9 POTENTIAL IMPACT IDENTIFICATION AND EVALUATION – UNPLANNED EVENTS

9.1 Introduction

This section describes the process being undertaken and management measures being implemented to reduce the risk of unplanned events and manage them in the unlikely event that they occur.

Unplanned events are not expected to occur during the pipeline's normal construction and operational phase activities.

The pipeline engineering design criteria were adopted with an aim to reduce the probability and consequences of unplanned events that could lead to impacts to social or environmental VECs. At each stage of the design process, a series of health, safety and environmental (HSE) studies has been, and will continue to be, undertaken.

This section includes:

- scope of evaluation of unplanned events
- the risk management approach
- risk reduction
- construction risks
- operational risks.

Unplanned events have been identified and assessed for:

- activities in all phases:
  - traffic accidents
  - fires
- construction, and commissioning phase activities:
  - damage to third-party assets
  - release of diesel from fuel storage tanks at the MCPY and construction sites
  - release of hydrotest water during commissioning
- operation:
  - potential external causes of a pipeline breach, including geotechnical (e.g., earthquakes, landslides) and sabotage
  - modelling of oil spills at sensitive locations.

The risks associated with other construction related activities, including minor unplanned spills, risk of communal violence and health epidemics have been considered in Section 8.

The risks associated with extreme meteorological conditions, non-project originating fires (wildfire), aircraft crashes, political coups, and cumulative impacts of unplanned project events occurring at the same time as a third-party development unplanned event are not evaluated as these cannot be reasonably predicted or prevented.

Occupational health and safety (OH&S) impacts associated with unplanned events are considered in Section 8.16. To ensure OH&S readiness of the workforce for unplanned events, the project will:

- use national and international standards
- use equipment that can accommodate unplanned events
- provide readiness training
- establish a corporate OHS management system.

9.2 Risk Management Approach

The project conducted a technological risk assessment during front end engineering and design (FEED) in accordance with the Tilenga feeder pipeline HSE risk assessment methodology.

Risk assessment has been undertaken to inform:

- the design process
- the environmental and social impact assessment (ESIA) process and the development of mitigation measures.

Additional risk assessment will be undertaken during detailed engineering and construction planning. This shall include updates to hazard identification (HAZID), hazard operability (HAZOP), and environmental aspects identification (ENVID) studies. Construction planning will also include risk assessment for high risk construction activities, such as traffic movement, heavy lifting and spills.

The additional risk assessment will also inform the environmental and social management planning for the project.

The commitments register in Appendix E4 includes a summary of the measures, plans and programmes including the preparation of an emergency response plan for the project in concordance with national requirements, the International Finance Corporation (IFC) performance standards and EHS Guidelines. The emergency response plan provides information on how the project will respond to a major emergency. As such, it describes:

- the pipeline emergency response organisation, based on defined accident scenarios
- functions and responsibilities of key personnel
- the resources required
- emergency procedures.

The emergency response plan will be comprised of several management plans and procedures, such as an oil spill contingency plan and spill management and response plan.

The project will also prepare a community, health, safety and security plan which will include:

- control of preventable diseases
- transport management and road safety
- community safety and security.

9.2.1 Preliminary Risk Rating

Work has been undertaken that supports the establishment of a preliminary rating of the risks and related significance, based on existing engineering knowledge and project design (Section 2), and professional judgement.

A summary of the modelling of the migration of oil released from the pipeline or aboveground installation (AGI) is included in Section 9.5.2. The preliminary risk assessments undertaken will be reviewed and updated as the project design is progressed.

9.3 Risk Reduction

Potential risks will be reduced through:

- design and construction mitigation
- health, safety, security, society and environment systems and procedures
- emergency response planning.

9.3.1 Design and Construction Mitigation

Design and construction mitigation measures have been incorporated to the pipeline to reduce risk during construction and operation, throughout the design process.

9.3.1.1 Construction

The following are risk reduction design and construction mitigation measures:

- Constructability risk was one of the main criteria evaluated during route selection. This included:
    - extensive route refinements that were made to reduce front and side slopes to ensure safe access for construction activities
    - safe access to work sites to reduce the risk of accidents during transport of materials, equipment or people to the works sites
    - construction methodologies that were evaluated to identify the options with lower risks. This included considering the number of construction spreads to be used, and options to reduce road traffic during construction.
- The HAZID undertaken at the FEED stage identified the main construction hazards (including loss of containment and mitigation measures) which require further development during later project phases.
- Additional constructability reviews will be undertaken for construction facilities which will include the development of CEMPs, and risk assessments, method statements (RAMS) for construction. The intention of these documents is to ensure that appropriate mitigation measures are identified and implemented throughout construction.

9.3.1.2 Operation

Substantial work to identify operational hazards and unplanned events was undertaken during the early design stages of the project. This included route and site selection as described in Section 3 and during the geological, geophysical and geotechnical assessment of the route. This was undertaken to avoid or reduce the risks of unplanned events occurring during the operational phase. This included avoidance of, as much as possible:

- socially sensitive features (including residential populations)
- environmentally sensitive areas
- flooding and landslide hazards
- seismic activity (such as active rift regions and volcanoes)
- security risks.

