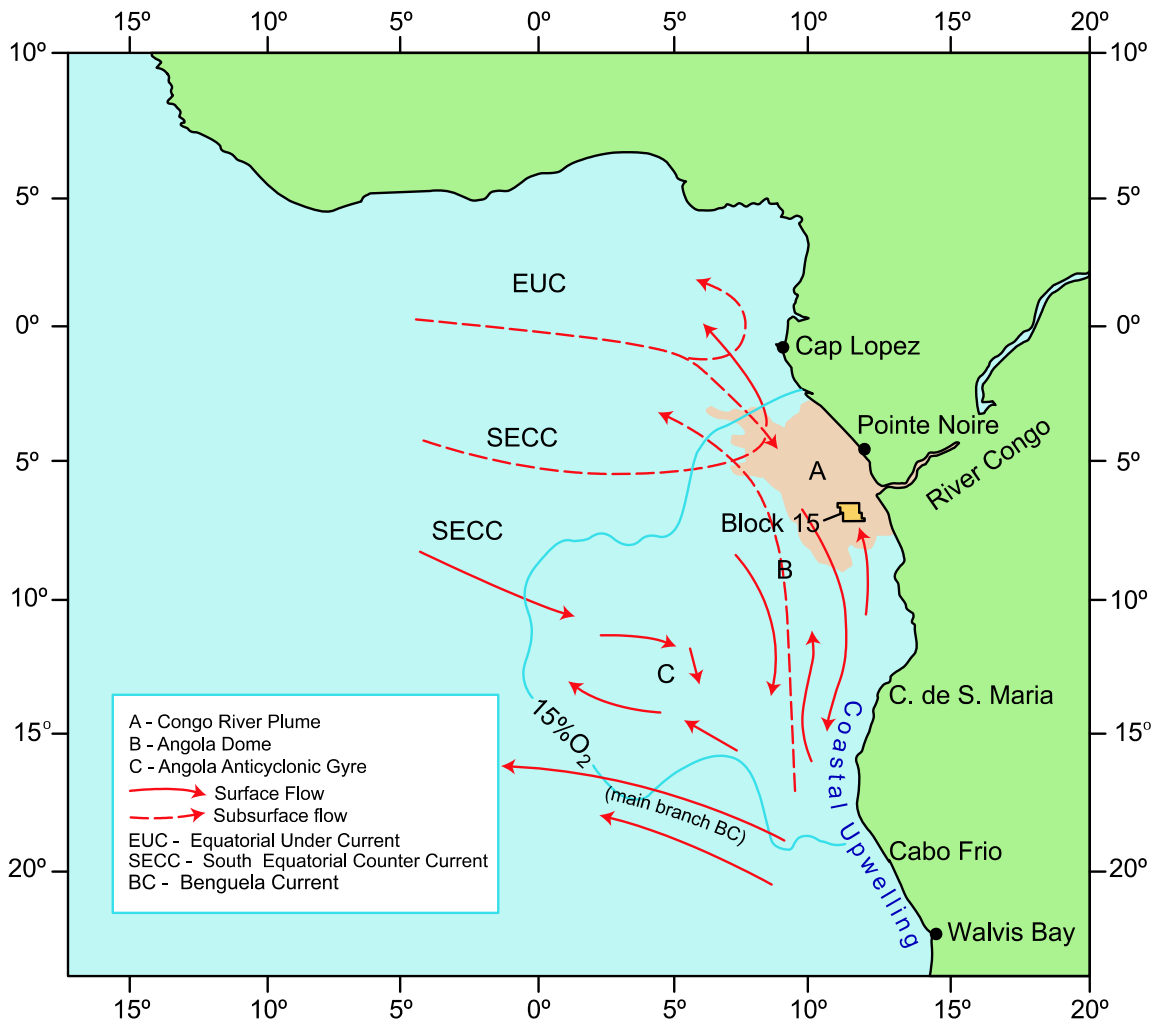
The coast from Angola to Gabon is impacted by swells generated in the South Atlantic. The notable aspect of the swells in the region is not their height but rather their long period. Tides on the western coast of Africa are semi-diurnal and comparatively small, mean tidal ranges being 1 - 1.2 m with spring tide attaining 1.6 m on the open coast. The Study Area is situated at the confluences of the South Equatorial Current (SEC), the diverging Benguela Current from the coast and the Angola current. The area is further complicated by the effect of the Congo River outflow and its associated upwellings (Figure 1.3).

Apart from the major feature of the Congo River canyon, the sea bottom slopes gently out of the shelf break at 100 m depth approximately 50 km offshore, and down to 5,000 m in the Angola basin at a distance of some 2,000 km offshore. On the shelf the isobaths are generally parallel to the coast trending NW-SE, this paralleling is disrupted by the Congo canyon. Seabed sediment samples taken as part of the Environmental Baseline Survey in Block 15 reveal predominantly soft, silty sediments. The region is strongly influenced by low salinity water from the Congo River.

A baseline environmental survey of Block 15 characterized the benthic community across the Survey Area as generally relatively sparse and patchy at water depths of over 400m. The fishing industry in Angola is an important sector in terms of generating revenue, with small pelagic fish and the Cunene horse mackerel constituting approximately 80% of the commercial catch from Angolan waters. Important large pelagic fish (tuna) are also fished in the Study Area, but are highly migratory and seldom resident in any area for long periods. Demersal fish are widespread shallower than the 200 m isobath along the entire Angola coast, but bottom fishing generally does not extend to the deepwater parts of Block 15.

In general, there are few quantitative data about seabirds for the area, but pelagic and offshore species appear to be sparse in waters off Northern Angola and Cabinda. Large pelagic and offshore species from the southern oceans do not appear to occur further north than the Southern coast of Angola. Smaller offshore species have been recorded off the Cabinda and Congo coasts. Offshore species from northern oceans probably reach their southern limits at about the mouth of the Congo River.

FIGURE 1-3: Schematic of surface and subsurface flows in the SE Atlantic Ocean (after van Bennekom & Berger, 1984).



A number of species of cetaceans are expected to occur in the Study Area, including humpback whales traveling through the area on their way to their breeding grounds off Gabon. However, there are few data on the present abundance and species richness of cetaceans off the northern Angola and Cabinda coast, and there are very few data for Congo. Marine turtles are also expected to occur in the Study Area.

There are limited data available regarding near-shore habitats and communities. Extensive mangrove communities occur on tidal mud flats at the mouth of the Congo River. Two conservation areas have been established in Angola, including the Kissama National Park on the coast in Bengo Province, and the Parc National des Mangroves has been established in the Democratic Republic of the Congo. Further to the north, there are two conservation areas bordering the coast of Gabon.

1.2.2 Block 15 Development Project Description

1.2.2.1 Initial Development Overview

The initial Block 15 development project targeted four primary reservoirs: Chocalho/Hungo, Dikanza, Kissanje and Xikomba. Collectively, these reservoirs have estimated reserves of 5 billion barrels of oil, of which approximately 2 billion barrels are expected to be recoverable. Based on the water depth in the project area, these reservoirs have been developed with FPSOs. Produced oil is stored offshore and transported to shore via tankers. Associated gas is reinjected into the reservoirs, until the offshore gas gathering system is developed. The three initial projects, referred to as Kizomba A, Kizomba B, and Xikomba, are summarized as follows.

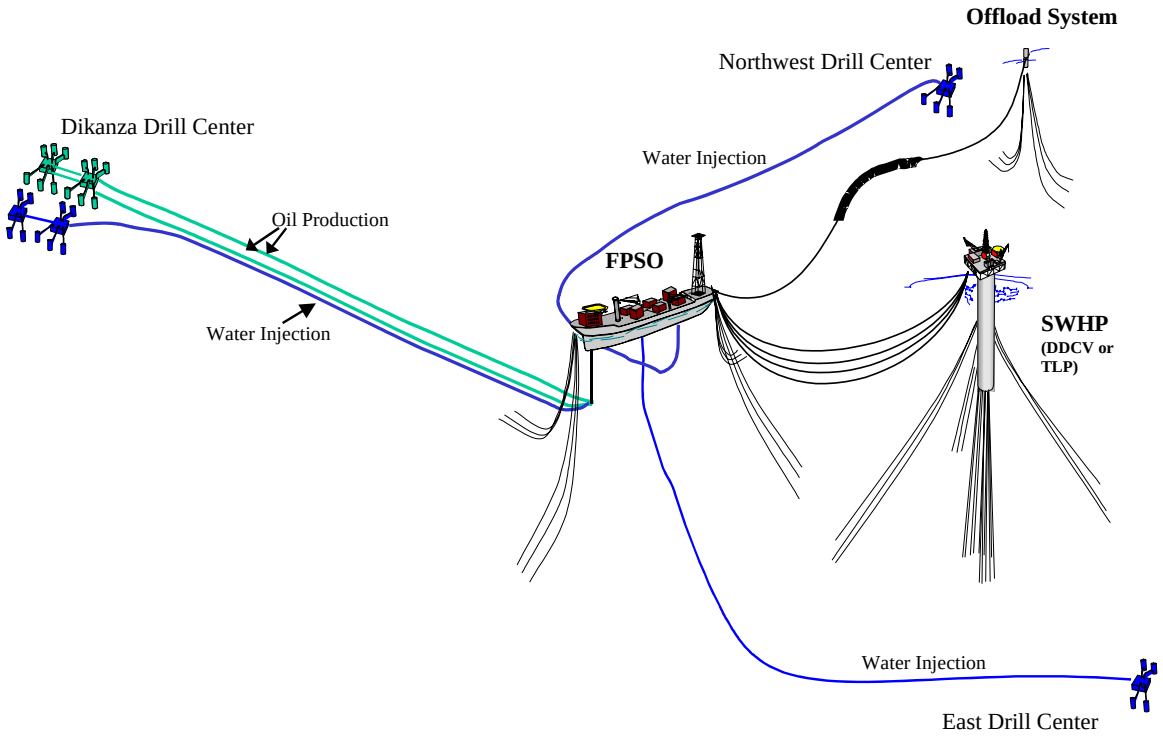
Kizomba A is associated with the Chocalho/Hungo reservoir. Production was brought on line in 2004, and the field is expected to continue in production for about 25 years. Kizomba A includes 59 production or injection wells, and production from the Kizomba A reservoirs flows to a Floating Production, Storage, and Offloading Vessel (FPSO). Due to the large number of wells and the size and spacing of the individual Kizomba A reservoirs, 33 wells are dry trees located on the Kizomba A TLP and the remaining 26 are subsea wells distributed between 4 satellite drill centers, with production flowing back to the Kizomba A FPSO through seabed flowlines.

Kizomba B is associated with the Kissanje and Dikanza reservoirs. Production was brought on line in 2005, and the field is expected to continue in production for about 25 years. Kizomba B includes 58 production or injection wells, and production from the Kizomba B reservoirs flows to a separate FPSO. As is the case for Kizomba A, 34 wells are dry trees located on the Kizomba B TLP and the remaining 24 are subsea wells distributed between 3 satellite drill centers, with production flowing back to the Kizomba B FPSO through seabed flowlines.

Xikomba is associated with the Xikomba reservoir. Production was brought on line in 2003 and is expected to continue for 6 to 8 years. The Xikomba development is comprised of 9 subsea production or injection wells, and production from the Xikomba reservoir flows to a separate FPSO.

A conceptual view of the Kizomba B Development is shown at Figure 1.4. This shows more distant reservoirs developed by subsea wells drilled at satellite drill centers, and highlights the similarities between the existing Kizomba A and B developments and the development method required for future satellite fields.

FIGURE 1-4: Conceptual View of Kizomba B Development.



1.2.2.2 *Development of the Marimba, Mondo, Saxi and Batuque reservoirs.*

Since the start of production operations in Block 15 from Xikomba and Kizomba A and B, Marimba North has been brought on stream as a small subsea satellite development flowing back to Kizomba A, and the Mondo and Saxi-Batuque reservoirs (collectively called the Kizomba C project) have been developed in a similar manner to Xikomba, with subsea satellite wells flowing back to two FPSOs. As the development methods and the basic impact on the environment were identical to those considered in the Block 15 Development EIA, supplements to the Block 15 Development EIA were prepared and approved for these later projects. The EIA Supplements include detailed descriptions of the two projects and their impact on the environment.

1.2.3 Impact Assessment

Based on the impact assessment completed for the Block 15 Development EIA for the proposed project activities in Block 15, the following were identified as the key aspects with potential to result in significant impacts to the environment:

- Discharge of drill cuttings;
- Emissions to air;

- Discharge of produced water; and
- Accidental hydrocarbon spills.

Summaries of the impact assessment conclusions for these aspects are presented below. More detailed discussion is provided in Section 6 of this Supplement.

1.2.3.1 Drill Cuttings

Drill cuttings discharged into the sea were concluded to have minimal long-term effects on marine life. Discharge models predict the maximum thickness of accumulated cuttings on the seabed occurs as expected immediately adjacent to the two TLPs, does not exceed about 320 cm, and reduces rapidly with distance from the drilling platforms. Thickness of drill cuttings at a distance greater than 250 m from the TLPs is expected to be less than 1 cm. Maximum thickness of drill cuttings at the satellite drill centers is significantly lower, due to the smaller number of subsea wells drilled at each location. Typically, maximum thickness of accumulated cuttings at a five well satellite drill center is estimated to be 35 cm, and thickness of cuttings at a distance greater than 145 m is expected to be less than 1 cm.

Measures adopted to minimize the impact of drilling on the environment included recycling of drilling fluids, use of water-based and low toxicity NAF based muds and monitoring of the seabed before, during, and after drilling operations. The localized immediate smothering effect of benthic organisms by the accumulated cuttings typically affects only those areas where the cuttings thickness is greater than 1 cm. The total area of the seabed affected by the discharge of mud and cuttings from development drilling activities was estimated to be less than 0.06% of the total area of Block 15.

1.2.3.2 Air Emissions

The main sources of air emissions associated with the Block 15 development are from marine vessels supporting the construction and development operations, gas turbines for compression and power generation for drilling and production, and flaring during well clean-up and production upsets.

Emissions from the Block 15 projects were modeled for the Block 15 Development EIA. The modeling was rerun for the EIA Supplement for the Kizomba C development. In both instances, results from the modeling indicate that concentrations of key emissions vary significantly on a daily basis throughout the year due to changes in atmospheric conditions. Even on peak days the concentrations of emissions offshore at the drilling and production facilities in Block 15 do not exceed normally accepted industry standards. The concentrations of emissions that reach shore are lower than the levels determined by the World Health Organization (WHO) as acceptable standards for long-term exposure of the general population.

1.2.3.3 *Produced Water*

During normal operations, produced water from the Kizomba A and B developments is reinjected into the reservoirs for pressure maintenance. However, during process upsets, produced water will be cleaned to 40ppm and discharged overboard. Produced water at Xikomba is cleaned to 40ppm and discharged overboard during normal operations because it cannot be reinjected due to the nature of the reservoir. Produced water discharge modeling was conducted, and results showed that oil concentrations in the receiving water would not be expected to result in significant impacts to marine organisms, due to the rapid dilution into the receiving water body. Monitoring is conducted to ensure that oil content in discharged produced water is below required limits.

1.2.3.4 *Hydrocarbon Spills*

The EIA addresses the accidental spillage of hydrocarbons during operations or tanker loading, and the extremely low risk of a major oil spill either from a well blowout or as the result of major damage to an FPSO from collision. Such events are extremely rare. Based on US data, 98.3% of reported oil spills reported in 1999 were smaller than 1 bbl, and 99.7% of spills were less than 10 bbl. Studies indicate that collision between a passing merchant vessel and an FPSO resulting in a spillage of more than 100,000 bbl might occur in marine areas more heavily trafficked areas than offshore Angola once in 8,333 years.[2] Therefore, the oil spill modeling for the Block 15 Development EIA assumed a worst case instantaneous oil spill of 250,000 bbl. Results of this modeling indicate that, if such a major spill were to occur, clean-up would be expected to be completed at sea, with only a low probability that oil would reach shore if no response efforts are undertaken. Proposed mitigation measures include implementation of an oil spill contingency plan (OSCP), establishing marine restricted areas around the FPSOs in Block 15, and noting the facilities and restricted areas on Admiralty charts.

1.2.4 Socioeconomic Impacts

The Block 15 EIA included an assessment of the socioeconomic impacts (positive and negative) of the Block 15 development. The Block 15 EIA concluded that the developments would provide expected benefits as a result of additional direct and indirect jobs and income to local employees, as well as economic growth in other sectors of the economy, stimulated by demand for goods and services of local people with increased disposable income.

The Block 15 EIA discusses EEAL's policy to recruit and train Angolan nationals for jobs at all levels in the organization, with the intent of increasing the local content for project activities. This includes a plan to provide training to provide the required industry experience and technical qualifications.

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[2] DNV 2000, quoted in US MMS Draft Environmental Impact Statement on the proposed use of Floating Production Systems on the Gulf of Mexico OCS, August 2000.

1.2.5 Environmental Management System

The Block 15 EIA described the Environmental Management System (EMS) for Block 15, including: discharge limits developed as part of the EIA, the Spill Prevention Plan, the Spill Response Plan, the Waste Management Disposal and Deposit Plan, and the Operational Discharge Management Plan (ODMP). Emissions and wastes are monitored and reported in accordance with regulatory requirements. Changes to systems and operating procedures are made to ensure continued compliance with environmental measures.

1.3 SCOPING FOR KIZOMBA SATELLITES SUPPLEMENTAL EIA

As discussed above and further in this Supplemental EIA, the Kizomba Satellites project will involve similar activities to those already assessed in the Block 15 EIA. Development of the Clochas and Mavacola reservoirs will involve drilling of wells and installation of subsea flowlines using the same general techniques assessed in the Block 15 EIA. Production from the satellite fields will flow directly to the existing Kizomba A and B FPSOs.

There are no other "associated projects" connected to the development activities for the Kizomba Satellites project. The Kizomba Satellites project will utilize onshore facilities in Angola for local fabrication and to support construction

In summary, the Kizomba Satellites project activities will be similar in nature to the initial Block 15 activities. The offshore installation, drilling and well workover activities will be smaller in extent and generally shorter in duration. Production will be routed to and processed on existing offshore facilities. Some modifications will be required to these facilities, but the peak daily production processed on the Kizomba A and B FPSOs will not exceed the peak daily production processed earlier in the lives of the Kizomba A and B oilfields.

The Environmental Baseline developed for the Block 15 Development EIA remains unchanged, as does the assessment of environmental effects for the individual activities associated with the Kizomba Satellites development. Accordingly, the scope of this Supplemental EIA is modeled after the scope addressed in the approved Block 15 EIA. A project description is provided, and the environmental effects of the project activities and the cumulative effect of these activities on the whole of Block 15 is reviewed and studied. Reference is made to the Block 15 Development EIA and to the Marimba and Kizomba C Supplements, as required.

2.0 KIZOMBA SATELLITES EXECUTIVE SUMMARY

Introduction

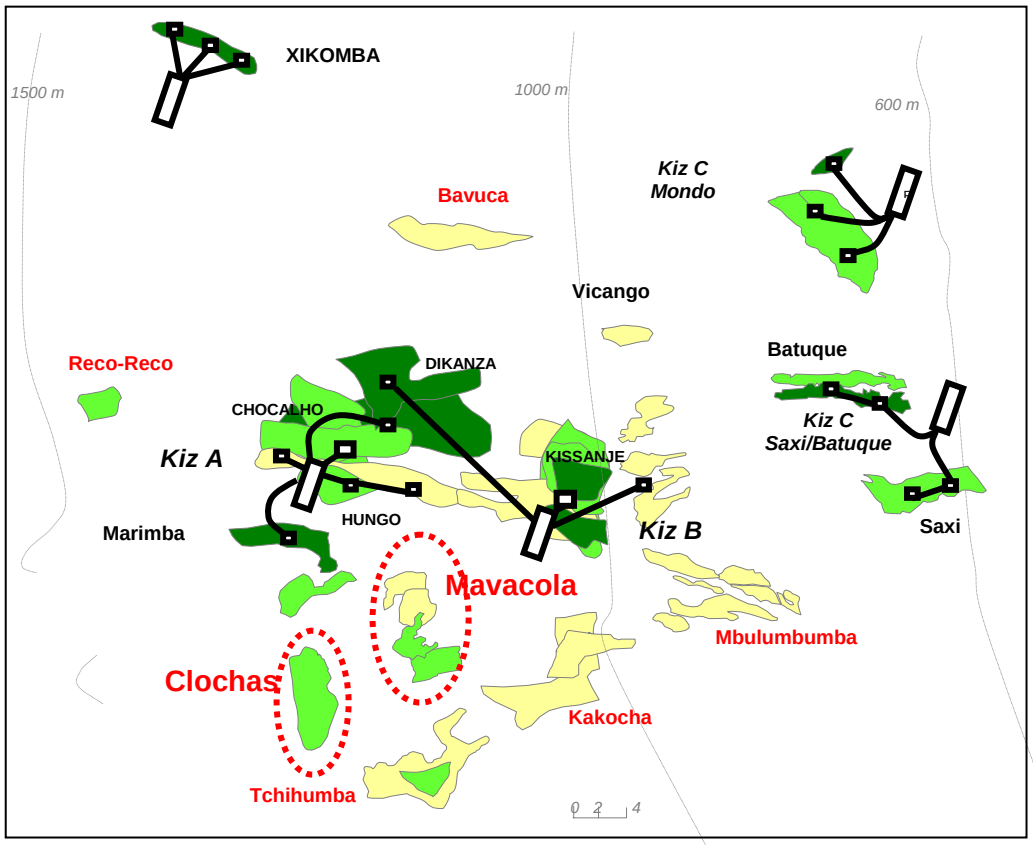
The Environmental Impact Assessment (EIA) prepared by Esso Exploration Angola (Block 15) Limited (EEAL) for development in Angola Block 15 was approved by the Angolan Ministry of Petroleum (MinPet) on November 15, 2001. The EIA (referred to as the "Block 15 EIA") describes plans for installation and operation of the Kizomba A, Kizomba B and Xikomba oilfield developments. Additional developments were considered in the Block 15 EIA, in order to estimate the total cumulative impact on the environment of further developments in Block 15. These were intended to be representative in scale and detail of likely future developments, and were referred to as 'Kizomba C' and 'Project Y'.

Since approval of the Block 15 EIA, EEAL has submitted and MinPet has approved supplements to the Block 15 Development EIA for two further projects. The first of these projects is a small subsea tieback to Kizomba A to develop the Marimba North reservoir. The second project involved the conversion of two vessels to floating production, storage and offloading vessels (FPSOs), and installation of additional wells to develop three more reservoirs, and is called Kizomba C.

The Kizomba Satellites Project (hereafter, "Kizomba Satellites") is intended to develop the remaining undeveloped Development Areas in Block 15. These include Mbulumbumba, Vicango, Mavacola, Reco-Reco, Clochas, Kakocha, Tchihumba, and Bavuca. The development of the Clochas and Mavacola assets comprises the initial scope of the Kizomba Satellites project, and is covered by this EIA Supplement.

The existing developments, the locations of the Kizomba A and Kizomba B FPSOs and the Clochas and Mavacola satellite reservoirs are indicated in Figure 2-1.

FIGURE 2-1: Existing Developments and Location of Proposed Kizomba Satellites Developments in Block 15



Clochas and Mavacola will be developed as subsea tiebacks to the Kizomba A and B FPSOs that are currently operating in the field, via a looped flowline system which will connect the two FPSOs. Water injection (WI) facilities will be provided by linking up to existing WI facilities on both FPSOs.

All processing will occur on the two FPSOs. Additional I-tubes will be installed and modifications made to their topsides as required to accommodate the tie-ins and increased infrastructure. Oil will be treated and stored for offloading to shuttle tankers. Produced water will be treated and either re-injected or disposed of overboard. Seawater will be treated and injected into the reservoirs for pressure maintenance depending upon specific field requirements. Produced gas will be treated for use as fuel gas, gas lift gas, and/or injection gas, and eventually will be exported to an onshore liquefied natural gas (LNG) facility via the Angola Gas Gathering pipeline system.

The Clochas and Mavacola developments will be designed and executed so that the remaining Development Areas (i.e., Mbulumbumba, Vicango, Reco-Reco, Kakocha, Tchihumba, and Bavuca) can be accommodated. The initial phase (Clochas and Mavacola) includes the installation of approximately 18 subsea

wells, with the possibility of an estimated additional 40 subsea wells to develop the other remaining assets in the future.

This EIA Supplement considers the present proposed Kizomba Satellites development relative to the project features assessed in the Block 15 EIA, and assesses the potential environmental impacts resulting from the initial phase of the Kizomba Satellites development. The activities associated with adding production from the satellites to the existing Kizomba A and Kizomba B facilities are similar to (and smaller in extent than) previous activities assessed for Block 15. Accordingly, as in the case of the Block 15 EIA, the following principal potential impacts are assessed for this Supplemental EIA:

- Air emissions from project construction and operations;
- Drilling-related discharges, including drill cuttings and drilling fluids;
- Operational discharges, including produced water and operations effluent streams; and
- Accidental hydrocarbon release from Project-related vessels or production infrastructure.

For each of these potential impacts, this Supplemental EIA discusses the method used to assess the impact, a conclusion regarding the potential impact, and mitigation measures to address the potential impact.

Air Emissions

The assessment of potential Kizomba Satellites effects on air quality focuses on onshore receptors, although predicted offshore air emission concentrations also are assessed. Because construction and operation of Kizomba Satellites will occur in conjunction with ongoing production activities from other established developments in Block 15, the potential air quality impacts associated with Kizomba Satellites were considered in combination with Kizomba A, Kizomba B, Marimba North, and Kizomba C.

In the Kizomba C Supplemental EIA, the Offshore and Coastal Dispersion (OCD) model was used to predict air quality impacts from combined activities for Kizomba A, Kizomba B, Marimba North and Kizomba C. Predicted maximum concentrations of nitrogen dioxides (NO_2), sulfur dioxide (SO_2), particulate matter (PM) and carbon monoxide (CO) were evaluated along the nearest shoreline, as well as in the waters surrounding the proposed project facilities. The predicted onshore concentrations were compared to the applicable World Health Organization (WHO) ambient air quality standards which have been developed to offer guidance in reducing the health impacts of air pollution to the population at large. Predicted offshore concentrations were also compared to standard worker exposure guidelines.[3]

[3] Environmental Impact Assessment Development Activities for Offshore Angola Block 15 - Supplement for Kizomba C Section 6.2.1

The modeling conducted for the Kizomba C Supplemental EIA predicted that all onshore concentrations would be below WHO guidelines, and that all offshore concentrations would be well below worker exposure guidelines. The modeling further showed that maximum concentrations offshore were estimated to occur infrequently, are limited to the immediate vicinity of emission sources within Block 15, and are associated with low-frequency meteorological conditions. Accordingly, it was concluded that air quality effects onshore and offshore represent a local, negligible impact.

For this Supplemental EIA, emission modeling for the Kizomba Satellites activities assessed the cumulative effects of emissions from Kizomba Satellite activities and from Kizomba A, Kizomba B, Marimba North, and Kizomba C. The emissions estimates indicate that the predicted maximum project emissions of the four modeled gases, NO_2, SO_2, PM and CO, occur prior to the start of activities on site associated with the Kizomba Satellites project, and that the emissions after the start of Kizomba satellite activities are lower than the estimated maxima.

Accordingly, the air quality impacts for Kizomba Satellites has already been effectively assessed in the Kizomba C Supplemental EIA, and the conclusions drawn therein are not changed.

Drilling Discharges

The potential impacts associated with drilling-related discharges include discharge of drill cuttings and drilling and completion fluids and the resulting effect on the seabed surrounding the drill centers. A total of 18 development wells are presently planned for the initial phase of the Kizomba Satellites development, with wells drilled from mobile offshore drilling units (MODUs) and concentrated at 4 drilling centers.

The primary potential impacts associated with drilling-related discharges include: physical smothering of benthic organisms covered by drilling solids; toxicity effects to benthic organisms due to the presence of hydrocarbons in the non-aqueous fluid (NAF) mud-based cuttings; and turbidity-related effects to species in the water column near the discharge points. For the Block 15 EIA, modeling was performed to assess these impacts, resulting in the following conclusions:

- Turbidity-related effects would be localized and short-term in nature, and would not be expected to result in long-term effects to aquatic organisms in the vicinity of the discharges; and
- Some degree of toxicity effects related to discharge of NAF-based mud cuttings would be expected based on deposition of hydrocarbon-affected drilling solids. However, the maximum anticipated hydrocarbon concentrations would decline rapidly.

Mud and cuttings discharge modeling based on a typical Block 15 development well has been carried out for small drill centers similar to those proposed for

Kizomba Satellites, and is fully described in Section 7.5.1 of the Block 15 Development EIA. The localized immediate smothering effect of benthic organisms by the accumulated cuttings typically affects only those areas where the cuttings thickness is greater than 1 cm. Discharge modeling predicts only very localized areas round each drill center where cuttings loading exceeds 0.1kg/m^2, which corresponds to a thickness of less than 0.08mm. The overall area of the seabed affected by the discharge of mud and cuttings is small, and recovery will begin after cessation of drilling activities at each drill center.

In addition, due to advances in cuttings cleaning technology since the Block 15 EIA, the anticipated hydrocarbon content in discharged NAF-based mud cuttings will be significantly lower than what was assumed in the Block 15 EIA. Thus, the anticipated toxicity effects would be reduced from that concluded in the Block 15 EIA, both in terms of magnitude and extent of effect. Therefore, there are no significant discharge related issues associated with drilling the Kizomba Satellite development wells

Production Discharges

An anticipated potential impact associated with operational discharges is from the discharge of produced water from the Kizomba A and Kizomba B FPSOs. Production from the Kizomba Satellites developments will flow back to the Kizomba A and B FPSOs, where it will be commingled with existing production from the Kizomba A and B oil fields and processed. Where the produced water is not reinjected into the Kizomba reservoirs for pressure maintenance due either to equipment downtime or for other operational or reservoir management reasons, it will be treated to reduce the average oil concentration below the discharge limit of 40 mg/l and then discharged into the sea.

For the Block 15 EIA, ExxonMobil Upstream Research Company modeled the fate of produced water discharged to the marine environment.[4] Based on a continuous discharge rate of 37,000 m^3/day, which was the maximum expected from a single source in Block 15, the model predicted produced water concentrations of less than 1% at 1,000m from the outfall. Under a continuous discharge scenario, the longest time an organism drifting into the effluent plume would be expected to be exposed to produced water concentrations in excess of 1% is between 1 and 8.5 hours, and the extent of concentrations in excess of 1% would be limited to between 100m and 1,000m from the discharge point.

The maximum expected discharge rates will increase due to the additional volume related to handling the Kizomba Satellites production on Kizomba A and Kizomba B FPSOs during the declining years of the Kizomba reservoirs. The maximum expected discharge rate for Kizomba A, including Kizomba Satellites production, is now 52,900 m^3/day and is expected to occur in year 2017. For

[4] Environmental Impact Assessment Development Activities for Angola Block 15 Section 7.5.3

Kizomba B, the maximum expected discharge rate is 36,200 m^3/day and is expected to occur in year 2020.

The predicted Kizomba A FPSO discharge rate associated with Kizomba Satellites is approximately 143% of that modeled for Kizomba A. However, due to mixing and the anticipated exponential decline in the concentration of oil and grease in the discharged produced water, the extent of the plume with produced water concentrations in excess of 1% and the associated organism contact times, are not predicted to significantly increase relative to what was predicted for Kizomba A. In the case of the Kizomba B FPSO, the predicted discharge rate is less than that modeled for Kizomba A. Accordingly, the extent of the plume with produced water concentrations in excess of 1%, and the associated organism contact times, would be predicted to decrease relative to what was predicted for Kizomba A.

Accidental Hydrocarbon Release

The Block 15 EIA considered the probability and likely environmental consequences of both small and large oil spills.[5] The probability of a large oil spill occurring with potential to significantly impact the environment is extremely low, but was modelled to assess potential transport of spilled hydrocarbons and the likelihood of oil reaching shore. The model runs assumed a 'worst case' oil release volume of 250,000 bbl, with no spill response. If a spill of this magnitude were to occur, results indicated between a 1% and 10% probability that oil would reach the shoreline. Predicted travel time from the spill site to the shore was between 14 and 20 days.

Based on a comparison of design features assumed in the Block 15 EIA to planned design features, the discussion in the Block 15 EIA remains applicable for the purpose of this Supplemental EIA. The probability of a release of the modelled magnitude from any given FPSO is extremely low and results in an insignificant change in overall oil release probability for Block 15.

[5] Environmental Impact Assessment Development Activities for Angola Block 15 Section 7.5.4

Socioeconomic Impacts

Potential socioeconomic impacts from Kizomba Satellites are expected to be net positive, and include increased revenue to the State, improved local employment opportunities to support the construction and operation of Kizomba Satellites, and a positive contribution to the local economy from the additional income generated.

The footprint of the Kizomba Satellites Project overlaps with marine activity of deepwater fishermen in offshore waters as well as waters in the approach to and next to onshore bases. Overall, however, the Project will have relatively limited maritime interaction with fishermen and a negligible impact on them.

Environmental Management System

The existing Block 15 EMS will be reviewed and updated as appropriate, and in place at the start of construction, drilling and production operations for Kizomba Satellites. The EMS includes: discharge limits, a Spill Prevention Plan, a Spill Response Plan, a Waste Management Disposal and Deposit Plan, and an ODMP. Emissions and wastes will be monitored and reported in accordance with regulatory requirements. The EMS will be audited at regular intervals. Changes to systems and operating procedures will be made as required, to ensure continued compliance with environmental measures.

3.0 REGULATORY FRAMEWORK

The Block 15 EIA discusses the environmental regulatory authorities and legislation in place at the time of the Block 15 EIA approval (2001). This section of the Supplemental EIA reviews the current Angolan regulatory authority framework, and discusses environmental regulations issued or updated since the approval of the Block 15 EIA.

3.1 REGULATORY AUTHORITIES

3.1.1 Ministry of Petroleum

The Ministry of Petroleum (MinPet), in collaboration with the state national oil company Sonangol and the Ministry of Environment, has overall responsibility for regulating onshore and offshore oil and gas exploration, development and production activities. The National Petroleum Directorate has industrial sector-specific responsibilities for nature conservation and environmental protection. Other relevant departments within MinPet include the Planning Department, Commercialization Department, Legal Department, and Foreign Marketing Department.

3.1.2 Ministry of Fisheries

The Ministry of Fisheries is responsible for promoting fisheries cooperation through negotiation of international agreements, as well as the management of fisheries through licensing and royalty fee agreements. The Ministry of Fisheries was formerly known as the Ministry of Fisheries and Environment until December 2002, when the Angolan government divided it into the Ministry of Fisheries and the Ministry of Environment.

3.1.3 Ministry of Environment

In November 2008, the Ministry of Urbanization and Environment was reorganized into two separate Ministries: the Ministry of Environment and the Ministry of Housing and Urban Development. The Ministry of Environment is responsible for the development and coordination of the Angolan environmental policy and the Angolan Environmental System. Within the Ministry of Environment, the National Directorate for Environment is the most relevant department for this project. The Ministry of Environment is required to review EIAs and advise MinPet on the acceptability of proposed development projects. The Ministry of Environment also is responsible for the General Environmental Law (5/98) and subordinate legislation.

3.2 ANGOLAN ENVIRONMENTAL LEGISLATION

Since the Block 15 EIA was completed in 2001, environmental legislation in Angola has continued to develop, and new laws and regulations have been

established. This section provides a brief discussion of the legislation issued or updated since the Block 15 EIA's approval.

- **Article 24 in the Law on Oil Activities (10/04).** This Article stipulates the general provision that oil activities must take necessary precautions with respect to environmental protection, with a view of guaranteeing conservation of the environment, particular with regard to health, water, soil and subsoil, air, conservation of biodiversity, flora and fauna, ecosystems, countryside, atmosphere and cultural, archeological and aesthetic values.
- **Aquatic Bioresources Law (6-A/04).** This Law sets the general guidelines and objectives for the use and exploitation of water biological resources, the fishery legal system, the rules for the protection of biological resources and aquatic ecosystems, the basic regulation on fishing vessels and ports, and the rules for scientific research and monitoring activities on aquatic biologic resources. Moreover, the Law regulates the licensing procedures for aquaculture as well as for fish and derived products, processing and commercial activities. Title II of the law governs the aquatic environment and includes the requirement to identify pollutant activities and adopt measures intended to prevent the pollution of the aquatic environment, as well as establish protected zones and enforce more stringent control of the protected zones and adjacent areas. Internal regulations related to this law have been approved in Decree 31/06 below.
- **Law on Environmental Protection Associations (3/06).** This law regulates the right of Environmental Protection Associations to participate and intervene in environmental management.
- **Water Resource Use Law (6/02).** This Law sets forth the requirements for general use and discharge of water, including surface and underground water sources.
- **Decree 59/07 – Environmental Licensing.** This Decree lays down the rules, administrative requirements, criteria, and procedures that regulate the environmental licensing of activities. Activities requiring licensing are the type subject to environmental impact assessment or susceptible of causing significant environmental and social impacts.
- **Decree 31/06 – Internal Regulations of the Aquatic Bioresources Integrated Management Council.** This Decree provides internal regulations relating to composition, oversight and functioning of the Aquatic Bioresources Integrated Management Council. The above Council is the consultative support body for the Ministry of Fisheries in the field of the periodic socio-economic agreement on fishery resources and aquaculture management.
- **Decree 28/06 – Internal Regulations of the National Directorate of Fisheries and Fishery Resources Protection.** This Decree provides internal regulations relating to structure and functioning of the National Directorate of Fisheries and Fishery Resources Protection. The above Directorate is the service of the Ministry of Fisheries with functions of the formulation, direction, control and implementation of fisheries policy, in respect of fishing and the protection and development of fishery resources.

- **Decree 51/04 - Environmental Impact Assessment.** Decree 51/04 falls under the jurisdiction of MinPet and sets out the requirements for environmental impact assessment for both public and private projects. The decree outlines the specific requirements for the technical aspects of the EIA as well as the public participation process to be followed
- **Decree 81/04 - Technical and Safety Conditions for Maritime Transportation of Petroleum Products.** This Decree establishes regulations prescribing technical and safety conditions for maritime transport of petroleum products in line with standards set by the International Maritime Organization (IMO).
- **Decree 39/00 - Environmental Protection for the Petroleum Industry (PIEPD)** has been amended by the following decrees issued since 2001:

  - **Executive Decree 8/05 - Regulations Governing Waste Management, Removal and Disposal.** This Decree became effective on January 5, 2005, and amended the requirements concerning waste management, removal and disposal. The Decree requires that operators produce a Waste Management, Removal and Deposit Plan that contains the following elements: a) classification of waste on the basis of risk analyses; b) consideration of all the activities that generate significant quantities of waste, including the standard that will apply in waste handling, storage, treatment and disposal and justification of selected waste minimization and treatment options; c) the form of waste control to be employed and how the appropriate records are maintained in accordance with the practices used by the industry; d) maintenance programs for equipment used in waste handling, treatment and disposal; and e) an environmental monitoring program for waste treatment, handling and disposal sites.
  - **Executive Decree 11/05 – Regulation on Procedures for Notification of the Occurrence of Spills**. Effective January 6, 2005, this Decree establishes and standardizes the notification procedure for the occurrence of oil spills, including submittal of a spill notification form. The Decree provides a standard Spill Notification Form outlining the required information that must be submitted. For particular notifications of oil spills over one barrel in quantity or for which environmental impact is significant, a spill notification form shall be submitted within eight hours after the occurrence is known by the operator. Notification for spills of less than one barrel in quantity or which do not have a significant impact on the environment are to be reported by forwarding a final report upon the completion of the spill control actions and the restoration of the environmental conditions at the spill location.
  - **Executive Decree 12/05 – Regulation on the Management of Operational Discharges.** This law became effective on January 6, 2005, and establishes the regulations for managing operational discharges by petroleum company operations located both onshore and offshore.