Additionally, the following are risk reduction design and operation mitigation measures:

- The layout of the project's AGIs has been developed in accordance with established best practice and hazard mitigation principles, including:
  - selection of simple process designs to remove equipment complexity and reduce risk levels at AGIs
  - equipment grouped by nature and/or homogeneous levels of risk
  - sufficient spacing is provided to prevent transfer of hazardous consequences from a source to neighbouring equipment
  - restricted areas are defined for internal areas permanently affected by operations.
- The pipeline will be designed primarily based on the following industry standards:
  - ASMEB31.4 2016 Pipeline Transportation Systems for Liquids and Slurries.
  - ASMEB31.3 Process Piping Standard (US/International Standard)
- The pipeline will be buried to a depth of 1.8–2 m.
- The pipeline will have welded joints with no flanges, meaning there is no potential for leakage at joints.
- The thickness of the pipe wall will be increased at waterbody and wetland crossings to reduce pipeline leakage risk.
- Fusion-bonded epoxy anticorrosion coating will be applied to protect the pipe against external corrosion over the course of its operational life.
- Corrosion inhibitors, (in the event that microbiologically induced corrosion is identified) will be selected to control internal corrosion.
- A dedicated pipeline integrity management system will be implemented during the commissioning and operations phase. This will include regular preventative maintenance including operational pigging, intelligent pigging and inspection campaigns to monitor the status of the pipeline. Regular pigging will maintain optimal flow by removing wax deposits, and the use of intelligent pigs will provide information on the line integrity and condition of the interior pipeline wall.
- Main line block valves (MLBVs) will be installed which can be closed to prevent oil from flowing into a damaged pipeline section. The primary consideration for MLBV location is to limit the spread of oil, particularly in areas where the

pipeline ascends or descends, and near water bodies and environmentally sensitive areas.

- Fault-line crossings have been designed with specific criteria regarding the angle of interception and the type of backfill used.
- Strain based design will be employed for the sections of pipeline traversing seismic fault locations.
- Electrical heat tracing (EHT) will maintain temperature of the oil in the pipeline above 50°C which will maintain the internal integrity of the pipeline system by minimising wax build up and preventing the crude oil's wax content from depositing inside the pipeline.
- A fibre-optic cable will be used for pipeline leak, strain and intrusion detection.
- Restricted areas have been designated at AGIs where the project is required to have control of all possible sources of ignition likely to be present in the restricted area.
- Drainage at AGIs will be designed to reduce the risk of hydrocarbon fires, collect the surface waste liquids and limit discharge of substances to the environment.

9.3.2 Health, Safety, Security, Society and Environment (H3SE) Systems and Procedures

An HSE management system will be established for pipeline construction and operation.

The HSE management system will include safe systems of work, and monitoring and training of personnel to ensure that the likelihood of unplanned events occurring during construction and operations are minimised. The system will include:

- development of focused management plans, including:
  - reinstatement plan (MP07)
  - stakeholder engagement plan (MP08)
  - labour management plan (MP10)
  - procurement and supply chain management plan (MP12)
  - community health, safety and security plan (MP14)
  - occupational health, safety and security plan (MP 15)
  - transport and road safety management plan (MP16)
- undertaking planned maintenance to maintain optimal operating performance.
- regularly inspecting facilities and safety critical activities to ensure they are within the intended design conditions
- monitoring of areas of geotechnical instability, erosion potential and flood prone areas.
- conducting active fibre-optic monitoring for intrusion or leak through the analysis of noise, vibration and temperature change, thus allowing for early detection of any leak, construction or other external activities near the pipeline
- putting in place a security system to provide layers of passive technical and physical measures to detect, deter and defend personnel and the installations against identified threats

- reviewing pipeline operational performance and industry case studies to identify opportunities for enhanced performance
- delivering training to provide process knowledge and tools to diagnose the causes of process deviations should they occur and how to respond appropriately
- installing equipment to ensure the protection of personnel working at the facilities
- in the case of an unplanned event, reinstating and compensating for third-party damage off the right-of-way (RoW), where appropriate.

9.3.3 Emergency Response Planning

An emergency preparedness and response plan (EPRP) will be prepared which identifies possible emergency scenarios, sets out actions to be taken in the event of an emergency, and defines resources that will be made available to respond to an emergency event. This plan will be developed in coordination with stakeholders including local communities where they could potentially be affected by emergency situations.

The emergency response plan will include provision for:

- a combination of warning and communication equipment at pipeline facilities
- essential and emergency power at AGIs
- emergency shutdown, pressure protection and relief systems which will shut down a facility to a safe state in case of an emergency situation, thus protecting personnel, communities, the environment and the facility
- a fire and gas detection system to detect the presence of abnormal concentrations of flammable gas and the existence of fire at the AGIs
- a fire protection and firefighting system to reduce the effect that fire can cause to the personnel and facilities at the AGIs, based on the following components:
  - passive fire protection – for example, spacing equipment, containment and fireproofing
  - active fire protection – for example, firewater pumps, deluge, foam, hydrants and monitoring equipment.
- escape, evacuation and rescue provisions to ensure the safety of personnel who survive the initial effects of a hazardous event
- emergency pipeline repair system: The objective is to return the pipeline to pre-incident condition while ensuring an effective, comprehensive response that will prevent injury or damage to workers and the public and reduce impacts on the environment.
- community protection measures where required.

In addition to the emergency evacuation and rescue facilities provided at the AGIs, the emergency response plan and the water management plan include procedures for managing emergencies to effect a coordinated and safe response to emergencies. They include spill response procedures, requirements for the storage of hazardous materials, and refuelling procedures. See Appendix E4 for the content of the emergency preparedness and response plans.

9.4 Construction Risks

Potential unplanned events during the construction phase include:

- traffic accidents
- fires
- damage to third-party assets
- release of diesel from fuel storage tanks at the MCPY and construction sites
- release of hydrotest water during commissioning.

Traffic accidents and fires are a risk during construction, commissioning and operation. Due to the intensity of activity, the likelihood of an accident and fire occurring is greatest in the construction phase, and they are therefore considered in this document as construction activities. It is noted however that many of the control measures described will also apply during the operational phase of the project.

9.4.1 Traffic Accidents

One of the most frequent causes of injuries or death in the construction industry is accidents involving vehicles. This includes journeys on public roads as well as on-site accidents. Pipeline-related journeys will include:

- delivery of machinery, material, fuel and chemicals from where it is sourced, imported or distributed, to site using public roads
- site workers commuting to their workplace using public roads
- distribution of machinery, materials, fuel, chemicals and workers to new work areas using the roads network
- movement of machinery, materials, fuel, chemicals and workers to new work areas using the RoW
- deliveries, service call-outs, waste management collections, project visitors, using public roads
- reinstatement of RoW after construction.