3.3 INTERNATIONAL TREATIES

Since the Block 15 EIA was issued in 2001, the Angolan National Assembly has ratified the following international environmental treaties:

- **Resolution 14/07 -** Approving for accession the 1997 Kyoto Protocol to the United Nations (UN) Framework Convention on Climate Change. The Protocol contributes to the efforts made by the international community to achieve stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
- **Resolution 7/07 -** . Approving the Rotterdam Convention on Chemical Products and Highly Toxic Pesticides – PIC. The Convention controls the international trade of certain banned or severely restricted chemicals and severely hazardous pesticide formulations.
- **Resolution 49/05 -** Approving the Stockholm Convention on Persistent Organic Pollutants (POP) which prohibits or restricts the production, use, import and export of certain persistent organic chemicals. Additionally, the storage, handling and disposal of such chemicals must be controlled to minimize environmental impact.
- **Resolution 22/01 -** Adoption of the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, committing Contracting Parties to "apply a precautionary approach to environmental protection from dumping of wastes or other matter whereby appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects."
- **Resolution 18/01 -** Ratification of the 1996 International Convention on Civil Liability and Compensation for Damages Due to Pollution by Hazardous and Noxious Substances - "HNS 96" creating uniform international rules and procedures for determining questions of liability and compensation in respect of damage caused from pollution by hazardous and noxious substances

3.4 MANAGEMENT PLAN UPDATES

As discussed above, Executive Decree 8/05 provides regulations governing waste management, removal and disposal. EEAL's approved Waste Management, Disposal and Deposit Plan addresses activities related to operation and construction of the Kizomba Satellites developments. In accordance with reporting requirements, EEAL will report annually to MinPet, through the National Directorate of Petroleum, the following for Kizomba Satellites: a waste summary that includes types and quantities of wastes generated by all operations, sources of wastes, transport and storage measures, and the final fates of the wastes.

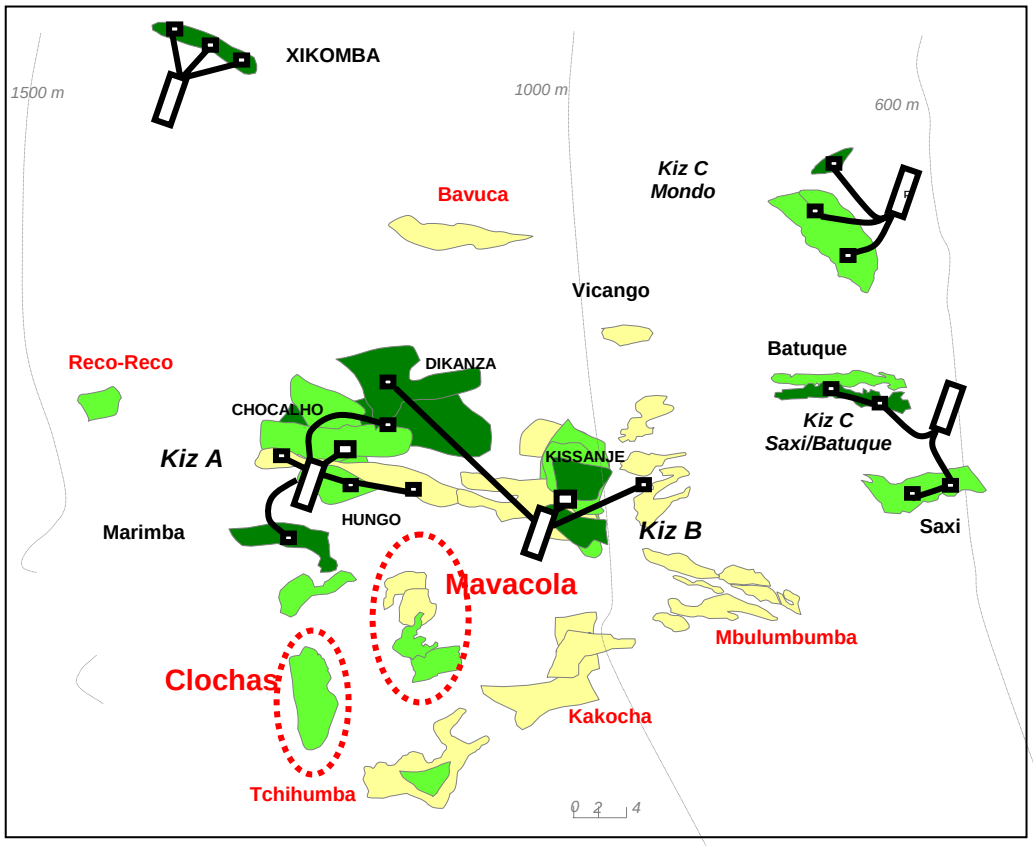
EEAL has approved spill response plans in place. Executive Decree 11/05, regulates notification procedures for spill occurrences. EEAL's Spill Notification Procedure meets or exceeds the regulatory requirements of Executive Decree 11/05, and covers all operations in Block 15 including the Kizomba Satellites development.

In accordance with regulatory requirements of Executive Decree 12/05, EEAL has submitted an updated Operational Discharges Management Plan to MinPet.

4.0 DESCRIPTION OF PROJECT

This section describes the planned Kizomba Satellites development. The location of Kizomba Satellites within Block 15, relative to the existing Block 15 developments, is shown in Figure 4-1. Kizomba Satellites will first develop the Clochas and Mavacola fields, with Mbulumbumba, Tchihumba, Kakocha, Reco-Reco and Bavuca as possible candidates for future development.

FIGURE 4-1: Proposed Kizomba Satellites Development in Block 15 (in red)



4.1 OVERVIEW OF DEVELOPMENT PLAN

4.1.1 Development Objective

An Angola Block (AB) 15 Blockwide Study (BWS) was completed in September 2006 to assess options to develop the remaining assets in Block 15. The BWS concluded that the remaining assets could most economically be commercialized in a common development as subsea tie-backs to the Kizomba A and B FPSOs. Kizomba Satellites has the potential to develop an estimated ultimate recoverable (EUR) 485 million barrels of oil (MBO). The initial development of Kizomba Satellites will develop oil and gas reserves from the Clochas and Mavacola fields. These fields are believed to have an EUR of 245 MBO. The project will be designed and executed so that future development of the other Kizomba Satellite

assets can easily be accommodated. These future projects would potentially develop oil and gas reserves from the Mbulumbumba, Tchihumba, Kakocha, Reco-Reco, and Bavuca fields. These fields are still being evaluated.

Associated gas separated from Kizomba Satellites production and not used for fuel on the FPSO facilities will be injected into existing Kizomba A and B gas injection (GI) wells to provide pressure support and/or to conserve it for future use. This gas will eventually be delivered to a tie-in point in the Block 15 Gas Gathering System. The gas will then be delivered to the onshore, Chevron-operated, Angola LNG (AnLNG) facility presently projected to start-up in mid-2011.

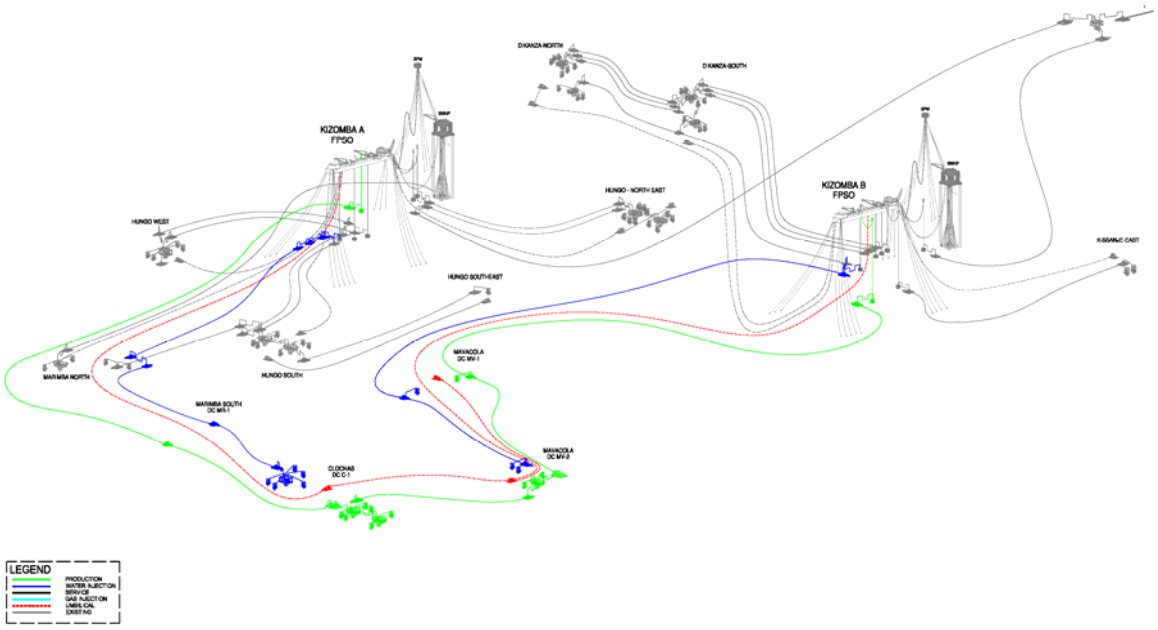
4.1.2 Development Concept

The development concept for Clochas and Mavacola is shown schematically in Figure 4-2. A total of 18 subsea development wells are planned, as depicted in Table 4-1. These wells (including production wells and WI wells) will be drilled from a total of four (4) drill centers, two (2) drill centers for Clochas and two (2) drill centers for Mavacola. Possible later developments envision as many as 40 further subsea wells drilled from an additional 11 drill centers.

TABLE 4-1: Kizomba Satellites Well Development Concept

Asset	# Wells	Drill Centers	# Production Wells	# Water Injection Wells
Phase 1				
Clochas	10	2	6	4
Mavacola	8	2	4	4
Subtotal	**18**	**4**	**10**	**8**

FIGURE 4-2: Kizomba Satellites Clochas and Mavacola Subsea Architecture



The Kizomba Satellite fields will be developed with subsea tie-backs to the existing Kizomba A and B FPSO vessels. Subsea production and WI wells will be tied back to the FPSOs via a looped system of flowlines and risers. All subsea umbilicals, risers and flowlines (SURF) facilities will be designed for a 25-year life. All production flowline segments will be designed to accommodate conventional cleaning pigs to facilitate pre-commissioning operations such as flooding, bulk dewatering, and drying, and to facilitate sweeping and cleaning during normal operations. Subsea equipment includes:

- Subsea trees;
- Manifolds and foundations;
- Jumpers;
- Umbilicals; and
- Subsea controls.

All processing will occur on the two existing FPSOs. FPSO vessel modifications, including additional produced water handling capability, are discussed in Section 4.4.

4.1.3 *Timing*

Drilling from Mobile Offshore Drilling Units (MODUs) is planned to start about mid-year 2010, depending on rig availability and market conditions, with installation of related subsea components to follow the next year. Drilling for Clochas is anticipated to continue through the first quarter of 2014, with the last Mavacola well drilled in 2015. It is presently anticipated that drilling for subsequent phases may start during 2012 and continue through 2016. Figure 4-3 provides a preliminary project schedule based on this timing. Figure 4-3 shows 20 wells, as two geological sidetracks are planned in addition to the 18 production wells.

FIGURE 4-3: Kizomba Satellites Preliminary Project Schedule

	2010	2011	2012	2013	2014	2015
Topsides Modifications						
Kizomba A						
Kizomba B						
Drilling (number of wells per year)						
Clochas		4	3	4		
Mavacola	2	1	3	2		1
Total	2	5	6	6		1
SURF Installation						
Clochas						
Mavacola						

4.1.4 *Alternative Concepts Considered*

Six concept alternatives were initially considered to develop the Kizomba Satellite reservoirs. Four involved tie-backs to Kizomba A and B, and two included an additional FPSO.

The reserves associated with Clochas and Mavacola will not require an extensive system of production wells (only 18 development wells are planned to be installed between 2010 and 2015). Therefore, a new separate surface facility is not required and the fields will be developed with subsea tie-backs to the existing Kizomba A and B FPSOs.

A number of different subsea flowline arrangements were reviewed, and the final concept with the flowline loop between the Kizomba A and B FPSOs was selected based primarily on operability requirements. Also, the execution plan for connecting the satellite fields to existing FPSOs minimizes disruption to existing operations, and reduces the environmental impact of the project. The

need to add a third compression train on each of the existing Kizomba A and Kizomba B to increase gas handling capacity was considered, but a compressor optimization study indicated that installation of additional compressor capacity is not expected to be required at this time.

Thus, the development of the satellites will utilize facilities (both onshore as well as offshore) that are already in place as a result of previous projects. Accordingly, there are no other "associated projects" connected to the development activities for the Kizomba Satellites.

4.2 WELL DESIGN

4.2.1 Drilling Program

The wells for the Kizomba Satellites development are planned to be drilled from MODUs. Most of the wells will be drilled at moderate to high-angles due to the shallow reservoirs. The subsea architecture will be based on wells situated around localized drill centers. The various drill centers will be directly connected to flowlines for production or WI. Each drill center also will be tied back to the one of the existing Kizomba A or Kizomba B FPSOs with an umbilical to control and provide chemicals to all subsea flowlines, manifolds and trees.

This well program allows drilling activity focused at localized drill centers, rather than distributed wells overlying the producing reservoirs. This approach reduces the number of manifolds, flowlines and umbilicals. Additionally, drilling from drill centers reduces the number of MODU locations, thereby reducing the areas potentially affected by drilling operations.

Natural oil seeps from the ocean floor are a common occurrence in the deepwater blocks off the coast of Angola. Seeps generally occur as a result of fractures and/or flow paths in the sediments below the ocean floor that allow oil to migrate from deeper reservoirs to the ocean floor. This migration of oil from deep horizons is a natural process that happens over very long periods of time. Some of these seeps result in a sheening of oil on the ocean's surface. This sheening has a negligible environmental impact since natural processes are very effective at dispersing and degrading the very small amounts of oil involved.

When wells are drilled through these fractures, alternative pathways may be created that allows this oil to migrate upwards to the seabed at or near the wellhead. EEAL has observed this process on a limited number of wells associated with the Kizomba A development. As a result, EEAL now completes a shallow hazard analysis that assesses the layout and site of the subsea drill centers in an attempt to locate wells away from potential faulting. EEAL has also adopted specialized drilling procedures to reduce the possibility of creating these potential pathways for oil migration by sealing them with specialized cementing methods.

Table 4-2 provides the present coordinates and water depths for the Clochas and Mavacola drill centers from which the wells will be drilled.

TABLE 4-2: Drill Center Coordinates

Drill Center	X (Easting) (meters)	Y (Northing) (meters)	Water Depth (meters)
Clochas (C1)	447,000	9,283,100	1,340
Clochas (C2)	449,020	9,285,500	1,280
Mavacola North (MV1)	455,083	9,288,900	1,130
Mavacola South (MV2)	454,730	9,286,133	1,150

4.2.2 *Typical Well Design*

A typical casing program for the Kizomba Satellites wells is presented in Table 4-3.

TABLE 4-3: Typical Casing Program

Casing	Diameter (in. [mm])[1]	Typical Hole Size (in. [mm])[2]	Estimated Setting Depth (m TVD SS)	Estimated Setting Mud Weight (MW) (ppg)[3]	Est. Shoe Pressure Integrity Test (PIT) (ppg)
Structural	36 [914]	Jetted	1,425	N/A	N/A
Conductor	20 [508]	26 [660]	1,900	8.6	±10
Surface	$13^{3}/_{8}$ [340]	$17^{1}/_{2}$ [444]	1,950-2,900	9.2 - 9.5	±10.3
Production	$9^{5}/_{8}$ x $10^{3}/_{4}$ [244 x 273]	$12^{1}/_{4}$ [311]	2,300-3,800	9.5 – 11.5	±10.8

1. US Customary units converted to mm (inches x 25.4) and rounded to nearest whole number
2. US Customary units converted to mm (inches x 25.4) and rounded to nearest whole number
3. 1 ppg (pound per US gallon) = 0.119823 (0.12) kg/liter

Based on wellbore stability analysis and experience gained from Block 15 development drilling, a low-toxicity non-aqueous fluid (NAF) is required to maintain borehole stability while drilling all intervals below conductor casing. The MODU will be equipped to properly process and handle the NAF and discharge the cuttings in accordance with Angolan government regulations.

A typical well drilling sequence is outlined below:

- Jet in 36-inch casing
- Drill 26-inch hole
- Run and cement 20-inch casing (20-inch may be eliminated on select wells)

- Run Blow-Out Preventer (BOP) and Marine Riser
- Drill 17-1/2 inch hole
- Displace to NAF
- Run and cement 13-3/8 inch casing
- Drill 12-1/4 inch hole
- Run and cement 9-5/8 inch casing
- Install SS Horizontal Tree
- Drill 8-1/2 inch X 9-7/8 inch hole or 8-1/2 inch hole for selected injectors
- Install lower completion
- Install upper completion

The operations sequence assumes that a 21-inch drilling riser and BOP stack will be used during well drilling below the 20-inch casing and completion operations. The operations sequence will continue to be optimized as detailed well design progresses.

Typical subsea oil production and WI wells are shown in Figures 4-4 and 4-5.

FIGURE 4-4: Typical Subsea Oil Production Well for Kizomba Satellites

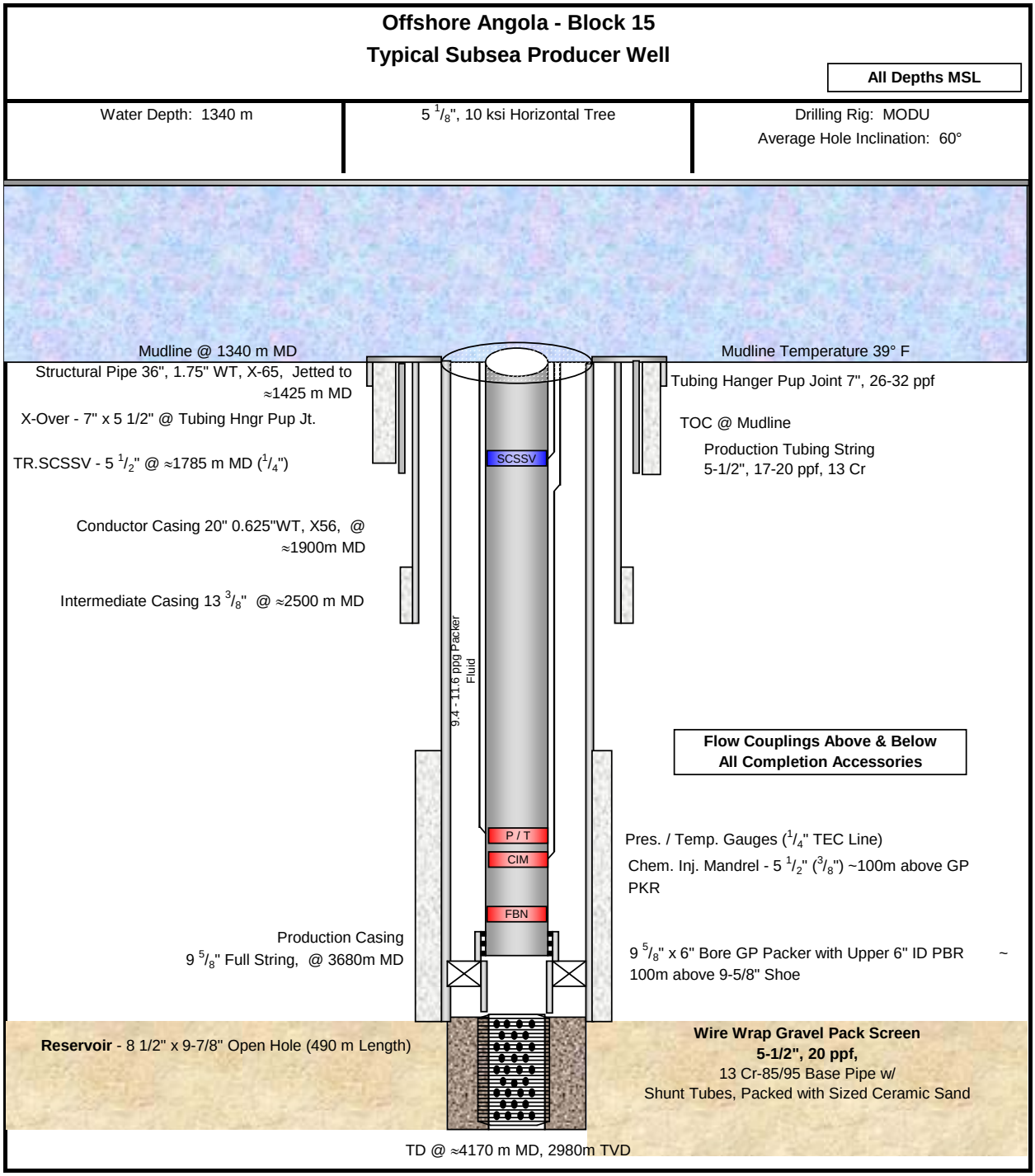
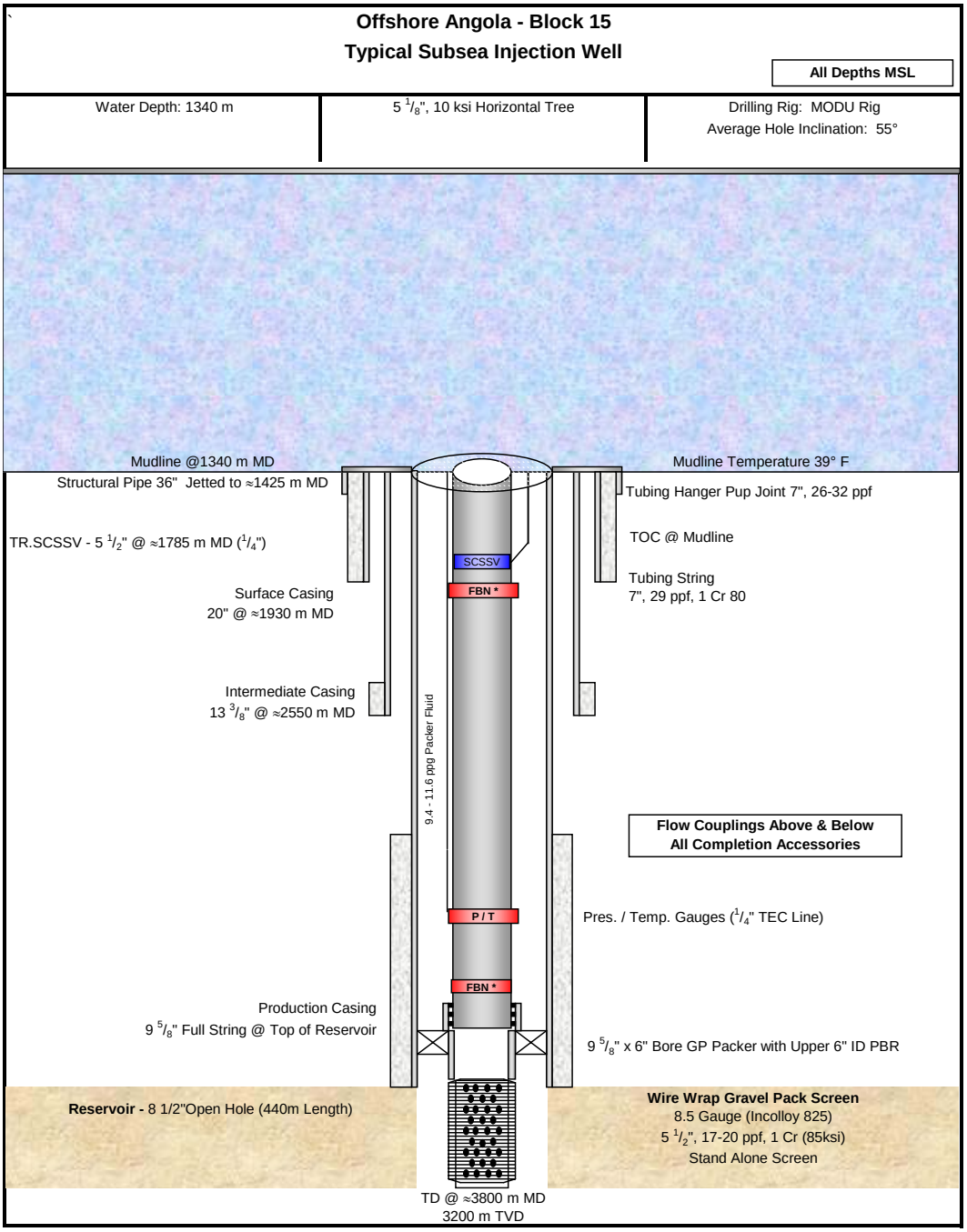


FIGURE 4-5: Typical Subsea Water Injection Well for Kizomba Satellites



4.2.3 Installation, Well Clean-up and Testing

Procedures for installing, testing and pre-commissioning the subsea flowlines and umbilicals are described in the Block 15 EIA. A specialist installation vessel will install the flowlines. Trees will be installed by work boat. Subsea production wells may be cleaned up and tested using a temporary test spread installed on the MODUs. Crude oil and gas will be flared at an operationally safe maximum rate. At present, there are no plans to flow test the subsea WI wells. Injectivity tests (4-12 hours) are planned on the WI wells to confirm well and mechanical integrity.

4.3 EXISTING FLOATING PRODUCTION, STORAGE AND OFFLOADING VESSELS (FPSOs) AND INFRASTRUCTURE

4.3.1 Kizomba A Facility Description

The Kizomba A FPSO vessel is a spread moored vessel designed to receive full wellstream production from the Kizomba A tension leg platform (TLP), and present and future subsea wells, and to process oil at a design rate of 250 thousand barrels of oil per day (kbd) via two process trains. The FPSO has been in operation since August 2004. The hull is capable of storing up to 2.2 MB of stabilized oil and offloading the oil at a rate of 40 to 50 thousand barrels per hour to shuttle tankers via an offloading Catenary Anchor Leg Mooring (CALM) buoy system. The gas from the oil production is processed, dehydrated, and compressed. Since start-up, associated gas not used for fuel has been re-injected into the reservoirs; provision has been made to allow future installation of a gas export system which will be executed by the Block 15 Gas Gathering Project. The Kizomba A FPSO is shown in Figure 4-6.

FIGURE 4-6: Kizomba A FPSO

4.3.2 *Kizomba B Facility Description*

The Kizomba B FPSO is a spread-moored vessel, similar to Kizomba A, designed to receive full wellstream production and to process oil at a design rate of 250 kbd via two process trains. The FPSO has been in operation since July 2005. The hull is capable of storing up to 2.2 million barrels of stabilized oil and offloading the oil at a rate of 40 to 50 thousand barrels per hour to shuttle tankers via an offloading CALM buoy system. The gas from the oil production is processed, dehydrated, and compressed. Since start-up, associated gas not used for fuel has been re-injected into the reservoirs. Provisions have been made to allow future installation of a gas export system which will be executed by the Block 15 Gas Gathering Project. Figure 4-7 shows the Kizomba B FPSO and adjacent TLP.

FIGURE 4-7: Kizomba B FPSO and Kizomba B TLP

4.4 *FLOATING PRODUCTION, STORAGE AND OFFLOADING VESSEL (FPSO) MODIFICATIONS*

The Kizomba A and Kizomba B FPSOs will be modified to accommodate the Kizomba Satellites Project.

The Kizomba Satellites production "loop" will require two new production risers, one at the Kizomba A FPSO and one at the Kizomba B FPSO. The nominal riser diameter will be 12 inches, which provides capacity to support the "loop" flowline and potential tie-ins from subsequent phases. The base case riser concept is pipe-in-pipe single hybrid risers (PIP-SHR) incorporating riser base gas lift, similar in design to the 12-inch PIP-SHR used for the Dikanza North and South tie-ins to the Kizomba B FPSO.

The designated tie-in point on the Kizomba A FPSO will be located on the west side of the hull (Figure 4-8). Provisions were made in the Kizomba A hull for the attachment of additional I-tubes, but the I-tube and protection structures to accommodate the additional production and gas lift flexible

jumper will need to be newly fabricated and installed offshore. The designated tie-in point on the Kizomba B FPSO will be located on the east side of the FPSO (Figure 4-9). The tie-in at Kizomba B will make use of existing spare I-tubes available on the FPSO.

On both FPSOs, production from the existing Kizomba and satellite reservoirs will be manifolded upstream of the phase 1 separators and handled by the existing process trains. Produced water will be treated and either reinjected into the reservoirs for pressure maintenance purposes or discharged overboard at an oil and grease content of less than 40 mg/l.

FIGURE 4-8: Kizomba A FPSO Topsides Modifications

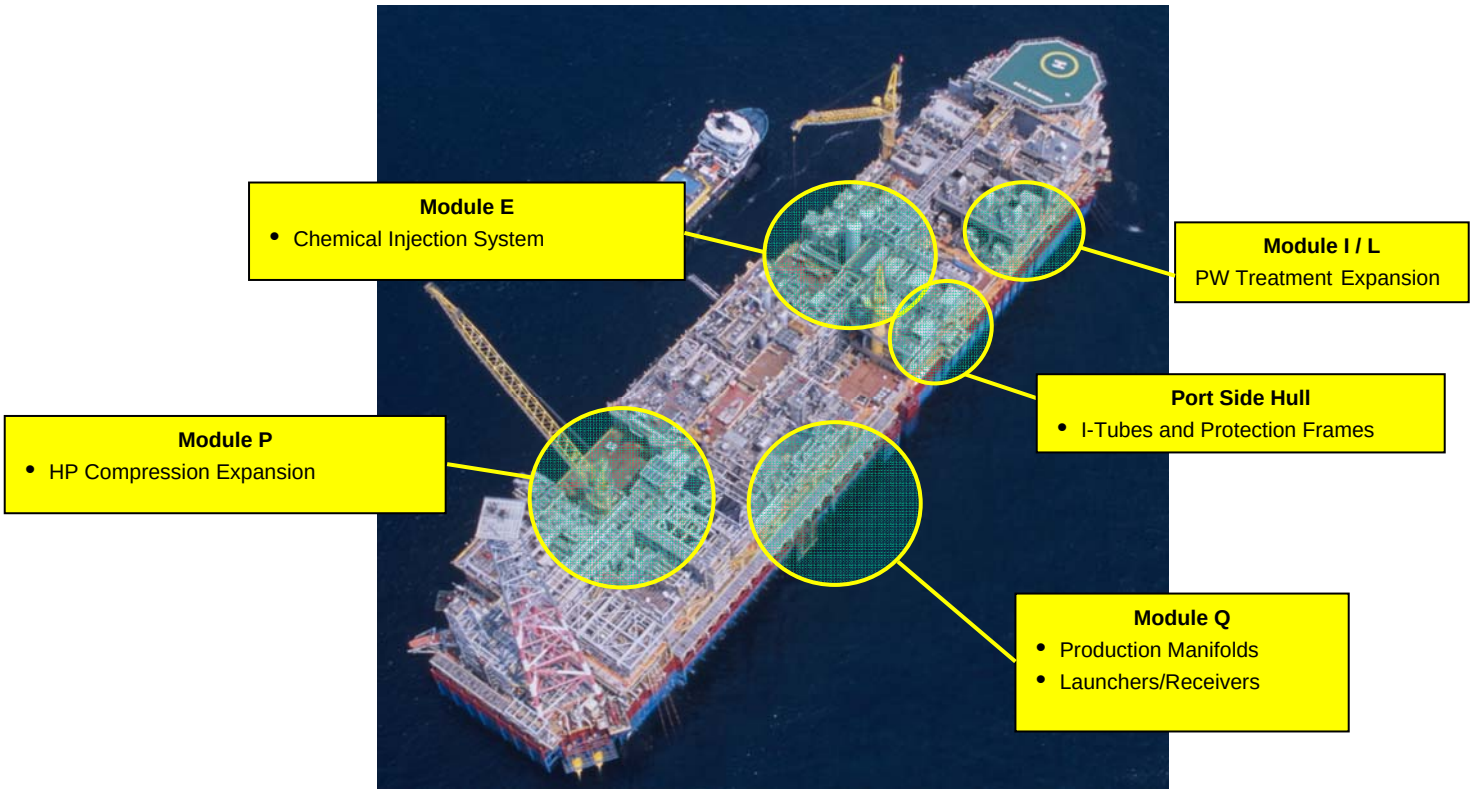
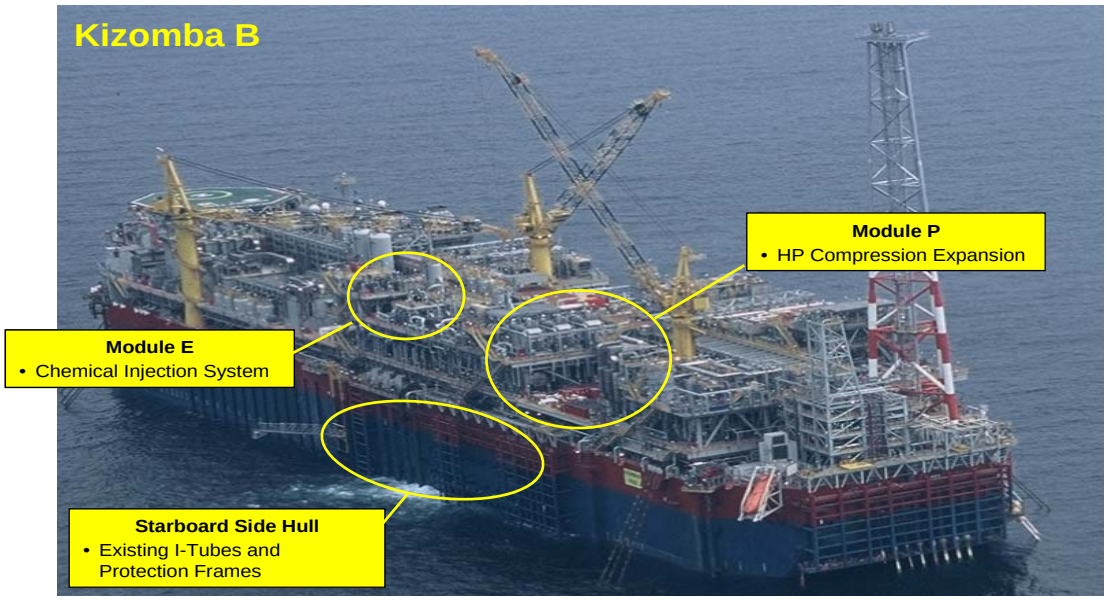


FIGURE 4-9: Kizomba B FPSO Topsides Modifications



4.4.1 Phase 1 Kizomba A FPSO Topsides Modifications

Facilities to be added or modified on the Kizomba A FPSO include:

1. Three I-tubes and protection frames required for the Clochas production riser, gas lift for the production riser, and Clochas umbilical;
2. One production manifold for the Clochas production with tie-ins into the two existing separation trains. One Clochas pig launder/receiver will also be incorporated into the manifold for flowline displacement pigging with crude oil for hydrate mitigation;
3. Tie-ins to the existing bulk methanol pumps and crude oil displacement pumps for hydrate management;
4. New chemical injection pump skids and tanks (to the extent necessary) for injection into the subsea umbilical topside umbilical termination assembly (TUTA) for treatment of the subsea production system. Chemicals include scale inhibitor, asphaltene inhibitor, corrosion inhibitor, wax inhibitor and emulsion breaker;
5. Expansion of the produced water treatment system to increase capacity from 105 kbd to 300 kbd. The equipment for this expansion consists of a hydrocyclone package, a flotation vessel, two 100% boost pumps and two 100% strainers;
6. Control system and electrical system modifications as necessary to support Kizomba Satellites production; and
7. A Multiphase Flow Meter (MPFM) on top of each production riser for verification and backup of the subsea MPFM.

Figure 4-8 shows Kizomba A with preliminary locations of modifications. Note that the figure indicates the location for potential future installation of a third high pressure (HP) compression train in Module P. However, a Compression Optimization Study has indicated that additional compression capacity for the Kizomba Satellites Project is not anticipated to be needed at this point in time.

4.4.2 Phase 1 Kizomba B FPSO Topsides Modifications

Facilities to be added or modified on the Kizomba B FPSO include:

1. Three I-tubes and protection frames required for the Clochas/Mavacola/Clochas production riser, gas lift for the production riser, and Clochas/Mavacola/Clochas umbilical;
2. One production manifold for the Clochas/Mavacola/Clochas production with tie-ins into the two existing separation trains. One Clochas/Mavacola/Clochas pig launder/receiver will also be incorporated into the manifold for flowline displacement pigging with crude oil for hydrate mitigation;
3. Two bulk methanol pumps and tie in to existing displacement pumps for hydrate management. Space is available for three 14 m^3/hr pumps for future subsea developments. The subsea methanol bullheading pumps are connected to the essential generator;
4. New chemical injection pump skids and tanks (to the extent necessary) for injection into the subsea umbilical TUTAs for treatment of the subsea production system. Chemicals include scale inhibitor, asphaltene inhibitor, corrosion inhibitor, wax inhibitor, and emulsion breaker;
5. Expansion of the produced water treatment system to increase capacity from 105 kbd to 300 kbd. The equipment for this expansion consists of a hydrocyclone package, a flotation vessel, two 100% boost pumps and two 100% strainers;
6. Control system and electrical system modifications as necessary to support Kizomba Satellites production; and
7. A Multiphase Flow Meter (MPFM) on top of each production riser for verification and backup of the subsea MPFM.

Figures 4-9 and 4-10 show the Kizomba B FPSO with preliminary locations of modifications. Note that the figures indicate the location for a potential future installation of a third (HP) compression train in Module P. However, a Compression Optimization Study has indicated that additional compression capacity for the Kizomba Satellites Project is not anticipated to be needed at this point in time.

FIGURE 4-10: Kizomba B FPSO Topsides Modifications

4.5 OPERATIONS

4.5.1 Marine Restricted Areas

The Hydrographic Office of the South African Navy (HYDROSAN) is the Navigation Area (NAVAREA) Coordinator for NAVAREA VII, which includes Angola. NAVAREA Coordinators are responsible for collecting and issuing long-range navigation warnings within their areas. The de-facto charting authority for offshore Angola is the United Kingdom Hydrographic Office (UKHO) located in Taunton, England.

The NAVAREA VII Coordinator will be advised of the location of MODUs drilling development wells and carrying out well workovers in Block 15, so that mariners can be advised by long-range NAVAREA broadcast. Safety zones with a 500 meter radius will be established around MODUs during drilling and workovers, in accordance with international agreements.

The NAVAREA VII Coordinator will be advised of construction activities associated with the Kizomba Satellites developments, so that this information may be promulgated in Notices to Mariners as appropriate.

UKHO will be advised of the final locations of the Kizomba satellites drill centers and flowline routes, so that these may be promulgated in Notices to Mariners and shown on marine charts.

4.5.2 Offloading/Export Tankers

Export tankers typically arrive from a day to several hours ahead of the scheduled loading time, as function of weather and ocean conditions. To accommodate these vessels, tanker waiting areas have been established several kilometers away from the Block 15 facilities. When the loading time is near, a Block 15 pilot guides the export tanker to the FPSO for offloading. During the period of maximum field production of 250 kbpd through each of the Kizomba FPSOs, an export tanker is expected approximately every four days at one of the FPSOs to offload the estimated 1 million bbl parcels. The offloading is expected to take 24 hours. The configuration and logistics of offloading is essentially unchanged from what was assumed in the Block 15 EIA, with the exception that the Kizomba Satellites project will extend the period of time over which offloading occurs.

4.5.3 Logistical Support

There currently are (on average) 40 helicopter flights per week to support offshore production operations in Block 15. It is estimated that during construction and installation for Kizomba Satellites, 9 flights per week will be added. Once the Kizomba Satellites wells are in production, only a small number of additional helicopter flights (specifically due to Kizomba Satellites) will be required, principally to support rigs during workover operations.

There will be a number of support vessel trips to the FPSOs. Based on current Block 15 activities, it is estimated that during construction, an average of 6.5 additional support vessel trips per week (specifically due to Kizomba Satellites) may be made to each FPSO, for a total of 13 additional trips per week.

4.5.4 Waste Management

Waste generated offshore will be minimized, recycled, and treated offshore where practicable, with the remainder directed for onshore treatment, recycling, reuse or disposal. Waste streams will be managed in accordance with the Block 15 Waste Management, Disposal and Deposit Plan, which has been approved by MinPet.

5.0 EMISSION, DISCHARGE AND WASTE INVENTORIES

5.1 INTRODUCTION

This section of the Supplemental EIA discusses the air emission, overboard discharge, and waste inventories anticipated for Kizomba Satellites. These inventories are based on the current project description discussed in Section 4. These updated inventories form the basis for the assessment of potential environmental impacts presented in Section 6. These inventories are considered to represent a reasonable maximum case for Kizomba Satellites.

5.2 INVENTORY OF AIR EMISSIONS

Consistent with the discussion in the Block 15 EIA, the principal sources of atmospheric emissions from Kizomba Satellites construction and operations will be combustion gas emissions, facility purging or venting emissions, and fugitive emissions. The majority of the emissions will be from the following activities:

- MODU drilling and workovers (exhaust emissions, fugitive emissions from onboard mud units);
- MODU rig moves (exhaust emissions);
- Well cleanups (combustion emissions from flaring);
- FPSO operation (process equipment exhaust emissions, process flaring, process fugitive emissions, tank venting emissions);
- Filling, offloading and operation of tankers (exhaust emissions, fugitive emissions from venting and material transfers);
- Helicopter support (exhaust emissions); and
- Marine support vessels (exhaust emissions).