Road traffic accidents can be attributed to several causes, including:

- driver fatigue
- driver behaviours and behaviour of other road users
- inappropriate level of driving experience for the vehicles being driven
- road conditions
- weather conditions
- vehicle maintenance
- congestion in town centres.

Road safety is a key consideration for the pipeline. The right to life[1] and the right to health[2] are the main human rights at risk. The UN has proclaimed 2011-2020 the International Decade of Road Safety and has developed documents to address the issue.[3] The project is committed to adhering to the highest standards of road safety.

All road traffic accidents are considered significant and can result in impacts to several VECs. Pedestrians, specifically children, as well as cyclists, are considered particularly vulnerable road users, and in the event that they are involved in a road traffic accident, the consequences are likely to be severe. Table 9.4-1 shows different types of road traffic accident can affect different VECs.

Table 9.4-1 VECs Affected by Potential Road Traffic Accidents

Type of Road Traffic Accident	VEC Most Affected	Mechanism of Effect
Vehicle collision with member of the public (pedestrian, cyclist or driver)	Community safety, security and welfare	Injury or mortality to member of the public
Vehicle collision with member of the workforce (pedestrian, cyclist or driver)	Workers health, safety and welfare	Injury or mortality to member of the workforce
Vehicle collision with livestock	Land-based livelihoods	Injury or mortality to livestock and consequent impact on livelihoods
Vehicle collision with community asset or structure	Social infrastructure and service	Physical damage to structure
Vehicle collision with project asset or structure	N/A	Physical damage to structure
Vehicle collision resulting in spillage of transported fuel or chemical	Soil, surface water, groundwater, flora and fauna	Contamination of soil and/or water, toxicity affecting living organisms

9.4.1.1 Preventive and Mitigation Measures for Traffic Accidents

To reduce the likelihood of traffic accidents, several management controls and mitigations have been adopted based on the hierarchy of risk management:

- design measures
- mitigation measures
- emergency response planning.

[1] Universal Declaration of Human Rights, article 3; International Covenant on Civil and Political Rights, article 6; African Charter on Human and Peoples' Rights, article 4.

[2] International Covenant on Economic, Social and Cultural Rights, article 12; African Charter on Human and Peoples' Rights, article 16. The right to health is an international human rights law standard in itself, and is also a component of the right to an adequate standard of living: Universal Declaration of Human Rights, article 25.

OHCHR, Fact Sheet on the Right to Health: http://www.ohchr.org/Documents/Publications/Factsheet31.pdf

Guidance on human rights and health from the World Health Organization: http://www.who.int/mediacentre/factsheets/fs323/en/

[3] The United Nations and Road Safety: http://www.un.org/en/roadsafety/documents.shtml

During the construction phase, the following measures have been or will be implemented.

Design Measures

Design measures are intended to avoid, eliminate or reduce the probability that unplanned events may occur, and their impacts. The following are design measures intended to reduce the risk of traffic accidents:

- completion of a traffic risk assessment as part of the engineering, procurement and construction management logistics study and assessment
- assessment of the potential to use alternative transportation modes to transport materials and chemicals
- identification of potential upgrades of road infrastructure to improve safety, especially at key junctions
- rest areas will be identified to allow drivers to comply with rest stop requirements and maximum daytime driving hours
- mandatory rest stops every two hours
- maximum daily hours of operation: 12 h/d
- maximum speed limits
- developing a strategy to minimise road movements by bulking up materials and by use of convoys
- site layout at construction facilities to segregate pedestrians and vehicles and reduce the requirement for reversing and operating a one-way system that separates in-coming traffic from exiting traffic
- developing traffic management measures that, where possible, avoid sensitive areas (e.g., schools or congested areas like town centres) or actively slow traffic.

Mitigation Measures

Measures to limit vehicle speed, restrict the routes used, ensure drivers are appropriately trained and are not fatigued or under the influence of drugs or alcohol when driving will be included in the transport and road safety management plan (TRSMP). The TRSMP also includes measures that will be taken to inform and educate local communities about expected traffic movements, and the risks they pose. The TRSMP will be prepared following completion of site-specific traffic risk assessments.

Emergency Response Planning

The emergency response planning framework described in Section 9.3.3 will include measures to manage construction and operational phase traffic related accidents, including loss of hazardous materials as a result of traffic accidents, and will describe the response required for managing traffic accident related unplanned events.

Additional studies to identify specific traffic risks, because of local road conditions, will be undertaken. The findings will be used to develop additional local mitigation measures prior to the commencement of construction.

9.4.2 Fires

Fires can be caused by accidental ignition of dry vegetation during certain operations involving hot work (e.g., welding, grinding, cutting). Fires could also be caused by inappropriate human behaviour, such as workers not properly discarding cigarettes, as well as actions by third-party activities, and by lightning strikes.

Fires can spread and cause environmental and social impacts. Section 6.4.1.2 describes the habitats that occur within the AOI that could be affected by fire. In view of the sensitivity of some of the habitats, it is important that stringent measures are enforced to minimise fire risks and the associated potential significant effects.

Fires can impact upon local community assets such as properties and local infrastructure and the health of community residents. Section 6.4.3.13 describes the land uses that occur within the AOI and within adjacent areas that could be affected by a fire. In the unlikely event of a fire, fire and smoke may cause both environmental and health effects.

The magnitude of impact from fires on the environment and communities will vary depending on the scale and location of the incident. While the impact of a minor fire will not be significant, the impact of a major fire resulting in harm to the personnel, the community, wildlife or loss of critical habitat would be significant.