The emission inventory focuses on a suite of parameters associated with oil and gas development including carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), non-methane volatile organic compounds (NMVOCs), and methane (CH_4).

Table 5-1 provides a summary of the predicted emissions from all present projects (excluding Kizomba Satellites) from 2006 through 2020. This table was originally presented in the Kizomba C Supplemental EIA and has been extended through 2020. Table 5-2 provides a summary of the predicted incremental air emissions from the Clochas and Mavacola developments for the period of 2009 through 2020. Table 5-3 provides a summary of the predicted emissions from all Block 15 projects (combined) for the period of 2006 through 2020.

TABLE 5-1: Kizomba A, Kizomba B, Xikomba, Marimba North and Kizomba C Annual Emissions Summary

Projected Emissions (tonnes)															
Parameter	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CH_4	2123	2785	2902	2905	2365	2219	2035	1875	1743	1617	1491	1442	1396	1363	1331
CO	5380	6449	7000	6658	5525	5645	5389	4636	4022	3401	3199	3103	2901	2877	2855
CO_2	2347871	2651729	3218385	3173851	2672837	2699130	2613536	2373536	2102696	1763991	1672147	1604348	1465397	1453957	1444780
NMVOC	8438	10691	11182	12266	7617	7577	7371	7050	6824	6589	6288	6238	6165	6140	6116
NOx	11725	15809	16466	17390	13750	13691	13481	13208	12607	11633	11185	10938	10466	10422	10390
PM	3194	3614	4015	3600	3071	3175	2980	2366	1910	1494	1375	1322	1205	1189	1174
SO_2	2609	4093	3427	3447	2629	2527	2464	2426	2400	2368	2278	2264	2252	2242	2233

TABLE 5-2: Kizomba Satellites Annual Emissions Summary

Projected Emissions (tonnes)															
Parameters	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CH_4	0	0	0	0	2	121	216	270	251	245	195	150	120	93	73
CO	0	0	0	0	169	237	367	606	378	834	790	498	459	364	269
CO_2	0	0	0	0	34275	42087	91813	132170	128704	305575	291848	195601	256235	226634	160159
NMVOC	0	0	0	0	19	80	183	296	242	357	326	216	175	132	99
NOx	0	0	0	0	646	1214	1084	855	436	920	676	568	935	900	676
PM	0	0	0	0	64	49	180	410	270	601	595	358	280	203	148
SO_2	0	0	0	0	421	780	649	452	173	278	149	142	135	127	124

TABLE 5-3: Kizomba A, Kizomba B, Kizomba C, Xikomba, Marimba, and Kizomba Satellites Annual Emissions Summary

Projected Emissions (tonnes)															
Parameters	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
CH_4	2123	2785	2902	2905	2367	2340	2251	2145	1994	1862	1686	1592	1516	1456	1404
CO	5380	6449	7000	6658	5694	5882	5756	5242	4400	4235	3989	3601	3360	3241	3124
CO_2	2347871	2651729	3218385	3173851	2707112	2741217	2705349	2505706	2231400	2069566	1963995	1799949	1721632	1680591	1604939
NMVOC	8438	10691	11182	12266	7636	7657	7554	7346	7066	6946	6614	6454	6340	6272	6215
NOx	11725	15809	16466	17390	14396	14905	14565	14063	13043	12553	11861	11506	11401	11322	11066
PM	3194	3614	4015	3600	3135	3224	3160	2776	2180	2095	1970	1680	1485	1392	1322
SO_2	2609	4093	3427	3447	3050	3307	3131	2878	2573	2646	2427	2406	2387	2369	2357

5.3 DRILLING-RELATED DISCHARGES

A total of 18 production wells and two geological sidetracks are presently planned for the initial phase of the Kizomba Satellites development, with wells drilled from mobile offshore drilling units (MODUs) and concentrated at 4 drilling centers. The *per-well* quantities of drilling fluid, cuttings, and other associated drilling discharges (e.g., cement slurry, workover fluids (WOF)) have been calculated based on the typical Kizomba satellites well.

Estimates of the volume of drilling muds and cuttings to be discharged per well drilled are presented in Table 5-4. Predicted associated chemical components for a typical Kizomba Satellites well are presented in Table 5-5. These estimates are based on the typical well configurations described in Section 4 of this Supplemental EIA. Using the proposed drilling schedule for the Kizomba Satellites Project, the estimated volumes of mud and cuttings, and the tonnage of mud components are calculated on an annual basis. Table 5-6 provides the potential combined annual estimated drilling discharges for the initial phase of the Kizomba Satellites project.

TABLE 5-4: Predicted Drilling Mud and Cuttings for a Typical Kizomba Satellites Well

Hole Diameter (mm) *Section TD (m MDBML)*	*Mud type*	*Borehole volume of cuttings*	*Volume of mud for WBMs and Volume on Cuttings for NAF (1)*	*Wet Cuttings Volume*
914 mm (0 to 85 m)	Seawater and Gel Sweeps	55.8 m^3 144.8 tonnes	47.7m^3 Gel Sweeps plus SW	Not Applicable
660 mm (85 to 875 m)	Seawater and Gel Sweeps	270.5 m^3 701.9 tonnes	400.0 m^3 Gel Sweeps plus SW	Not Applicable
	Pad Mud		450.0 m^3 Pad Mud	
445 mm (875 to 1,620 m)	NAF Mud	115.5 m^3 299.7 tonnes	18.9 m^3 15 tonnes NAF	133.9 m^3
311 - 343 mm (1,620 to 2,530 m)	NAF Mud	84.0 m^3 218.0 tonnes	13.8 m^3 10.9 tonnes NAF	98.1 m^3
216 – 250 mm (2,530 to 3,030 m)	NAF Mud	24.7 m^3 64.1 tonnes	4.1 m^3 3.3 tonnes NAF	28.8 m^3
Total Dry Cuttings Discharged = 550.5 m^3 or 1428.5 tonnes				
Total Gel Sweep Mud Discharged = 447.7 m^3				
Total Pad Mud Discharged = 450.0 m^3				
Total NAF Discharged on Cuttings = 36.8 m^3 or 29.2 tonnes				
(1) Cuttings dryness assumed 5% w/w Retained on Cuttings (wet) for NAF Mud				

TABLE 5-5: Predicted Associated Component Chemicals for a Typical Kizomba Satellites Well

Gel Sweeps (3) Chemical Function	***Ecotoxicology (6) LC_{50}***	***Tonnage Used***
Viscosifying Clay (Bentonite)	>10,000 ppm	10 tonnes
Sea Water Treatment (Soda Ash)	>10,000 ppm	1 ton
pH Regulator (Caustic)	>10,000 ppm	1 ton
Lime	>10,000 ppm	1 ton
Biocide (Glutaraldehyde) (7)	100-1000 ppm	0 tonnes
Pad Mud (5) Chemical Function	***Ecotoxicology (4) LC_{50}***	***Tonnage Used***
Viscosifying Clay (Bentonite)	>10,000 ppm	14.7 tonnes
Sea Water Treatment (Soda Ash)	>10,000 ppm	1.5 tonnes
pH Regulator (Caustic)	>10,000 ppm	1.5 tonnes
Lime	>10,000 ppm	1.5 tonnes
Filtrate Control (PAC-R or Cellex)	>1,000,000 ppm	0.7 tonnes
Shale Inhibition (KCl)		11.0 tonnes
Secondary Viscocisfier (BARAZAN D+)	51,200 ppm	0.4 tonnes
Weight Material (barite)	>10,000 ppm	112.8 tonnes
Biocide (Glutaraldehyde)	100-1000 ppm	0 tonnes
NAF Mud Chemical Function (Whole Mud On Cuttings)	***Ecotoxicology (6) LC_{50}***	***Tonnage Used***
NAF	>1,000,000 ppm	51.4 tonnes, 64.2 tonnes, 50.6 tonnes

Comments:
(1) Cuttings dryness assumed 5% w/w Retained on Cuttings (wet) for NAF Mud
(2) Concentration in 9.5ppg NAF Mud: Base Fluid 65.6%, Barite 6.8%, Water 22.3%
(3) Quantity per well of high-viscosity mud for gel sweep pills
(4) Quantity per well of high-viscosity sweeps
(5) Quantity per well of Pad mud
(6) Ecotoxicology for sediment re-worker (Corophium)

TABLE 5-6: Estimated Annual Drilling Discharges for Kizomba Satellites

Year	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	**Total**
Number of Wells	2	5	6	6	0	1	20
Water Base Cuttings m^3	361.6	904	1084.8	1084.8	0	180.8	3616
Gel Sweep mud m^3	349.8	874.5	1049.4	1049.4	0	174.9	3498
Pad Mud m^3	515.8	1289.5	1547.4	1547.4	0	257.9	5158
NAF Mud Cuttings m^3	347.8	869.5	1043.4	1043.4	0	173.9	3478
NAF Mud on cuttings m^3	97.4	243.5	292.2	292.2	0	48.7	974
Total m^3	1672.4	4181	5017.2	5017.2	0	836.2	16724
Whole NAF on Cuttings (tonnes)	110.8	277	332.4	332.4	0	55.4	1108
Viscosifying Clay (Bentonite) (tonnes)	49.4	123.5	148.2	148.2	0	24.7	494
Viscosifying Agent (Barazan D+) (tonnes)	0.8	2	2.4	2.4	0	0.4	8
Viscosifying Agent (Guar Gum) (tonnes)	3.4	8.5	10.2	10.2	0	1.7	34
Shale Control (KCl) (tonnes)	22	55	66	66	0	11	220
Water Treatment (Soda Ash) (tonnes)	5	12.5	15	15	0	2.5	50
pH Regulator (Caustic) (tonnes)	5	12.5	15	15	0	2.5	50
Filtrate Control (PAC-R or Cellex) (tonnes)	1.4	3.5	4.2	4.2	0	0.7	14
Lime (tonnes)	5	12.5	15	15	0	2.5	50
Biocide (Glutaraldehyde) (tonnes)	0	0	0	0	0	0	0
Weight Material WBM (Barite) (tonnes)	225.6	564	676.8	676.8	0	112.8	2256

Based upon wellbore stability analysis and experience gained from Block 15 development drilling, a low-toxicity non-aqueous fluid (NAF) is required to maintain borehole stability while drilling all intervals below conductor casing. The MODUs will be equipped to properly process and handle the NAF and discharge the cuttings in accordance with Angolan government regulations.

5.4 OPERATIONAL DISCHARGES

This subsection describes the operational discharges that will be associated with Kizomba Satellites. These include produced water from reservoir development, and drainages and wastewater from FPSO operation.

5.4.1 Produced Water

Production from the Kizomba Satellites developments will flow back to the Kizomba A and B FPSOs, where it will be commingled with existing production from the Kizomba A and B oil fields and processed. Where the produced water is not reinjected into the Kizomba reservoirs for pressure maintenance due either to equipment downtime or for other operational or reservoir management reasons, it will be treated to reduce the average oil concentration to meet regulatory discharge limits (the current regulatory discharge limit to sea is a monthly average of 40 mg/l, with a reporting requirement if daily average maximum oil concentrations exceed 60 mg/l).

5.4.2 Process Water Discharges

Process water discharges will occur from the FPSOs' cooling water systems and from the reject water due to sulfate removal from the seawater injection system. This was addressed in the Block 15 EIA and the rates remain unchanged.

5.4.3 Drainages and Wastewater Effluents

Additional operational discharges will result from MODUs, drilling and working over the Kizomba Satellites wells. These discharge streams include service waters (cooling water, lab sink drainage, ballast water, potable water maker effluents), domestic wastewaters (effluents from sewage and grey water treatment, macerated putrescible food wastes), and drainages (deck drainage and rig wash). Discharges of this nature will also result from operation of the export tankers and the various supply vessels that serve the Kizomba A and B FPSOs. The projected types of these discharges are essentially unchanged from the discharges assumed for the Block 15 EIA. Thus, the conclusions regarding potential environmental effects from these discharges are unchanged from the Block 15 EIA.

5.5 SOLID WASTES

The Block 15 EIA discusses solid wastes that will be generated during operations. Consistent with that discussion, solid wastes that cannot be reused or recycled onboard the FPSOs will be temporarily stored onboard and transferred to onshore facilities for reuse, recycling, incineration or disposal. Thus, the conclusions regarding potential environmental effects from these wastes are unchanged from those discussed in the Block 15 EIA.

6.0 ASSESSMENT OF ENVIRONMENTAL EFFECTS

This section assesses the potential environmental impacts associated with the development of Kizomba Satellites. The Block 15 EIA included an assessment of the cumulative environmental impacts that potentially would result from construction/operation of Kizomba A, Kizomba B, Kizomba C and Xikomba projects, as well as further developments forecasted in Block 15. These were referred to as 'Kizomba C' and 'Project Y' and intended to be representative in scale and detail of likely future developments.

The project features for which potential impacts were assessed in the Block 15 EIA are similar in nature to the features of the currently planned Kizomba Satellites development. Accordingly, the types of associated potential environmental impacts for Kizomba Satellites have already been addressed in the Block 15 EIA. This Supplemental EIA focuses on discussion of the key potential environmental impacts related to the current Kizomba Satellites development, in terms of the amount of additional features (and potential impacts) relative to the amount of features and potential impacts associated with the Block 15 EIA.

For perspective, the Block 15 EIA was based on an assessment of construction and operation of three FPSOs, and 190 wells drilled from 20 separate drill centers. The development of Clochas and Mavacola includes an additional 18 development wells installed from a further 4 separate drill centers.

The Kizomba Satellites project will involve similar activities to those assessed in the Block 15 EIA. The Kizomba Satellites project will utilize onshore facilities to support construction, but these will primarily be existing facilities, and it is unlikely that modifications to the facilities will be required as a result of the Kizomba Satellites project. In summary, the Kizomba Satellites project activities will be similar in nature to the initial Block 15 activities, and in fact will generally be smaller in extent and shorter in duration. Accordingly, the scope of this Supplemental EIA was modeled after the scope addressed in the approved Block 15 EIA.

The additional potential impacts of the Kizomba Satellites components are considered in more detail below.

6.1 ENVIRONMENTAL BASELINE

An environmental baseline describing the broader study area was provided in the Block 15 EIA, extending from Lobito, Angola, in the south to Cap Lopez, Gabon, in the north and seawards to the limit of the EEZ (200 miles from shore).

A further marine survey has been carried out for the portions of Block 15 affected by the Kizomba Satellites development activities.[6] In addition to providing data

[6] C&C Technologies, Inc. 2008 AUV Survey - Kizomba Satellite Fields Development Phase 1 - Clochas and Mavacola Area Offshore Angola Block 15, November 2008

necessary to finalize detailed well and subsea infrastructure design, this further survey also assessed the presence of potentially sensitive habitat or ecology. EEAL will review the results prior to initiation of construction and will amend the locations of proposed project features as necessary to avoid impacts to sensitive receptors, should any be identified.

6.2 ASSESSMENT METHODOLOGY

For the purposes of this Supplemental EIA, the following terminology is used to assess impacts.

Definition of Impact*:* An impact is a change to a resource or receptor brought about by the presence of the project or by the execution of a project-related activity.

- *Negative* – an impact that is an adverse change from the baseline, or introduces an undesirable element into the baseline.
- *Positive* – an impact that is considered to represent an improvement to the baseline or to introduce a new desirable factor.

Impact Types:

- *Direct (or primary)* – impacts resulting from a direct interaction between a project activity and the receiving environment;
- *Secondary* – impacts resulting from the primary interactions between the project and its environment, resulting in subsequent interactions within the environment;
- *Indirect* – impacts resulting from other activities as a consequence of the project; and
- *Cumulative* – impacts, together with impacts from planned or future projects that affect the same receptor.

Duration:

- *Temporary* - impacts predicted to be of short duration and of an intermittent/occasional nature;
- *Short-term* - impacts predicted to last during construction;
- *Medium-term* – impacts predicted to last for an intermediate period extending beyond the end of construction;
- *Long-term* - impacts predicted to continue over an extended period; and
- *Permanent* - impacts that occur during the development of the project, causing a permanent change to the baseline.

Impact Scale:

- *Local* - impacts that affect locally important environmental resources or that are restricted to the project area and its immediate surroundings;

- *Regional* - impacts that affect regionally important environmental resources or that are felt at a regional scale as determined by administrative boundaries and habitat type;
- *National* - impacts that affect nationally important environmental resources or that affect an area that is nationally important/protected;
- *International* - impacts that affect internationally important environmental resources such as areas protected by International Conventions; and
- *Trans-boundary* - impacts that are experienced in one country as a result of activities in another.

Impact Extent:

- *No impact or negligible significance* - impacts that are indistinguishable from the background/natural level of environmental change;
- *Minor significance* - impacts of low magnitude, within standards, and/or associated with low or moderate value/sensitivity receptors/areas, or impacts of moderate magnitude affecting low value/sensitivity receptors/areas;
- *Moderate significance* - broad category within standards, but impact of a low magnitude impact affecting high value/sensitivity receptors/areas, or moderate magnitude affecting moderate value/sensitivity receptors, or of high magnitude affecting moderate sensitivity receptors/areas; and
- *Major significance* – impacts that exceed acceptable limits and standards, or that are of high magnitude affecting high or moderate value/sensitivity receptors/areas or of moderate magnitude affecting high value/sensitivity receptors/areas.

6.3 IMPACT ASSESSMENT

Based on a consideration of the current Kizomba Satellites design features and the impact assessment completed for the Block 15 EIA, this Supplemental EIA discusses potential environmental impacts related to the following:

- Air emissions from project construction and operations;
- Drilling-related discharges, including drill cuttings and drilling fluids;
- Operational discharges, including produced water and operations effluent streams; and
- Accidental hydrocarbon release from project-related vessels or production infrastructure.

For each of these potential impacts, the Supplemental EIA discusses the method used to assess the impact, a conclusion regarding the potential impact, and mitigation measures to address the potential impact.

6.3.1 Air Quality

As in the case of the Block 15 EIA, the assessment of potential Kizomba Satellites effects to air quality focuses on onshore receptors, although predicted offshore air emission concentrations also are assessed.

6.3.1.1 Methodologies for Assessing Impacts

Because construction and operation of Kizomba Satellites will occur in conjunction with other development activities in Block 15, the potential air quality impacts associated with Kizomba Satellites were considered in combination with Kizomba A, Kizomba B, Kizomba C, Xikomba and Marimba North.

In the Kizomba C Supplemental EIA, the Offshore and Coastal Dispersion (OCD) model was used to predict air quality impacts from Kizomba C activities occurring in conjunction with Kizomba A, Kizomba B, Kizomba C, Xikomba and Marimba North activities. Predicted maximum concentrations of nitrogen dioxides (NO_2), sulfur dioxide (SO_2), particulate matter (PM) and carbon monoxide (CO) were evaluated along the nearest shoreline, as well as in the waters surrounding the proposed project facilities. The predicted onshore concentrations were then compared to the applicable World Health Organization (WHO) standards for ambient air quality (WHO, 2000 and WHO, 2005).

Because occupational settings are excluded from consideration of the WHO guidelines [as these usually apply to adult working populations which may differ in susceptibility to pollutants in a number of ways from the general population, and where the risk management approaches may be different than those applicable for ambient air (WHO 2005)], offshore concentrations were compared to standard worker exposure guidelines from the American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH).

In the Kizomba C Supplemental EIA, EEAL provided an estimate of the total maximum emissions from all Block 15 activities for each year of projected construction and operation (see Table 5-1 in this document), and dispersion modeling was conducted for the maximum yearly (combined) emissions for each parameter.

To the extent practicable, project-specific and site-specific data were utilized in the modeling. However, assumptions were used in some cases where project-specific or site-specific data were not available. The data used as inputs to the model are summarized below.

OCD Model

The Offshore and Coastal Dispersion (OCD) model was developed to simulate the effect of offshore emissions from point, area, or line sources on the air quality of coastal regions. A brief description of the OCD model taken from the User's Guide issued by the US Minerals Management Service follows.[7]

The OCD model was developed to simulate plume dispersion and transport from offshore point, area, or line sources to receptors on land or water. The OCD model is an hour-by-hour steady state Gaussian model with enhancements that consider the differences between over water and overland dispersion characteristics, the sea-land interface, and platform aerodynamic effects. Hourly meteorological data from both over water and overland locations are needed as input.

The over water measurements include wind direction and speed, mixing height, over water air temperature and relative humidity, and the sea surface temperature. Overland data include the standard EPA UNAMAP model requirements. Over water and overland turbulence intensities are used by the model but are not mandatory. For over water dispersion, the turbulence intensities are parameterized from boundary layer similarity relationships if they are not measured.