Fire risk associated with project activities will be minimised through the definition and enforcement of strict control measures, including the adoption of a “permit to work” system for hot works. This will include use of dedicated fire waters, mobile fire protection measures (fire trucks and mobile firefighting measures). Smoking shall be strictly controlled by providing designated smoking areas for workers during all phases of the project, and other ignition sources such as welding and cutting systems will only be used under controlled conditions.

With appropriate control measures and monitoring in place, the likelihood of fires occurring during construction, commissioning or operation is expected to be low.

9.4.3 Damage to Third-Party Assets

Large mobile construction machinery items, such as excavators, dozers, and construction vehicles have the potential to cause damage to third-party property.

The risk is considered low given the chosen pipeline route, however in some locations the pipeline may cross buried utilities, and some impacts such as vibration may affect properties set slightly further back from the site preparation and enabling works activities. Impacts caused by vibration during construction are assessed in Section 8.10.

If damage to third-party assets were to occur, the impacts are expected to be local to the site of the unplanned event and short in duration.

Third-party assets will be identified by a pre-commencement survey and delineated by temporary fencing to prevent accidental intrusion on third- party land. Transport routes will be pre-planned and described as per the TRSMP mentioned in Section 9.4.1.1.

Before construction local and national utilities companies will be consulted and utilities maps reviewed by the contractors. Local and national utilities companies to be consulted will include, but not be limited to:

- Ministry of Information and Communications Technology and National Guidance
- Uganda Communications Commission
- National Information Technology Authority
- Uganda Telecom Limited (national fixed line mobile and internet provider)
- National Water and Sewerage Corporation
- Uganda Electricity Transmission Company Limited , Electricity Regulatory Authority , Rural Electrification Agency
- Uganda Electricity Distribution Company Limited
- Ministry of Works and Transport
- Uganda Railways Corporation
- Civil Aviation Authority.

Should any utilities be identified or suspected, certain equipment may be prevented from using the right of way to avoid accidental damage. Procedures to stop work will also be implemented until the nature of the services can be established and the risk deemed safe. Pipeline construction activities would restart following the definition of appropriate working methods which would avoid impacting upon the integrity of the subject services or the health and safety of the workers.

With appropriate control measures and monitoring in place, the probability of damage to third-party assets occurring is low.

9.4.4 Fuel Storage Tank Release - Main Camp Pipe Yard and Construction Sites

The construction phase will require the use of large mobile equipment, power generation equipment, and vehicles. It is therefore envisaged that bulk fuel storage facilities will be required at the MCPY and each of the construction sites to support construction spread activities. Most oil or chemical spillage incidents are likely to be limited inventory during the construction phase (typically less than 100 L). However, there is potential for larger scale spillages from the bulk fuel storage (typically between 100 L and 10 m^3) resulting from a larger tank rupture, human error or equipment failure during fuel transfer activities. An indicative inventory for fuel storage during construction is described in Table 2.3-4 of Section 2.

The likelihood of fuel storage releases is considered medium due to the level of activity and the frequency of fuel transfer operations during construction. There is the potential for acute and chronic impacts caused by larger fuel spillages depending on the type of fuel, the volume spilled, location, mobility and receptor sensitivity.

During the construction phase, the following measures will be implemented by the EACOP project:

Design Measures

- All fuels shall be stored within secondary containment providing appropriate containment in event of a spill. Such facilities shall be designed in accordance with best practices.
- Fuels will be supplied in vehicles specifically designed for the transportation of fuels oils and be made of sufficiently robust construction to prevent leaks/spills.
- All fuel storage tanks shall be fitted with accurate level measurement.
- Ancillary equipment, e.g. valves, filters, sight gauges, vent pipes and fill points will be located within the secondary containment system.
- Pipework shall be made of suitable material for use with fuel, supported and protected against corrosion and damage by impact or collision.
- Pumps used for refuelling will be equipped with automatic shut off and fuel storage shall be fitted with electronic or mechanical overfill protection devices.
- Underground pipework shall be avoided wherever practical.

Mitigation Measures

The potential impacts will be managed by implementation of measures in the pollution prevention plan, water management plan and emergency preparedness and response plan. These plans specify storage requirements for hazardous materials, define refuelling procedures, and specify actions to be taken in the event of an unplanned release of fuel. They also require the development, maintenance and testing of emergency response plans.

9.4.5 Hydrotest Water Release

Hydrotesting of pipelines is a pre-commissioning activity that tests the pipe weld and wall for defects and general pipeline strength and integrity as described in Section 2.4.4.2. It is therefore an essential mitigation for minimising the unplanned events of a release of oil from the pipeline (Section 9.5.2). However, if the test identifies a defect, the test water will be released through the defect. Depending on the size of the defect, test water can be released into the environment.

Once satisfactorily cleaned and gauged, the pipeline section will be filled with water to remove all air from the test section and will be pressurised to conduct a combined leak and strength test.

Approximately 35–50 km sections of the pipeline will be tested. The volume of water contained in a 50-km section of pipeline is 16,000 m^3 and is the theoretical maximum volume of test water that could be released through a defect. However, the realistic maximum release of hydrotest water is less than this for the following reasons:

- The pipeline will have main line block valves as described in Section 2.3.3.4 which when actuated, will isolate the section of the pipeline that has the defect limiting the volume of the release to portion of the test water contained in the segment. The portion would be dependent on the location of the defect, less if the defect is in the upper part of the pipeline.
- If a leak is detected, the test will be stopped and the pipeline inspected for the location of the defect(s) and repaired.

- In most credible leak scenarios, only a relatively small portion of the test water in the pipeline would be released.

The quantity of a potential release to the environment should therefore be minimised, with the impacts being localised erosion near the location of the release. Overall, if it did happen the impacts would be localised and short term.

With control measures and monitoring in place, the likelihood of an undetected hydrotest water release during hydrotesting is low.