Specifications of emission characteristics and receptor locations are similar to the standard EPA UNAMAP models. Hourly emission rate, exit velocity, and stack gas temperature may also be specified. Plume reflection off elevated terrain is calculated following the method proposed in the EPA TUPOS model (Turner et al., 1986). Plume impaction on elevated terrain is calculated following procedures in the EPA RTDM (Rough Terrain Diffusion Model) (ERT, 1982). That is, if the plume is below the critical dividing streamline height (Hc), the plume impacts the terrain, and if the plume is above Hc, the plume flows up over the terrain. A revised platform downwash algorithm based on laboratory experiments is incorporated in OCD. Partial plume penetration into elevated inversions is treated using Briggs' model. A virtual source technique is used to change the rate of plume growth as the over water plume intercepts the thermal internal boundary layer (TIBL) at the shoreline. The TIBL is assumed to be terrain following.

Emission Rates and Stack Parameters

Project emissions and stack parameters used in the modeling were based on the project equipment planned for use during the construction and operational phase of the Kizomba C Project. The primary emission-generating equipment includes: FPSOs, MODUs, filling/offloading tankers, aviation support and marine support. For the purpose of modeling, it was assumed that each FPSO

[7] US Minerals Management Service Report No AO85-1 November,1989

would include up to three separate sources: a turbine, a boiler, and a flare. Where appropriate, the FPSO and the TLP were considered to be one source.

Emissions Estimates

EEAL provided an estimate of the total maximum emissions from Block 15 activities for each year of projected construction and operation. The total maximum annual emissions were categorized into the following activities: MODU drilling, MODU movements, well cleanup, FPSO/SWHP operations, filling/offloading tankers, aviation support, and marine support. The emissions associated with these activities were then assigned to specific sources for input into the model. Assumed emissions, in tonnes per year, by source, are provided in Table 6-1.

Table 6-1: Emission Rates by Source (in tonnes per year) – Kizomba C Supplemental EIA Scenario)

Location	Emission Rate			
	CO (tonnes per year)	NOx (tonnes per year)	PM (tonnes per year)	SOx (tonnes per year)
Kizomba A				
- Turbine - Flare	1341	1854	930	8
MODU - (H-NE)	10	39	4	47
MODU - (H-W)	10	39	4	47
MODU - (H-S)	10	39	4	47
MODU - (H-SE)	10	39	4	47
F/OL	50	177	19	133
Kizomba B				
- Turbine - Flare	1210	1918	833	8
MODU - (D-N)	11	27	5	63
MODU - (D-S)	11	27	5	63
MODU - (K-N)	11	27	5	63
MODU - (K-E)	11	27	5	63
F/OL	50	177	19	133
Kizomba C - Mondo				
FPSO - Boiler - Turbine - Flare	658	1178	444	8
MODU - Mondo1	19	79	9	50
MODU - Mondo2	19	79	9	50
MODU - Mondo3	19	79	9	50
F/OL @ FPSO	21	83	8	67
Kizomba C - Saxi/Batuque				
FPSO - Boiler - Turbine - Flare	577	1432	377	8
MODU - Saxi1	17	53	8	71
MODU - Saxi2	17	53	8	71
MODU - Bat1	17	53	8	71
MODU - Bat2	17	53	8	71
F/OL @ FPSO	16	83	6	0
Marimba				
MODU - M	201	306	135	13
Xikomba				
FPSO - Boiler - Turbine - Flare	714	1272	411	13
MODU - X1	16	35	6	41
MODU - X2	16	35	6	41
MODU - X3	16	35	6	41
F/OL @ FPSO	7	21	2	16
Helicopters	14	17	3	56
Supply boats	1885	8053	712	2629
TOTAL	7000	17390	4015	4093

The aviation support (i.e., helicopters) was modeled as area sources, meaning that emissions were represented as being dispersed over a given area. Other sources were modeled as point sources. Marine support (i.e., supply boats) was modeled as a series of points along the route of the supply boats from Soyo to Block 15, as shown on Figure 6-2. A list of point sources within Block 15 under the Kizomba C Supplemental EIA scenario, by location, is provided in Table 6-2. Note that because the MODUs move throughout the year for drilling purposes, emissions from the MODUs were divided evenly among each of the drill centers within an area (drill center designations are shown in parentheses in Table 6-2).

Table 6-2: Point Sources Used in Model Runs (Kizomba C Supplemental EIA Scenario)

Kizomba A	*Kizomba B*	*Kizomba C - Mondo*	*Kizomba C - Saxi/Batuque*	*Xikomba*	*Marimba*
FPSO - Turbine	FPSO - Turbine	FPSO - Boiler	FPSO - Boiler	FPSO - Boiler	MODU - M
- Flare	- Flare	- Turbine	- Turbine	- Turbine	
MODU - (H-NE)	MODU - (D-N)	- Flare	- Flare	- Flare	
MODU - (H-W)	MODU - (D-S)	MODU - Mondo1	MODU - Saxi1	MODU - X1	
MODU - (H-S)	MODU - (K-N)	MODU - Mondo2	MODU - Saxi2	MODU - X2	
MODU - (H-SE)	MODU - (K-E)	MODU - Mondo3	MODU - Bat1	MODU - X3	
F/OL	F/OL	F/OL @ FPSO	MODU - Bat2	F/OL @ FPSO	
			F/OL @ FPSO		

Stack Parameter Development

The model requires detailed information describing how each source releases emissions into the atmosphere (i.e., 'stack parameters'). Required stack parameters include: height of the release, stack diameter, stack exit temperature and stack exit velocity. These parameters were provided by EEAL and/or manufacturers. For the FPSO flares, the effective stack diameter was calculated using the gross heat release, net heat release, and molecular weight of the gas being flared. A list of stack parameters is provided in Table 6-3.

Table 6-3: Stack Parameters (Kizomba C Supplemental EIA Scenario)

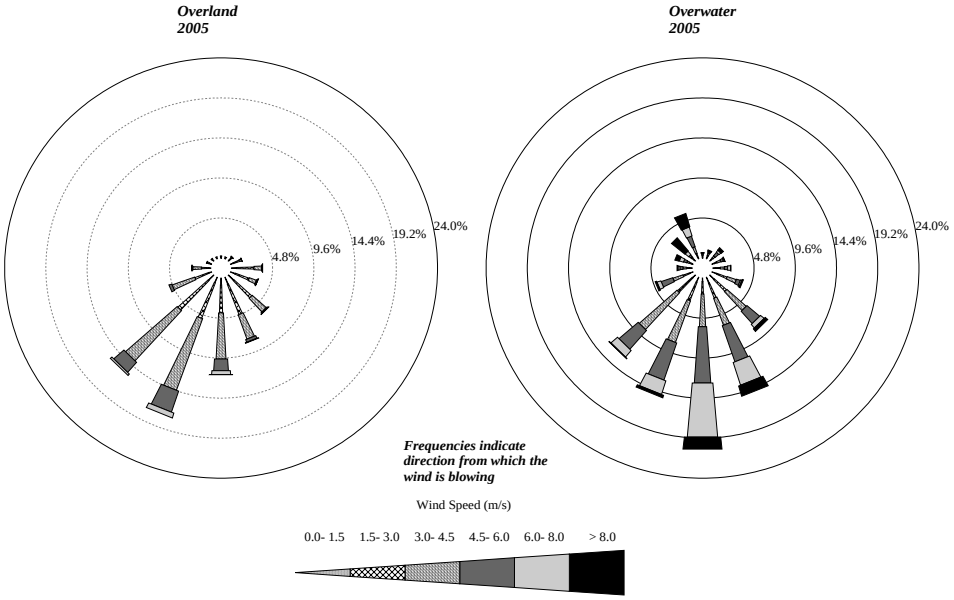
Location	Stack Parameters			
	Stack height m	Exhaust Temp K	Stack Diameter m	Exit Velocity m/s
Kizomba A				
- Turbine	21.000	783.150	1.130	44.083
- Flare	136.860	1273.000	13.600	20.000
MODU - (H-NE)	22.000	682.600	0.762	40.590
MODU - (H-W)	22.000	682.600	0.762	40.590
MODU - (H-S)	22.000	682.600	0.762	40.590
MODU - (H-SE)	22.000	682.600	0.762	40.590
F/OL	30.4	384.15	7.75	70.83
Kizomba B				
- Turbine	21.000	783.150	1.130	44.083
- Flare	136.860	1273.000	13.600	20.000
MODU - (D-N)	22.000	682.600	0.762	40.590
MODU - (D-S)	22.000	682.600	0.762	40.590
MODU - (K-N)	22.000	682.600	0.762	40.590
MODU - (K-E)	22.000	682.600	0.762	40.590
F/OL	30.4	384.15	7.75	70.83
Kizomba C - Mondo				
FPSO - Boiler	30.400	384.150	7.750	70.830
- Turbine	12.000	573.150	0.995	58.210
- Flare	127.215	1273.000	0.020	20.000
MODU - Mondo1	22.000	682.600	0.762	40.590
MODU - Mondo2	22.000	682.600	0.762	40.590
MODU - Mondo3	22.000	682.600	0.762	40.590
F/OL @ FPSO	30.4	384.15	7.75	70.83
Kizomba C - Saxi/Batuque				
FPSO - Boiler	30.400	384.150	7.750	70.830
- Turbine	12.000	573.150	0.995	58.210
- Flare	127.215	1273.000	0.020	20.000
MODU - Saxi1	22.000	682.600	0.762	40.590
MODU - Saxi2	22.000	682.600	0.762	40.590
MODU - Bat1	22.000	682.600	0.762	40.590
MODU - Bat2	22.000	682.600	0.762	40.590
F/OL @ FPSO	30.4	384.15	7.75	70.83
Marimba				
MODU - M	22.000	682.600	0.762	40.590
Xikomba				
FPSO - Boiler	30.400	384.150	7.750	70.830
- Turbine	12.000	573.150	0.995	58.210
- Flare	127.215	1273.000	0.030	20.000
MODU - X1	22.000	682.600	0.762	40.590
MODU - X2	22.000	682.600	0.762	40.590
MODU - X3	22.000	682.600	0.762	40.590
F/OL @ FPSO	30.4	384.15	7.75	70.83
Helicopters	914.000	298.000	64000.000	0.00001
Supply boats	24.000	350.000	1.000	5.00000

Meteorological Data

The model requires both hourly overland and over water meteorological data to predict over water plume transport and dispersion, as well as changes that take place as the plume crosses the shoreline. Over water meteorological data were supplied by EEAL. Overland meteorological data were obtained from the National Oceanic and Atmospheric Administration (NOAA) for the closest station to Angola: Point Noire, Congo. Both the over water and overland data

for the year 2005 were processed to create the required input to the model. The wind roses included in Figure 6-1 show the differences in wind speed and direction between the overland and over water meteorological data.

Figure 6-1: Wind Roses for Overland and Overwater Data



Dispersion Modeling Scenarios

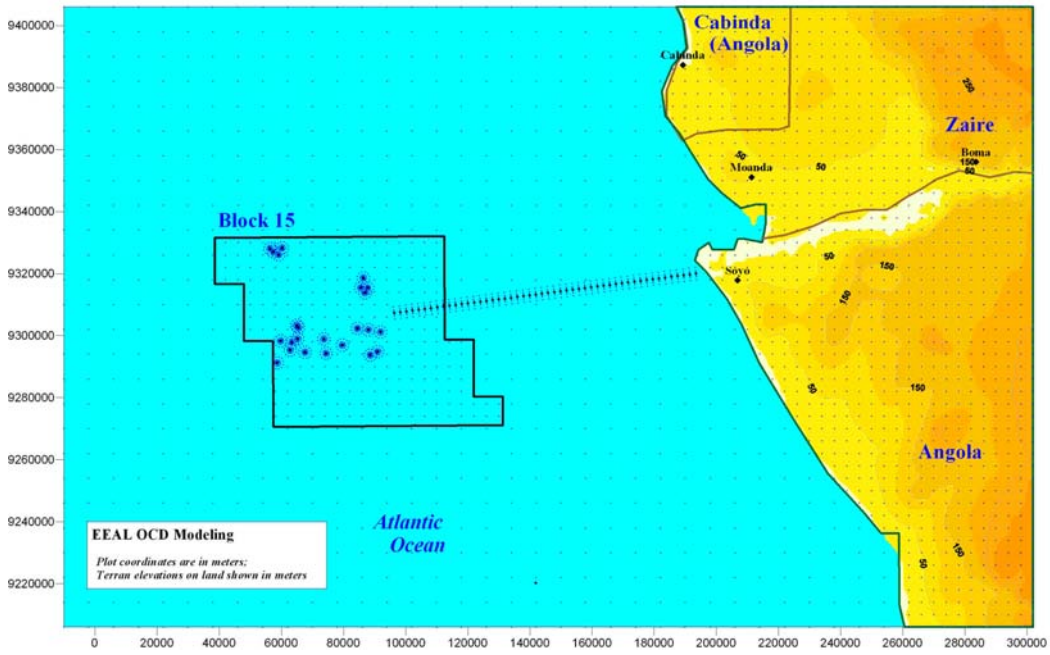
EEAL calculated the total maximum emissions for each year of operation and construction. The calculations indicated that the maximum SO_2 emissions would occur in the year 2007, the maximum CO and PM emissions would occur in the year 2008, and the maximum NO_2 emissions would occur in 2009. Therefore, to conservatively estimate the potential air quality impacts resulting from EEAL's construction and operation activities within Block 15, the emissions associated with these years were utilized in model runs. Table 6-4 summarizes these total maximum emissions for each year; maximum values used in the model are shaded.

Table 6-4: Total Maximum Emissions (tonnes per year) (Kizomba C Supplemental EIA Scenario)

Emission	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
CO	5,380	6,449	7,000	6,658	5,525	5,645	5,389	4,636	4,022	3,401
NOx	11,725	15,809	16,466	17,390	13,750	13,691	13,481	13,208	12,607	11,633
PM	3,194	3,614	4,015	3,600	3,071	3,175	2,980	2,366	1,910	1,494
SO2	2,609	4,093	3,427	3,447	2,629	2,527	2,464	2,426	2,400	2,368

For the purpose of modeling, a receptor grid was established for points at which concentrations of various emissions would be calculated in the vicinity of Block 15. The grid is shown in Figure 6-2.

Figure 6-2: Locations of Receptors and Sources



Dispersion Modeling Results

For the Kizomba C Supplemental EIA, the OCD model was run for a full year of hourly meteorological data, and estimated concentrations due to emissions from all sources at all receptors. The results were analyzed and the maximum concentrations were identified in two areas: at the nearest onshore location, and at offshore locations.

With regard to potential onshore receptors, results of the dispersion modeling analysis for the Kizomba C Supplemental EIA scenario are presented again in Table 6-5 below. For each of the four parameters modeled, maximum concentrations were predicted over various averaging periods (e.g., 1-hour, 8-hour, annual, etc.). The averaging periods were selected to match the averaging periods for which WHO Air Quality Guidelines (AQGs) have been developed. For each of the emissions, Table 6-5 lists the applicable WHO AQGs and the percentages of the WHO AQGs represented by each predicted maximum average concentration. As shown in Table 6-5, the modeling for the Kizomba C Supplemental EIA scenario predicted that no WHO AQGs would be exceeded at onshore locations.

TABLE 6-5: Onshore Dispersion Modeling Results (Kizomba C Supplemental EIA Scenario)

Emission	NO_2 (ug/m³)		CO (ug/m³)		SO_2 (ug/m³)		PM (ug/m³)	
Averaging Time	1-hr	annual	1-hr	8-hr	1-hr	24-hr	24-hr	annual
Max Conc.	182.27	3.33	59.31	16.76	78.24	11.79	3.66	0.42
WHO AQG	200	40	30,000	10,000	500	20	50	20
Percent of WHO AQG	91%	8.3%	0.2%	0.2%	16%	59%	7.3%	2.1%

With regard to potential offshore receptors, results of the dispersion modeling analysis for the Kizomba C Supplemental EIA scenario are presented again in Table 6-6 below. For each of the four parameters modeled, average concentrations were predicted over various averaging periods (e.g., 1-hour, 8-hour). The averaging periods were selected to include the averaging periods for U.S. worker exposure guidelines developed by ACGIH, OSHA or NIOSH. For each of the emissions, Table 6-6 lists guidelines from these organizations.

TABLE 6-6: Offshore Dispersion Modeling Results (Kizomba C Supplemental EIA Scenario)

Emission	NO_2 (ug/m³)			CO (ug/m³)		SO_2 (ug/m³)			PM (ug/m³)			
Averaging Time	1-hr	8-hr	annual	1-hr	8-hr	1-hr	8-hr	24-hr	1-hr	8-hr	24-hr	annual
Max Conc.	663.37	410.45	14.94	438.42	272.62	200.38	47.60	24.80	303.08	188.34	83.08	6.96
ACGIH TLV	---	5,600	---	---	29,000	---	5,200	---	---	---	---	---
OSHA PEL	---	---	---	---	55,000	---	13,000	---	---	15,000	---	---
ACGIH STEL	9,400	---	---	---	---	13,000	---	---	---	---	---	---
OSHA ceiling	9,000	---	---	---	---	---	---	---	---	---	---	---
NIOSH ceiling	---	---	---	229,000	---	13,000	---	---	---	---	---	---

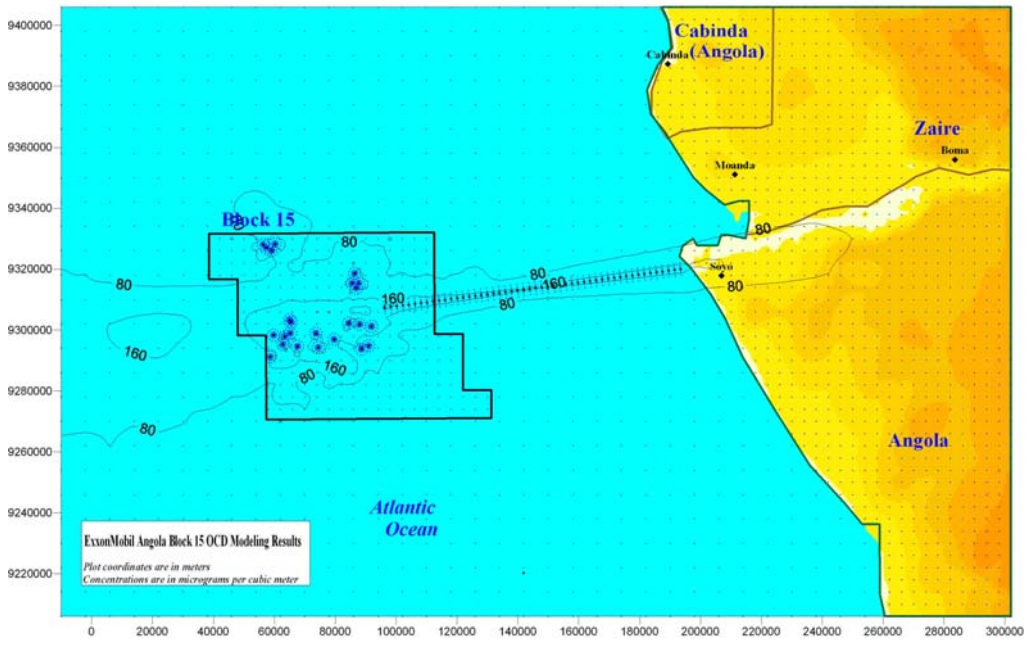
TLV = Threshold Limit Value (8-hr time-weighted average)
PEL = Permissible Exposure Limit (8-hr time-weighted average)
STEL = Short Term Exposure Limit (15-min time-weighted average)
Ceiling = concentration that should not be exceeded at any time
Note: Where no values are shown, these numbers are not in the referenced standards.

As expected from the variability of the hourly meteorological data, the maximum onshore and offshore concentrations listed above are associated with meteorological conditions that combine to occur at a low frequency and affect limited areas in the vicinity of the sources. Figures 6-4 and 6-5 show examples of the variability in predicted concentrations, the variability being due to variations in meteorological conditions throughout a given year.

The maximum onshore concentrations for modeled emissions are all associated with the operation of supply boats (see for example, Figure 6-3), and occur during meteorological conditions that occur infrequently. For example, while the maximum onshore 1-hour NO_2 concentration is predicted to be approximately 91% of the WHO AQG, only 1% (88 out of 8,760) of the predicted 1-hour average onshore concentrations within the modeled year exceed 10% of the WHO AQG. This same variability is also seen offshore (see Figure 6-4). Similarly for SO_2, although the maximum 24-hour onshore concentration is predicted to be 59% of

the WHO AQG, concentrations close to this level also only occur infrequently (see Figure 6-5).

Figure 6-3: Maximum Concentration Isopleths – NO_2 (1-hour)[8]



[8] Environmental Impact Assessment Development Activities for Angola Offshore Block 15 Supplement for Kizomba C - Figure 6-7

Figure 6-4: Variability of Predicted 1-hour Offshore NO_2 Concentrations[9]

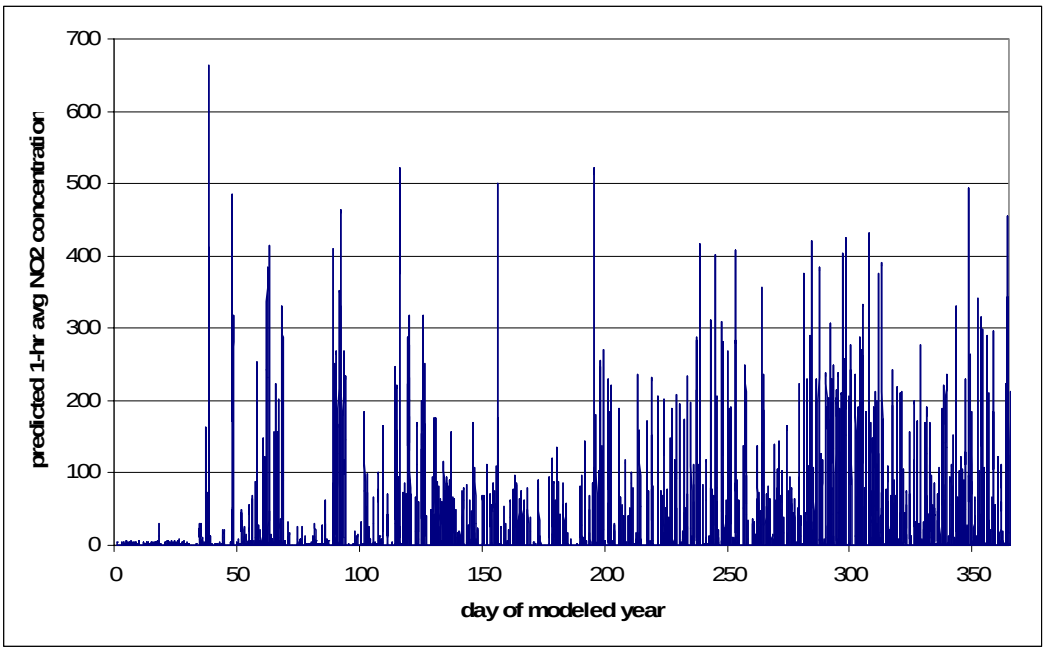
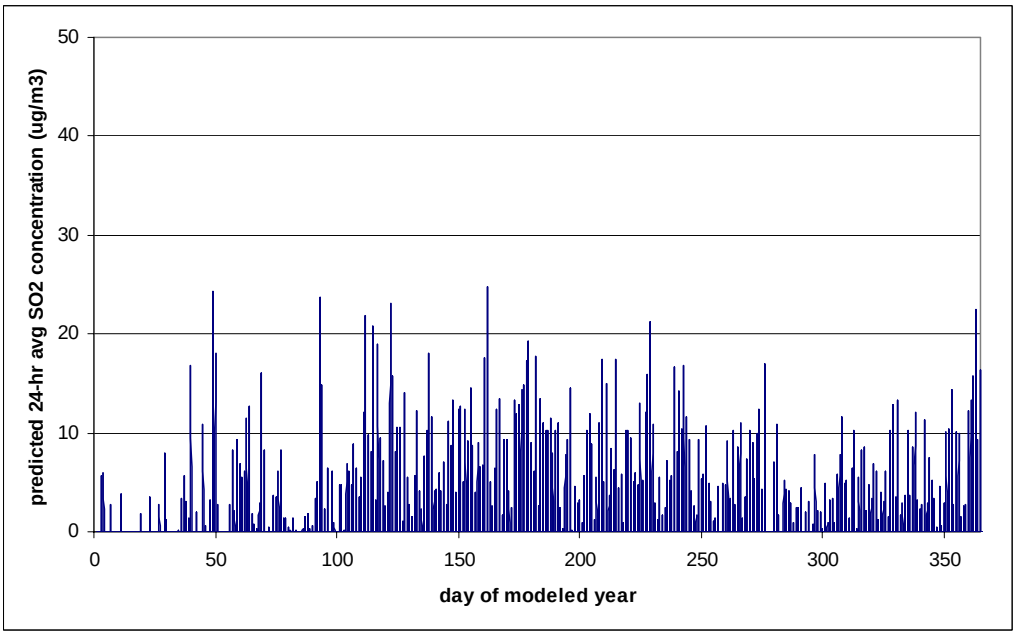


Figure 6-5: Variability of Predicted 24-hour Offshore SO_2 Concentrations[10]



For the Kizomba Satellites Supplemental EIA, emissions estimates were developed for Kizomba Satellites activities occurring in combination with

[9] Environmental Impact Assessment Development Activities for Angola Offshore Block 15 Supplement for Kizomba C - Figure 6-3

[10] Environmental Impact Assessment Development Activities for Angola Offshore Block 15 Supplement for Kizomba C - Figure 6-5

Kizomba A, Kizomba B, Marimba North, and Kizomba C (see Table 5-3 in this document). The emissions estimates indicate that the predicted maximum project emissions of NO_2, SO_2, PM and CO were the same for the Kizomba Satellites Supplemental EIA scenario as they were for the Kizomba C Supplemental EIA scenario. Based on these comparisons, the modeling conducted for the Kizomba C Supplemental EIA was used to assess the impacts to air quality from the Kizomba Satellites project activities, occurring in conjunction with other Block 15 activities.

6.3.1.2 Potential Impacts

As described above, for NO_2, SO_2, PM and CO, the air quality impacts for Kizomba Satellites have already been effectively assessed in the Kizomba C Supplemental EIA, and the conclusions drawn therein are not changed. Accordingly, conclusions remain the same, and predicted onshore and offshore concentrations are below the respective comparison standards.

Accordingly, as was stated in the Kizomba C Supplemental EIA, results of the OCD dispersion modelling analysis indicate that, assuming construction and operation of the Kizomba Satellites development in conjunction with operation of existing Block 15 developments, no predicted maximum onshore concentrations will exceed WHO AQGs. Additionally, it is noted that the WHO AQGs were developed to protect the general public health from the effects of air pollution, and thus the predicted concentrations are expected to be protective of public health. It is thus concluded that air quality effects to onshore receptors and offshore workers represent a direct, local impact that is of a negligible significance for the vast majority of the time, increasing to a minor significance (i.e., of low magnitude and within standards) during periods associated with the low frequency meteorological conditions described above. From a duration standpoint, the peak emissions will occur during periods of drilling and, therefore, can be considered short-term in nature.

Potential exposure of fishermen and other non-worker marine traffic receptors to air emissions from the Block 15 operations was also considered. Predicted high concentrations for NO_2, SO_2 and PM occur infrequently and are limited to the immediate vicinities of the offshore facilities within Block 15; it is unlikely that offshore non-worker receptors will be present within these immediate vicinities. Accordingly, it is concluded that such air quality effects to offshore non-worker receptors represent a direct, local, short-term, negligible impact.

6.3.1.3 Mitigation Measures

All predicted maximum onshore and the vast majority of predicted maximum offshore concentrations are below WHO AQGs. All predicted maximum offshore concentrations are below standard U.S. worker exposure guidelines. Additionally, predicted maximum offshore concentrations within areas expected to be occasionally occupied by offshore non-worker receptors are below WHO AQGs. Accordingly, no mitigation measures are required with respect to air

emissions.

6.3.2 Drilling-related Discharges

The main impacts associated with drilling-related discharges include discharge of drill cuttings and drilling fluids and the resulting effect on the seabed immediately surrounding the drill centers. As summarized above, a total of 18 wells, concentrated at four drill centers, are planned to develop the Mavacola and Clochas reservoirs.

6.3.2.1 Methodologies for Assessing Impacts

For the Block 15 EIA, modeling was performed to predict the fate of the drill cuttings and mud particles discharged to the marine environment. The modeling was performed using the Offshore Operators Committee Mud and Produced Water Discharge Model (the OOC Model). The OOC Model was used to predict the seabed loading of drilling sediments and the extent and thickness of drilling solids accumulation around each well center. The OOC Model simulations incorporated deposition of water-based mud (WBM) and WBM cuttings directly to the seabed (for upper sections of each well) and deposition of NAF mud and NAF cuttings via a sub-sea discharge pipe. Results of the modeling included a total area within which drilling solids deposition was predicted to exceed 1 centimeter (cm) in thickness. A thickness of 1 cm has been identified by the U.S. Minerals Management Service (MMS) as the thickness above which physical smothering effects would be expected to occur.

6.3.2.2 Potential Impacts

The primary potential impacts associated with drilling-related discharges include: localized physical smothering of benthic organisms covered by drilling solids; turbidity-related effects to species in the water column near the discharge points; and toxic effects to benthic organisms due to the presence of hydrocarbons in the NAF mud-based cuttings. The Block 15 EIA included an assessment of these impacts and concluded the following (current impact criteria added in parentheses):

- For the Kizomba A, Kizomba B, Xikomba, and Kizomba C and Project Y developments, the total area within which drilling solids deposition was predicted to exceed 1 cm in thickness (i.e., the area within physical smothering effects would be expected to occur) was less than 0.06% of the area of Block 15 (i.e., a direct, short-term, local, minor effect).
- Turbidity-related effects would be localized and short-term in nature, and would not be expected to result in long-term effects to aquatic organisms in the vicinity of the discharges (i.e., a direct, temporary, local, minor effect).
- Some degree of toxic effects related to discharge of NAF-based mud cuttings would be expected based on deposition of hydrocarbon-affected drilling solids. However, the maximum anticipated hydrocarbon concentrations at drill centers, assuming a 10% hydrocarbon content in discharged NAF-based

mud cuttings, is less than 100,000 ppm, and declines rapidly with increasing distance from the discharge location (resulting in localized toxicity of a direct, medium-term, local, minor effect).

Relative to physical smothering effects, the Block 15 EIA modeling was based on drilling 190 wells from a total of 20 drill centers. Development of Mavacola and Clochas includes drilling 18 development wells from 4 drill centers. Based on the results of the OOC modeling conducted for Block 15, the Kizomba Satellites drilling would be expected to result in physical smothering effects covering less than an additional 0.01% of Block 15 for Phase 1. As in the case of the initial developments, this additional impact is considered to be short-term (as re-colonization will occur following cessation of deposition), direct, local and minor in effect.

Relative to turbidity-related and toxic effects, Kizomba Satellites would be expected to result in similar effects to the development components assessed in the Block 15 EIA (temporary to medium-term, direct, local, minor effects).

6.3.2.3 Mitigation Measures

Cuttings dryers have been installed on the rigs drilling development wells in Block 15 to properly process and handle the NAF drilling fluid and discharge the treated cuttings in accordance with Angolan government regulations. The use of cuttings dryers has significantly reduced the percentage of NAF-based muds discharged on cuttings, compared with the numbers presented in the original Block 15 EIA. EEAL has incorporated this into its EMP, and will perform post-drilling sediment monitoring in the vicinity of the drill centers to further assess changes in physical, biological and chemical characteristics of the sediments.

6.3.3 Operational Discharges

The main impacts associated with operational discharges include water column effects from the discharge of produced water from the FPSOs, and the discharge of other effluents from the FPSOs, MODUs and support vessels. Because produced water discharges constitute over 95% of the total operational discharges for the project, this impact discussion focuses on the produced water discharges.

6.3.3.1 Methodology for Assessing Impacts

For the Block 15 EIA, ExxonMobil Upstream Research Company predicted the fate of produced water discharged to the marine environment using the Offshore Operators Committee (OOC) Mud and Produced Water Discharge Model (the OOC Model). A brief description of the OOC Model and results of the simulation runs follows.

OOC Model

The OOC Model is a numerical model capable of predicting the dispersion of produced water discharged into marine environments. The model was developed by Exxon Production Research Company (EPR) with partial funding from the Gulf of Mexico Offshore Operators Committee (OOC). Model development started in 1978 and a drilling mud discharge model was released to industry and regulatory users in 1983 (Brandsma and Sauer, 1983). The model's capabilities have been continuously improved since the initial release as a result of model research and field validation tests sponsored by the Offshore Operators Committee and EPR (O'Reilly et al. 1989, Smith, et al. 1994). An updated version of the model, which includes the capability for modeling produced water discharges, was released to OOC member companies in March 2000 (Brandsma and Smith, 1999). The model requires data on effluent temperature and salinity, discharge rate and duration, discharge pipe configuration, and ambient conditions of the receiving water to predict dispersion of produced water.

Simulation of produced water discharges

To simulate the produced water discharge plumes, the OOC Model utilized data on the effluent temperature and salinity, discharge rate and duration, discharge pipe configuration, and the ambient conditions of the receiving water. The model was run for the original Kizomba A and Kizomba B discharges, under both continuous (steady state) and discontinuous discharge scenarios. Three current speeds were used for the modeling (3.3, 14 and 31 cm/sec) corresponding to the 5th, 50th and 95th percentile current speeds, respectively. The maximum discharge rate was 37,000 m^3/day based on Kizomba A. For the purpose of the modeling, a single current direction was assumed so that the maximum plume travel distance would be predicted.

Results from the modeling were used to determine the maximum produced water concentration as a function of distance from the discharge point. The volume of the steady-state effluent plume containing greater than 1% produced water is predicted to be equivalent to a sphere with a diameter of between 18 and 25 m depending on the current speed modeled. The range of predicted maximum produced water concentrations at 100 m from the outfall was 1.1% for the slow current conditions to 1.9% for the fast current conditions. The produced water concentration dilutes to less than 1% for all discharge scenarios at 1,000 m. As a single current direction was assumed so that the maximum plume travel distance would be predicted, these results are independent of the current direction in the receiving water.

As noted above, the maximum discharge rate used in the model runs was 37,000 m^3/day. For the Kizomba Satellites Project, the maximum expected discharge rates will increase due to the additional volume related to handling the Kizomba Satellites production on Kizomba A and Kizomba B FPSOs during the declining years of the Kizomba reservoirs. The maximum expected discharge rate for Kizomba A, including Kizomba Satellites production, is now 52,900 m^3/day and

is expected to occur in calendar year 2017. For Kizomba B, the maximum expected discharge is 36,200 m^3/day and is expected to occur in calendar year 2020. In both cases, the conservative assumption was made that the oil and grease content in the discharged water was at the maximum permitted level of 40 mg/l.

6.3.3.2 Potential Impacts

As discussed and referenced in the Block 15 EIA, produced water toxicity studies have indicated that toxicity effects are generally associated with produced water concentrations in excess of 1%. For example, a substantial body of data from Gulf of Mexico produced water toxicity studies performed on mysid shrimp showed that 98% of 96 hour LC_{50} values were above 1%, and that the mean 96 hour LC_{50} was approximately 11.5%.

Model runs for Kizomba A and Kizomba B predicted that, under a continuous discharge scenario, the produced water concentration drops below 11.5% before the plume travels 5 m away from the discharge point, and the extent of concentrations in excess of 1% is limited to between 100m and 1,000m from the discharge point. The model runs also predicted that the longest time an organism drifting into the effluent plume would be expected to be exposed to produced water concentrations in excess of 1% is between 1 and 8.5 hours. This is significantly shorter than the 24 to 96 hour exposure times required by most toxicity testing protocols.

The predicted Kizomba A FPSO discharge rate associated with Kizomba Satellites is approximately 143% of that modeled for Kizomba A. However, due to mixing and the anticipated exponential decline in the concentration of oil and grease in the discharged produced water, the extent of the plume with produced water concentrations in excess of 1% and the associated organism contact times, are not predicted to significantly increase relative to what was predicted for Kizomba A. In the case of the Kizomba B FPSO, the predicted discharge rate is less than that modeled for Kizomba A. Accordingly, the extent of the plume with produced water concentrations in excess of 1% and the associated organism contact times would be predicted to decrease relative to what was predicted for Kizomba A. In conclusion, the discharge of produced water is expected to result in a direct, long-term, local, minor effect.

6.3.3.3 Mitigation Measures

As discussed above, produced water will be treated so that resultant oil concentrations are less than 40 mg/l (monthly average, per Angolan Regulation Executive Decree 12-05 Article 7 for Produced Water). Consistent with EEAL's current operations in Block 15, these concentrations will be monitored, and reports will be issued in the event that daily measurements show average oil concentration greater than 60 mg/l.

6.3.4 Accidental Hydrocarbon Releases

The Block 15 EIA conducted a detailed review of the potential impacts of an accidental hydrocarbon release, including oil spill modelling to assess potential transport of spilled hydrocarbons. Other than extending the length of time that operations will be occurring in Block 15, the Kizomba Satellites project does not significantly increase the potential for impacts related to accidental hydrocarbon releases. In this regard, the Block 15 EIA assumptions regarding Kizomba A and Kizomba B operations are representative of the related risks associated with the Block 15 planned Kizomba Satellites operations.

6.3.4.1 Summary of Historic Oil Spill Data from Production Operations

Historic spill data due to production operation is analyzed in the Block 15 EIA. A summary of this information includes the following. The overwhelming majority of spills from production operations are very small. The US Minerals Management Service collects oil spillage data in the Safety and Environmental Performance records. In 1999, 98.3% of recorded oil spills were smaller than 1 bbl. Furthermore, 99.7% of recorded oil spills were smaller than 10 bbl. A large spillage from production operations is a very uncommon occurrence. The Deepstar report (Deepstar 1999) suggests that control of small spillage events on FPSOs results in a limitation of oil release to the sea of 2.1 bbl per million bbl of throughput. This may be taken as typical FPSO performance.

In regard to the possibility of oil spills during offshore loading operations, oil tanker industry figures (ITOPF, 2001) show that approximately one third of spills from tankers result from loading/discharging operations. However, the vast majority of these spills (90%) are of less than 7 tonnes (50 barrels). In one study for the Irish Sea, it has been estimated that from loading operations somewhere between 0.1 and 0.25 barrels of every million bbl produced would be lost due to loading spillage (ERT, 2000). There are approximately 3,000 million barrels of recoverable oil projected from the present and planned developments in Block 15. If 0.1 barrel is spilled from loading operations for each 1,000,000 barrel produced, the lost oil could amount to as little as 300 barrels during the combined project lives.

In regard to the possibility of a major oil spill resulting from collision of a passing vessel with an FPSO, one risk assessment (DNV 2000) suggests that, in an area of heavy marine traffic such as the Gulf of Mexico, collision between a passing merchant vessel and an FPSO, resulting in spillage of more than 100,000 bbl of oil, might occur once in 8,333 years. The FPSOs proposed for Block 15 are moored in maritime exclusion zones, and are equipped to monitor maritime traffic. It is anticipated that any spillage at Kizomba will be typified by small volume releases.

6.3.4.2 Methodology for Assessing Impacts

Behavior of oil spills in the sea and the impact on the environment of accidental oil spills is fully discussed in the Block 15 EIA. The use of dispersants on small

oil spills occurring a long way from shore and away from sensitive marine areas is not generally recommended.

In regard to major oil spills, two possible scenarios were modeled in the Block 15 EIA using the OILMAP 97 model: an uncontrolled well blowout; and a collision at sea resulting in an FPSO tank uncontrollably leaking oil into the sea. For the latter scenario, the model runs assumed a 'worst case' oil release volume of 250,000 bbl, with no spill response. This assumption remains appropriately conservative for the purpose of this Supplemental EIA. Notably, in the history of the offshore oil industry, spillage on this scale is very infrequent.

The model was run for 16 scenarios, to represent the release of different product types under both wet season and a dry season conditions. Model results were then interpreted to assess the probability of oiling areas on the surface water, the probability of oiling shoreline areas, and the predicted travel time for the spill to reach the shoreline.

Results indicated a 1-10% probability that a (worst case scenario) 250,000 bbl release would reach the shoreline (under both wet and dry season conditions). Depending on seasonal conditions, the model predicted a travel time of between 14 and 20 days from the spill site to the shoreline.