9.5 Operational Phase Risk

9.5.1 Potential Causes of a Pipeline Breach

Unplanned releases of oil during operations is considered in Section 9.5.2. This section considers other risks associated with the commissioning and operational phase of the project, noting that some of the design and operational mitigation measures related to this phase (e.g., pipeline integrity management system, transport and road safety management plan) will be developed as part of later phases of engineering.

9.5.1.1 Geophysical Hazards (e.g., Earthquakes, Landslides)

The Tilenga feeder pipeline route traverses sub-parallel, and bisecting (at approximately KP55), the North Toro Bunyoro Fault that bounds the south-eastern edge of the Albertine Graben. This seismically active area is part of the northern section of the western branch of the East African Rift, a major plate tectonic feature that is dividing the African continent under northwest-southwest extension (Midzi et al. 1999)). Bwambale et al. (2015) (Ref. 20-18) reported that the return period for an earthquake capable of causing damage to engineering structures is averaged at 30 years in the Albertine region (including Hoima and Buliisa). It is possible that the project may experience one earthquake during its lifetime. Should a seismic event occur, an earthquake may directly and indirectly cause unstable ground conditions, including liquefaction. The pipeline has been engineered to withstand earthquakes. However, an earthquake of a severe magnitude may result in a breach of the pipeline or slope failure causing land-slides and a release of oil.

Many of the risk reduction measures described in Section 9.3.1 will reduce the likelihood of a breach of the pipeline caused by a geotechnical event. In addition, to increase the project's resilience to earthquakes, the project has considered the following risks and will implement several actions through the emergency preparedness and response management plan (Section 10.7):

- site-specific site response analyses: The project area contains areas of soft soil and there is a potential for significant ground motion modification as the seismic waves propagate from the bedrock to the ground surface. A good understanding of this through developing site-specific response analyses in the emergency response plan will aid emergency preparedness.
- slope failure hazard: Slope failures are the dominant driver of hazards to engineered facilities and may pose a hazard to parts of the project. Mapping and controlling slopes that are at risk of failure within the project area is crucial

to preventing land-slides that may endanger the project site. The pipeline design and emergency response plan will both consider final slope design.

- surface fault rupture hazard: Surface fault rupture hazards occur when fault plane dislocation is of sufficient size to propagate to and intersect the ground surface. As parts of the pipeline may be near the top of the surface projection of major active faults, the emergency response plan will include a surface fault rupture hazard.
- liquefaction: Liquefaction occurs as seismic waves propagate through low plasticity fine sediment layers that are (partially) saturated, leading to a local deformation of soils. As pore water pressures increase, the sediment layer softens, and structures are at further risk of collapse. Liquefaction may lead to a loss of bearing capacity, and permanent ground failure. Site specific ground testing will therefore be performed to identify continuity of the liquefiable soils

The emergency response plan will include response measures to naturally occurring seismic events.

Should a high magnitude seismic event occur, it could potentially cause extensive damage to the pipeline and AGIs, releasing oil in amounts that would cause impacts that would be significant.

9.5.1.2 Sabotage

The pipeline could experience deliberate damage from people and communities, as part of community protests, terrorist attacks, or to illegally siphon oil for personal use or sale. This has the potential for either environmental or social and community impacts, depending on the nature and scale of the sabotage and ability to respond to the damage.

If sabotage does occur, the impacts from a release of oil, depending on the environmental and social sensitivity of the location, have the potential to be significant.

The AGIs will be monitored using closed-circuit television and protected with security fencing.

Pipeline operational monitoring systems (Section 2.4.5.6) include equipment and pressure sensors designed to detect release and loss of oil from the pipeline, will quickly identify sabotage which has compromised the integrity of the pipeline. Aerial surveillance of the RoW will also be employed to detect human activity in the RoW which has the potential to compromise pipeline integrity. When an act of sabotage is suspected, a response team will be activated.

9.5.2 Oil Spill Modelling

This section summarises the oil spill modelling which has been conducted for the pipeline to consider the risks associated with oil releases from the pipeline or AGIs during operation. The oil spill modelling report is included in Appendix I.

This modelling applies to any unplanned release of oil (for this section “oil spills” is used interchangeably) from the pipeline, whether due to geological hazards, deliberate sabotage, corrosion, or for any other reason.

9.5.2.1 Oil Spill Modelling Process Overview

The main objective of the oil spill modelling was to assess the potential consequence of an unplanned oil spill for valued environmental and social components .

Several locations were determined to be at greater risk from oil releases, and specific impacts were quantitatively assessed for these locations using modelling software. The software package used was the widely-used RBCA model with supporting modelling undertaken using the UK Environment Agency-approved remedial targets methodology (RTM) A description of the modelling, including descriptions of the software used, the operational scenarios modelled and the model input parameters is described in Section I1.3.3 of the report included in Appendix I, and the results are summarised in Sections 9.5.2.9–9.5.2.12.

9.5.2.2 Data Sources

Several sources of information were used for the oil spill modelling.

Geographic information system (GIS) data, including primary data collected during field work, topographic data and community surveys (water well and population size information), were used to assess overall environmental and social (based on impacts on water quality) sensitivity and selection of locations for more comprehensive assessment.

Review of several third-party documents and preliminary pipeline design information was the basis for the development of worst case spill scenarios. The documents consulted are referenced within the oil spill modelling report.

The ESIA Section 6.3.2 (physical environment) and appendices (Appendix A5 for geology and soils, Appendix A6 for surface water, and Appendix A7 for groundwater, including data from borehole surveys) were also used for the oil spill modelling.

9.5.2.3 Initial Sensitivity Analysis

Using the data available, including mapping of surface watercourses and the location of areas of greater population density, an assessment of environmental and social sensitivity was undertaken for a 2 km wide corridor for the pipeline route.

9.5.2.4 Oil Spill VEC Sensitivity Maps

The GIS datasets were used to rank sensitivity for groundwater, surface water and ecological VECs, and the data was then represented graphically as colour-coded oil spill receptor sensitivity maps. Resulting scores for the three VECs were then used to produce combined environmental sensitivity maps (provided in Appendix I).

The information assessed for each VEC and sensitivity scoring and weighting are provided in Appendix I.

9.5.2.5 Environmental and Social Sensitivity

A map presenting a summary of oil spill VEC sensitivity is provided as Figure 9.5-1, which illustrates the overall environmental and social sensitivity to a potential oil spill within the 2-km corridor, for 10-km sections. The pie charts (shown on these figures) associated with each 10-km section shows the proportions of the different sensitivity zones within that section (with sensitivity ranked from very high to very low). The locations at which detailed modelling and risk assessment has been undertaken are also shown.

9.5.2.6 Preliminary Quantitative Risk Assessment

The initial sensitivity analysis identified locations considered to have higher environmental sensitivity. From these areas, several locations were selected for more, site-specific quantitative risk assessment.

This assessment considered direct impacts to groundwater and surface water VECs, with an indirect assessment of impacts to human health.

The sites for further assessment were chosen based on whether there was high groundwater or surface water sensitivity, shallow groundwater, community use of water resources, legally protected, internationally or nationally recognised areas and wetlands. The information provided by modelling at the selected higher sensitivity sites can be used in a surrogate manner, to evaluate the potential impacts of oil spills on other parts of the pipeline route with similar attributes.

The summary map shows that approximately half of the pipeline has medium environmental sensitivity and half has high environmental sensitivity. The preliminary quantitative risk assessment (PQRA) of unplanned oil spills at selected sensitive locations is described in Sections 9.5.2.9–9.5.2.12.

Details of the process for selection of the study sites along with the conceptual site model for each location are presented in the report in Appendix I. The range in results between modelled locations is due to the variability in ground (e.g. soil permeability) and groundwater (e.g., groundwater depth) conditions along the pipeline route.

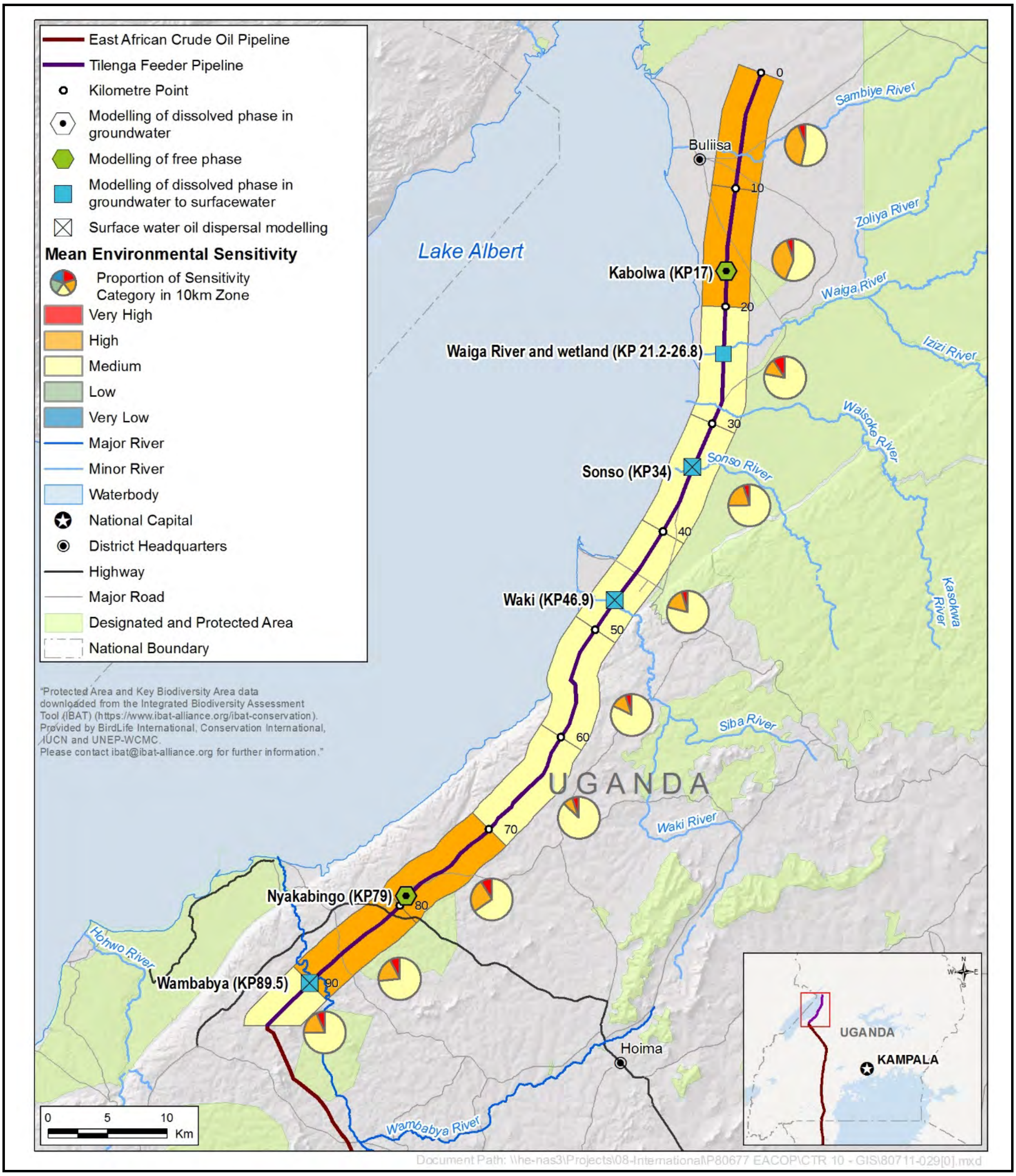

Figure 9.5-1 Oil Spill VEC Sensitivity

9.5.2.7 Guidance Values

To assess the impact of oil releases on the environment, it is necessary to have a set of guidance values, so that it is clear what concentrations of oil components are unacceptable in the environment. The guidance values used in this assessment are the World Health Organization (WHO) drinking water standards (DWS) when considering groundwater VECs, in the absence of standards specific to Uganda.