6.3.4.3 Potential Impacts

Depending on the actual magnitude of an accidental release, as well as on a number of environmental and response factors, an accidental release from drilling or production operations in Block 15 could result in a direct, negligible to major impact, likely on a local scale. Along this same scale of potential magnitudes, impacts would be expected to range in duration from short-term (i.e., for a small spill that did not reach shore) to long-term (i.e., for the extremely unlikely large spill that resulted in oiling of the shore). The Block 15 EIA included a detailed discussion of the potential impacts resulting from an accidental release of hydrocarbons. That discussion remains applicable for the purpose of this Supplemental EIA, and includes impacts of oil spills on the marine environment (cetaceans, turtles, adult fish, eggs and larvae, benthos, crustaceans, plankton), offshore and coastal birds, artisanal fishery resource, and on the coastal environment (wetlands and coastal lagoons, manatees, estuaries and mangroves). To date, more than 200 development wells have been drilled or are planned for existing developments in Block 15. The Kizomba Satellites development described in this Supplement requires the drilling of a further 19 production wells, and may extend planned production through the existing Kizomba A and B FPSOs based on present reservoir evaluations by four years for Kizomba A and by two years for Kizomba B. Therefore, the Kizomba Satellites development represents an insignificant change in overall oil release probability for Block 15.

6.3.4.4 *Mitigation Measures*

In conjunction with the construction and start-up of Kizomba Satellites, the existing Block 15 Oil Spill Response Plan (OSRP) will be reviewed and updated as required to include Kizomba Satellites construction and operations components. As is currently performed for other Block 15 activities, employees will be trained in appropriate responses to hydrocarbon releases. To reduce the probability of a significant hydrocarbon release, the Kizomba Satellites design incorporates various engineering controls and procedures designed to minimize the extent and/or probability of a release, such as the use of blow out preventers on wells during drilling, and the use of trained pilots to guide export tankers to each FPSO.

7.0 ASSESSMENT OF SOCIOECONOMIC IMPACTS

7.1 SCOPE OF SOCIOECONOMIC IMPACT ASSESSMENT

The Block 15 EIA provided a general description of the social and economic situation of the Republic of Angola, the local situation at the three onshore support activity facilities at Soyo, Luanda, and Lobito, and the impact of the Xikomba, Kizomba A and Kizomba B developments, particularly with respect to direct and indirect jobs created in Angola as a result of these developments. This section builds on EEAL's activities in Angola since the start of development and production operations in Block 15, and focuses on socioeconomic impacts that are directly attributable to Kizomba Satellites. Accordingly, this section considers:

- The Angolan socioeconomic 'footprint' of the Kizomba Satellites project during construction and production; and
- Potential socio-economic impacts associated with the Kizomba Satellites project.

7.2 SOCIOECONOMIC FOOTPRINT OF THE PROPOSED DEVELOPMENT

The Kizomba Satellites project builds on the existing infrastructure established and already in place for the Kizomba A, B and C developments. The Kizomba Satellites project will develop oil and gas reserves from additional Block 15 reservoirs, which collectively have an estimated total of up to 505 million barrels of recoverable oil in place and which would be uneconomical to develop without existing infrastructure. Oil production and export from the first phase of the Project is planned for the first quarter of 2011. To support this goal, MODU drilling is planned to start in 2009, with installation of the first subsea components to follow later in 2010. A further phase of satellite developments is possible, and production from the satellite field developments is estimated to prolong the productive life of Block 15 and continue for more than 20 years.

The socioeconomic footprint of the Kizomba Satellite project's activities in Angola includes:

- Onshore sites used for fabrication, supply and trans-shipment of project materials and/or for project administration, as well as the interface between these sites and neighboring communities;
- Offshore sites and maritime transport routes, as well as the interface between these sites and routes with fishermen and other sea-going vessels; and
- Non site-specific dimensions of the project that produce socioeconomic effects, such as employment, procurement and generation of revenue for the Government of Angola.

A procurement plan has been developed and implemented that optimizes national content for fabrication and offshore construction, and that realizes synergies with other projects and other operations in Angola. Existing onshore

bases will be used as supply and trans-shipment sites. Offshore construction and production for the Kizomba Satellites project will utilize three existing onshore support activity facilities in Soyo, Luanda, and Lobito. EEAL maintains administrative offices and housing in Luanda and Soyo.

7.3 POTENTIAL SOCIOECONOMIC IMPACTS

This section discusses the potential socioeconomic impacts of Kizomba Satellites construction and operations.

7.3.1 Revenue

The Kizomba Satellites development will extend the economic life of Block 15 production facilities, and will add an estimated 485 million barrels to the recoverable reserves from Block 15. Thus, the Kizomba Satellites project will result in a significant, beneficial impact to national revenue generation.

7.3.2 Employment - Direct and Indirect Jobs

The Kizomba Satellites development will produce short term jobs through contractors for project design, onshore fabrication and offshore construction, and long term jobs due to the requirements for support from Angola contractors for the additional offshore operations. Since Kizomba Satellites builds on the infrastructure established by EEAL for the Kizomba A , B and C operations, the project will generate less direct long-term operations jobs than were generated for the Kizomba A, B and C developments.

EEAL's policy and high priority is to transition the makeup of the Block 15 workforce such that the ultimate majority of employees are locals (i.e., Angolans). EEAL's recruitment and training policy is geared toward achieving this goal in the short-term. Article 12 of Concession Decree 14-94 establishes a local hiring plan between EEAL and MinPet; progress of this plan is reviewed regularly. Currently, about 49% of the Kizomba A and B offshore workforce is Angolan. This is expected to increase to more than 80% by 2015 as a result of nationalization. This is done through an active mentoring and competency assessment program and a fast track program to enable high potential Angolans to occupy positions of higher responsibilities sooner.

The additional direct employment and the additional revenue injected into the local economy by the Kizomba Satellites project is expected to incrementally increase income generation for the local area and indirect employment over current levels; these expected positive impacts are consistent with the assessment provided in Chapter 8 of the Block 15 EIA.

The Kizomba Satellites operations also will create indirect employment opportunities for people in Angola. These will include potential increased numbers of employees for existing services, such as:

- Soyo and Kwanda onshore base support (e.g., warehouse and dock workers, cooks, maids, maintenance workers);
- Marine vessel crews;
- Aviation (e.g., pilots, dispatchers, clerks, handlers);
- Housing and expatriate personnel support (e.g., drivers, security guards, maids, catering, gardeners, maintenance workers);
- Travel services (immigrations, customs);
- Logistics (e.g., shipping, barge crews);
- Construction and maintenance of project facilities; and
- Expansion of other industries supporting the offshore oil operations.

In summary, the project is expected to result in positive, direct, local impacts of minor significance (through additional direct employment) as well as positive, indirect, local impacts of minor significance (through additional related service employment). These impacts will range in duration from short-term (in the case of construction jobs) to long-term (in the case of operations jobs).

7.3.3 Procurement - Demand for Goods and Services

A procurement plan has been developed and implemented for design, fabrication and construction activities; this plan optimizes national content, and realizes synergies with other projects and other operations in Angola. The Kizomba Satellites project will increase demand for goods and services, but this increase would only be expected to represent a positive, direct, local, short-term, minor impact.

7.3.4 Local Economic Development

The demand for onshore goods and services to support the offshore operations for the Kizomba Satellites project is expected to create additional indirect jobs and stimulate the local economy. Based on the size of the combined Block 15 EIA developments relative to the size of the local economy, Kizomba Satellites is not likely to impact inflation rates. Accordingly, it is concluded that the Kizomba Satellites project's impact to inflation would represent a negligible impact.

7.3.5 Loss of Access to Onshore Resources/Services or Potential Resettlement

The procurement plan for Kizomba Satellites aims to further develop and make the optimum use of Angolan fabricators and support contractors. It is expected that this will result in increased onshore activities within areas already designated for industrial development. Therefore, the use of onshore facilities for Kizomba Satellites is not expected to displace any people from their place of residence or employment. Furthermore, Kizomba Satellites activities are not expected to require an increase in base capacity sufficient to prompt expansion (which might cause such displacements). It can therefore be concluded that

Kizomba Satellites is not likely to cause any loss of access to onshore resources or any economic or physical resettlement, and this impact is therefore considered to be negligible in significance.

7.3.6 Fishing Activities

The footprint of the Kizomba Satellites development could overlap with marine activity of fishermen in offshore waters. Overall, however, the project is expected to result in relatively limited maritime interaction with fishermen and a negligible impact on them, as discussed below.

According to a 2005 Marine Fisheries Institute (IIM) Report, recent surveys recorded 350 fishing vessels, including industrial and larger semi-industrial vessels, in the Block 15 area within the preceding five years leading up to the study. Table 7-1 provides information on the distribution of these vessels by type, classified by fishing license, as well as the approximate water depth range in which the vessels were observed.

TABLE 7-1: Vessel Type Distribution Based On Fishing License

Vessel Type	*Percentage of Fleet*	*Water Depth Range (m)*
Shrimp Trawlers	16%	50-950
Bottom Fish Trawlers	18%	10-800
Pelagic Trawlers	15%	20-1,000
Purse Seiners	33%	15-300
Gillnetters	2%	10-200
Handlines	13%	10-400
Pelagic Longline	2%	50-2,000
Pole and Line	1%	50-2,000

Bottom trawling is generally confined to water depths of a few hundred meters due to technical difficulties in using this technology at greater depths. Some bottom fishing occurs in the shallower portion of Block 15, but the amount of activity is low. The IIM Report concludes that, in general, less than one percent of the total trawling activity occurs below 900 meters. The bulk of Kizomba Satellites facilities will be located in water depths between 1,000 meters and 1,500 meters. As for pelagic fishing efforts, the IIM Report indicates that there is little or no fishing by purse seiners or pelagic trawlers in Block 15. Data are not available to quantify the number of tuna vessels fishing with longline or pelagic driftnets in the area. These vessels are typically non-Angolan vessels that come into Angolan waters to fish for tuna during limited periods of the year.

In summary, for the categories of vessels described above, the information available to IIM indicates that there is no or limited fishing in the area of Block 15. Fishing activity distribution maps indicate that the Kizomba Satellites operations fall in activity zones classified as "low" or "extremely low / non-existent" activity. Based on this information, the Project is expected to have negligible impacts on local fishing activities. Direct, short-term, local, minor impacts to fishermen will occur on a limited basis due to their exclusion from the

work area during the construction phase. No long-term impacts to fishermen are anticipated from the Kizomba Satellites development.

8.0 ENVIRONMENTAL MANAGEMENT SYSTEM

8.1 GENERAL

The Environmental Management System for the Project will be covered by the existing system in place for other EEAL developments in Block 15. This system is fully described in the Block 15 EIA, and has been successfully implemented for Kizomba A, Kizomba B, Kizomba C, Marimba, and Xikomba.

Angola Decree 39-00 on Environmental Protection for the Petroleum Industry requires a number of environmental plans to be filed and approved prior to initiation of relevant operations. These plans include:

- Environmental Impact Assessment;
- Spill Prevention Plan;
- Spill Response Plan;
- Waste Management, Disposal and Deposit Plan;
- Operational Discharge Management Plan (ODMP); and
- Site Abandonment and Rehabilitation Plan.

8.2 SUBMISSION OF PLANS

The Block EIA was approved by MinPet in November 2001. With the exception of the Site Abandonment and Rehabilitation Plan, all of the other EMPs referenced above were submitted and approved prior to the start of relevant operations in Block 15. These plans are updated as required and to remain current with developments in Angolan regulations and reporting requirements. The most current revisions are as follows:

- Spill Prevention Plan (July 2003);
- Spill Response Plan (September 2005);
- Waste Management, Disposal and Deposit Plan (September 2007); and
- Operational Discharges Management Plan (July 2007).

The Site Abandonment and Rehabilitation Plan for production and operations will be submitted in accordance with the timing requirements of Decree 39-00, at least one year before the first production operations are abandoned.

8.3 ENVIRONMENTAL MANAGEMENT

8.3.1 Key Environmental Commitments for the Block 15 Developments

The key environmental commitments established by EEAL for the Block 15 developments, based on Angolan legal requirement and industry best practice, are summarized in Table 8-1. EEAL's existing EMS monitors performance against these standards, and establishes procedures to take corrective action if

the performance is not in accordance with the standard. For each regulated item (e.g., produced water, material handling, etc.), Table 8-1 lists, in the second column, the practice/standard to which EEAL has committed that it will hold its Block 15 projects (including the Kizomba Satellites development). The third column in the table describes the specific monitoring and corrective action activities that will be employed to ensure these commitments are satisfied.

TABLE 8-1: Key Environmental Commitments for the Block 15 Developments

Regulated Item	*Practice/Standard*	*Monitoring/Corrective Action Activities*
Discharges to Sea		
Produced water	Maximum monthly average of less than 40 mg/l oil and grease.	Daily sampling, analysis, and recording of oil and grease content. Corrective action to meet limit of less than 40 mg/l oil and grease. Reports issued for daily measurements with average oil concentration in excess of 60 mg/l.
Subsea Hydraulic Fluid Discharge	Discharge allowed. Use water-soluble, low-toxicity fluid.	None, other than assurance of proper fluid use.
Cooling Water	No sheen allowed on the receiving water body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Well Treatment, Completion, or Workover Fluids	No sheen allowed on the receiving body. Maximum monthly average of less than 40 mg/l oil and grease. Chemicals selected based on optimum operational performance and obtained from approved suppliers.	Daily sampling, analysis, and recording of oil and grease content. Corrective action to meet limit of less than 40 mg/l oil and grease. Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Hydrostatic Test Water	No sheen allowed on the receiving body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Wash-down Water	No sheen allowed on the receiving body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Rain Water/Deck Drainage	No sheen allowed on the receiving body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.

Regulated Item	*Practice/Standard*	*Monitoring/Corrective Action Activities*
Boiler Blowdown	No sheen allowed on the receiving body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Desalinization Blowdown	No sheen allowed on the receiving body.	Daily visual monitoring of the sea and recordation of observations. Corrective action if sheen observed.
Gray Water	No solids greater than 25 mm in diameter.	Quarterly check of grinding mechanism performance.
Black Water	Certified sewage treatment plant meeting the requirements of Resolution MEPC 2(VI) of the International Maritime Organization or of the United States Coast Guard (USCG) for a Type II MSD. No floating solids and no solids greater than 25 mm in diameter. Total residual chlorine in the range of 0.8 to 1.5 mg/l. Note: construction vessels operating in Block 15 are covered by MARPOL 73/78 Annex V and are required to have installed and operating Marine Sanitation Devices approved by their flag administrations.	Daily visual monitoring of the sea and recording observations. Corrective action if floating solids observed. Daily record of free chlorine in discharge, which should be between 0.8 mg/l and 1.5 mg/l. Monthly performance check of the treatment unit free chlorine. Corrective action if less than 0.8 mg/l or greater than 1.5 mg/l.
Food Preparation Wastes	No solids greater than 25 mm in diameter.	Quarterly check of grinding mechanism performance.
Drilling Mud and Cuttings Handling		
Water Based Mud Discharge	Discharge allowed (no environmentally sensitive area in proximity). Maximum average daily flow of 1,000 bbl/hour.	Number of days visual sheen observed. Rate of drilling fluid discharged during each hour to be recorded and reported as estimated average daily value. Chemicals used to be recorded

Regulated Item	*Practice/Standard*	*Monitoring/Corrective Action Activities*
Water Based Mud on Cuttings Discharge	Discharge allowed (no environmentally sensitive area in proximity).	Measure and report volume of cuttings discharged.
Non-aqueous Fluid (NAF) Based Mud Discharge	No discharge of neat mud allowed.	Report neat mud spills as oil spill.
Non-aqueous Fluid (NAF) Based Mud on Cuttings Discharge	Discharge allowed (no environmentally sensitive area in proximity).	Daily estimated volume of drill cuttings based on gauge hole volume. Daily monitoring of oil retained on cuttings when discharging using wet weight ratio method described in API 13-B2. Daily estimated % NAF on cuttings to be recorded. Take corrective action if oil on cuttings exceeds level permitted by Angolan regulations. Monitor seabed before and after drilling via video at selected locations. Compare findings to model predictions of accumulations and expectations of biological disturbances.
Emissions to Air		
Produced Gas	No continuous flaring.	Measure and record gas flared annually. Obtain MinPet approval in advance of longer duration flare events. Compare annual measurement to maximum annual estimates in EIA. Model results if measured flare volumes significantly exceeds maximum annual EIA estimate. Corrective action if modelling indicates unacceptable onshore impact from offshore emission.
Gas-freeing of Process Equipment	Route to collection header and flare.	None; very low volume emissions

Regulated Item	*Practice/Standard*	*Monitoring/Corrective Action Activities*
Internal Combustion Engine Emissions	No emissions controls.	Measure and record fuel consumption annually. Maintain equipment to manufacturer's specifications. Compare annual measurement to maximum annual estimates in EIA. Model results if measured fuel consumption significantly exceeds maximum annual EIA estimate. Take corrective action if modelling indicates unacceptable onshore impact from offshore emission.
Gas Turbine Emissions	No emissions controls	Measure and record fuel consumption annually. Maintain equipment to manufacturer's specifications. Compare annual measurement to maximum annual estimates in EIA. Model results if measured fuel consumption significantly exceeds maximum annual EIA estimate. Take corrective action if modeling indicates unacceptable onshore impact from offshore emission.
Fugitive Emissions	No emissions controls	None; very low volume emissions
FPSO Storage Tanks Venting	Inert gas generation and blanketing. Vent tank to atmosphere.	Estimate and report composition and volume of vent gas annually. Compare to maximum annual estimate in EIA. Model results if estimated volume significantly exceeds maximum annual EIA estimate. Corrective action if modeling indicates unacceptable onshore impact from offshore emission.
All other vents (methanol, diesel, slop system, base oil, etc.)	No vapor recovery.	None; very low volume emissions

Regulated Item	*Practice/Standard*	*Monitoring/Corrective Action Activities*
Well clean-up	High efficiency burner configuration	Monitor performance during flaring. Make operating changes for peak performance during flaring considering water cut, etc. Take corrective action as needed to maintain performance.
Glycol Dehydration	No vapor recovery.	Estimate and record composition and volume of vent gas. Compare to maximum annual estimates in EIA. Model results if estimated volume significantly exceeds maximum annual EIA estimate. Corrective action if modeling indicates unacceptable onshore impact from offshore emission.
Materials Management		
Flammable/Explosive Material Handling, Storage, and Disposal	Disposal will be onshore incineration facility or recycle.	Measure and report volumes for disposal. Document incidents. Take corrective action to reduce/eliminate incidents.
Produced sand/tank bottoms	Ship to shore for landfarm, landfill or incineration	Measure and report volumes for disposal. Document incidents. Take corrective action to reduce/eliminate incidents.
Other solid wastes	Ship to shore for recycle, landfill or incineration as appropriate	Measure and report volumes for disposal. Document incidents. Take corrective action to reduce/eliminate incidents.
Decommissioning and Rehabilitation		
Decommissioning and Rehabilitation	A Decommissioning and Rehabilitation Plan will be submitted to the Angolan Ministry of Petroleum (MinPet) at least one year prior to the end of operations	(none)

8.3.2 Monitoring of Discharges

EEAL operations personnel monitor, measure (or estimate), and report emissions and wastes in accordance with government requirements. The following streams are monitored and reported:

Produced Water

- Volume of produced water discharged;
- Volume of oil in produced water discharged; and
- Concentration (mg/l) of oil & grease in produced water discharged, with number of exceedances (>40 mg/l monthly average and >60 mg/l daily).

Air Emissions

- Gas flared (only during facility upset);
- Hydrocarbon venting from FPSO;
- Fuel gas consumed; and
- Diesel fuel consumed.

Muds on Cuttings Discharged

- Volume of mud discharged; and
- Oil retention on cuttings (ROC %).

In addition, EEAL plans from time to time to monitor the drill cuttings accumulation, at a minimum by television camera mounted to a remotely operated vehicle (ROV). EEAL will plan this activity to obtain some baseline videos before drilling begins and then to periodically assess the accumulations as well as qualitative biological effect on the seabed.

Oil Spills

- Oil spills, number and volume.

Chemical Spills

- Chemical spills, number and volume.

8.3.3 Regulatory Compliance

EEAL's policy requires compliance with Angola laws rules, regulations, decrees, and other Project agreements. EEAL's operations personnel have developed a comprehensive Regulatory Compliance Plan that identifies Angola legislation and regulation pertinent to oil and gas operations. This Plan is used to manage compliance planning aspects. A key feature of the Plan deals with management of change to identify new laws and regulations and integrate them into the environmental compliance planning process.

8.3.4 Environmental Auditing Strategy

Periodically, EEAL will audit its project EMS to ensure that it is performing as required. Changes will be made to the EMS if the audits indicate that these are necessary to improve the system.

9.0 REFERENCES

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