9.5.2.8 Spill Scenarios

The oil that will be transported is considered heavy oil, characterised by a pour point of 31–40°C (the temperature at which a liquid becomes semi-solid and loses its flow characteristics) and a waxing temperature of 45–57°C (the temperature at which the oil first precipitates). The general chemical and physical properties of the heavy oil influences the potential migration and impact of a release, as it tends to solidify when exposed to air or water which are at temperatures below those stated above.

The worst-case spill scenario was selected for assessment. This considered a volume of 1430 m^3 of oil, released from a 600-mm-diameter hole in the pipeline for a one-hour period, causing a pool of oil 127 m in diameter extending across the ground surface.

For an explanation of the assessment parameters selected, refer to the report in Appendix I. For each location, the movement of oil was considered, assuming the spill spread without mitigation measures being implemented.

This is most important for modelling migration of dissolved phase substances in groundwater, which without intervention would occur over a number of years. To account for the fact that oil would be removed, further analysis has been undertaken in addition to the modelling to assess how removing free oil from the environment within one year might reduce potential impacts.

The complete results for unplanned loss of oil to soil, surface water and groundwater sources and other oil constituents are included in the report in Appendix I.

9.5.2.9 Surface Water Impacts from Groundwater Migration of Dissolved Oil Spill Components

The report in Appendix I includes the predictions for four locations of quantitatively modelled impacts to surface water. Descriptions of the modelling software, the parameters used and assumptions made during the assessment are included in the report in Appendix I.

The model considered migration of dissolved oil components such as benzene, toluene, ethylbenzene, xylene and other small-chain total petroleum hydrocarbon (TPH) fractions in groundwater from oil in contact with groundwater beneath the spill location, or residual oil in soil, where groundwater is expected to be deeper than predicted reasonable worst-case vertical oil migration.

The modelling predicted that, without intervention, a failure of the pipeline could cause dissolved oil components impacts on surface waterbodies by groundwater transport within a radius of 12 m to 85 m beyond the extent of the oil spill area. The modelling included attenuation of the dissolved components.

Migration of dissolved hydrocarbons to the maximum modelled distances would take several years. Remediation to contain and remove the oil would be undertaken quickly and would prevent the spill from affecting areas as large as those predicted in the worst-case scenario.

The rapid recovery of oil would limit dissolved component infiltration into groundwater and being transported. This reduction in potential impact has been evaluated in an additional assessment considering removal of oil within one year presented in Appendix I. In summary, this indicates that remediation within one year would result in reduction of the distance in which there may be potential impact to surface water to between 3 m and 18 m.

9.5.2.10 Groundwater Impacts from Migration of Dissolved Oil Spill Components

The report in Appendix I includes the predictions for the two locations of quantitatively modelled impacts to groundwater. For each location, the model considered migration of dissolved oil components in groundwater from residual oil in soil, and oil in contact with groundwater beneath the spill location.

The travel distances predicted by the modelling are distances that lighter constituents of dissolved oil may travel within groundwater beyond the initial spill extent.

The modelling predicted that, without intervention, a failure of the pipeline could cause dissolved oil components to impact groundwater quality based on drinking water use, within a radius of 14 m to 25 m (depending on local conditions, including soil type) beyond the extent of the oil spill area. It should be noted that travel times for dissolved oil components in groundwater over distances greater than 200 m would likely be greater than one year.

As with surface water impacts, the model is based on a worst-case scenario as remediation following a large spill would be expected to take place rapidly after the incident occurred. This would remove the source of oil to the extent that it would no longer produce dissolved components that would infiltrate into groundwater.

Predicted distances for groundwater impact assuming remediation of the oil spill taking place within one year (not groundwater remediation) range between 4 m and 7 m. It should also be noted that the maximum modelled distances for dissolved oil migration would be for areas of the pipeline route with the most permeable ground conditions. For other areas of the pipeline, migration distances may be substantially less.

Additional description of mitigation and remediation of oil spills is provided in Section 9.5.3.

9.5.2.11 Unsaturated Zone Impacts from Oil Spills

The report in Appendix I includes the predictions for the two locations of quantitative modelling of the potential maximum depth of vertical migration of oil into unsaturated soil, to assess whether the oil could reach the water table. Based on the characteristics of the heavy oil, it will solidify upon contact with groundwater, and hence there would be no lateral migration of oil beyond the extent of the spill zone.

The complete results of the oil migration modelling are in the report in Appendix I. The modelling predicted that the depth to which oil could migrate within the unsaturated zone is approximately 1.45 m below a pipeline spill. The depth to groundwater could be as shallow as 1 m, and hence oil may reach the water table in this scenario at some locations.

There is inherent conservatism within the assessment model, and the oil would have very low mobility at ambient temperatures if a pipeline spill occurs. The migration depths modelled are conservative and the modelled scenario is considered to represent the possible worst case.

9.5.2.12 Surface Water Crossings Impacts from Oil Spills

The potential impacts of oil spills at surface water crossings caused by a failure of the pipeline have also been modelled. Three locations were assessed, with full details provided in Appendix I.

The rivers are so narrow that an oil spill would cover the entire river surface. The pour point temperature of 40°C means the oil will solidify in the water, and hence minimise the spreading of oil. The oil quickly will become extremely sticky and will hence, in solid form, either stick to the riverbanks or to the vegetation. In this solid state, the oil will quickly introduce a “barrage effect” that will further reduce drift and spreading, particularly in narrow areas of the rivers. The narrowness and curvature of the rivers and the small discharge contribute to the high retention of oil in the vicinity of the spill.

The modelling suggests that at four of the five crossing locations, the modelled length of river affected ranges between 0.5km and 0.9km. The relatively short transport distances are attributable to the high viscosity of the oil and the curvature of most of the rivers.

The predicted distance represents the potential length of significant impact, defined as the area where the majority of the oil (90–95%) will stay. A smaller amount of oil can be expected to drift down the river as small tar balls. The oil is slightly less dense than water and is therefore not expected to sink to the river bed. It is important to note that for watercourses crossed by the Tilenga feeder pipeline this modelled migration distance would, in some cases, imply oil dispersal potentially extending to receptors downstream, including Lake Albert.

Furthermore, this prediction does not account for any recovery or cleanup of oil.

When considering the predictions, it should be noted that they are a worst-case scenario. In particular, the following factors are expected to limit the likelihood and extent of releases and hence the impact:

- The modelled quantity of oil is unlikely to be released owing to the design measures described in Section 2 and the risk reduction described in Section 9.3.
- The inclusion of block valves in the pipeline design provides a means of restricting the volume of oil released from a breach of the pipeline. The location of block valves in proximity to the sensitive locations modelled is shown in Table 9.5-1.

Additional description of the mitigation and remediation of oil spills is included in Section 9.5.3.

Table 9.5-1 Block Valves Near Sensitive Locations

Location	KP	KP of Closest Block Valve to North	KP of Closest Block Valve to South	Distance Between Block Valves
Kabolwa	17.0	0.0	21.20	21.20 km
Waiga River and wetlands	21.2 to 26.8	21.20	28.10	1.48 km/5.42 km*
Sonso River	34.0	29.40	54.00	24.60 km
Waki River	46.9	29.40	54.00	24.60 km
Nykabingo	79.0	74.74	94.54	19.80 km
Wambabya tributary	89.5	74.74	94.54	19.80 km

NOTE: *In this location, there is also an intermediate block valve within the sensitive area at KP22.68, splitting this section into two.

9.5.3 Preventive and Mitigation Measures Reducing Impact of Oil Spills

Preventive and mitigation measures to avoid, reduce, or control impacts from an oil spill from the pipeline have been considered during the design process, and will continue to be considered during the development of operating procedures. The preventative and mitigation measures which apply to the unplanned release of oil are considered in Section 9.3.

9.6 Decommissioning

The pipeline will be decommissioned based on Ugandan regulations and standards, and international standards and protocols. The decommissioning plan is described further in Section 2.4.6.2. It will include specific consideration of unplanned events which may occur during decommissioning consistent with Tilenga feeder pipeline requirements.

9.7 Summary of Unplanned Events

A summary of the unplanned events, their potential impacts, and the key mitigation measures which will be in place to prevent or manage impacts is provided in Table 9.7-1.

Table 9.7-1 Summary of Unplanned Events

Unplanned Event	Potential Impact	Key Mitigation Measures	Likelihood of Event (Low, Medium, High)
Construction			
Traffic accidents	Vehicle collision resulting in injury or mortality to member of public/workforce or livestock, or physical damage to community asset/structure or pipeline asset	Transport and road safety management plan Emergency preparedness and response plan	Medium to High
Traffic accidents	Vehicle collision leading to spillage of transported fuel or chemical and resulting in contamination of soil and/or water, toxicity affecting living organisms		Medium to High
Fire	Impact to environmental and social VECs including biodiversity, community safety, security and welfare and land and property (e.g., sensitive habitats, local community assets and the health of local community residents).	Emergency preparedness and response plan.	Low
Damage to third-party assets	Physical damage to third-party property.	Transport and road safety management plan Infrastructure and utilities management plan	Low
Diesel release from oil storage tanks at the MCPY and construction sites	Diesel release resulting in contamination of soil and/or water, toxicity affecting living organisms	Pollution prevention plan Water management plan Emergency preparedness and response plan	Low (MCPYs) Medium (construction sites)
Loss of hydrotest water during commissioning	Localised erosion.	Emergency preparedness and response plan.	Low
Operation			
Traffic accidents	Vehicle collision resulting in injury or mortality to member of public/workforce or livestock, or physical damage to community asset/structure or pipeline asset	Transport and road safety management plan Emergency preparedness and response plan	Low
Traffic accidents	Vehicle collision leading to spillage of transported fuel or chemical and resulting in contamination of soil and/or water, toxicity affecting living organisms		Low

Table 9.7-1 Summary of Unplanned Events

Unplanned Event	Potential Impact	Key Mitigation Measures	Likelihood of Event (Low, Medium, High)
Fire	Impact to environmental and social VECs including biodiversity, community safety, security and welfare and land and property (e.g., sensitive habitats, local community assets and the health of local community residents).	Emergency preparedness and response plan.	Low
Geophysical hazards	Rupture of pipeline and/or slope failure leading to land-slides, and oil spills	Emergency preparedness and response plan	Low
Sabotage	Deliberate damage with environmental and social impacts.	Emergency preparedness and response plan	Medium (political)–Low (theft)
Modelled oil spill from pipeline or AGIs	Impact to surface water via migration of oil components dissolved in groundwater.	Emergency preparedness and response plan	Low
Modelled oil spill from pipeline or AGIs	Impacts to groundwater via migration of oil components dissolved in groundwater.	Emergency preparedness and response plan	Low
Modelled oil spill from pipeline or AGIs	Impacts to soil from non-aqueous phase liquids (NAPL) in the unsaturated zone.	Emergency preparedness and response plan	Low
Modelled oil spill from pipeline	Oil dispersal on surface water following leak at pipeline crossings.	Emergency preparedness and response plan	Low