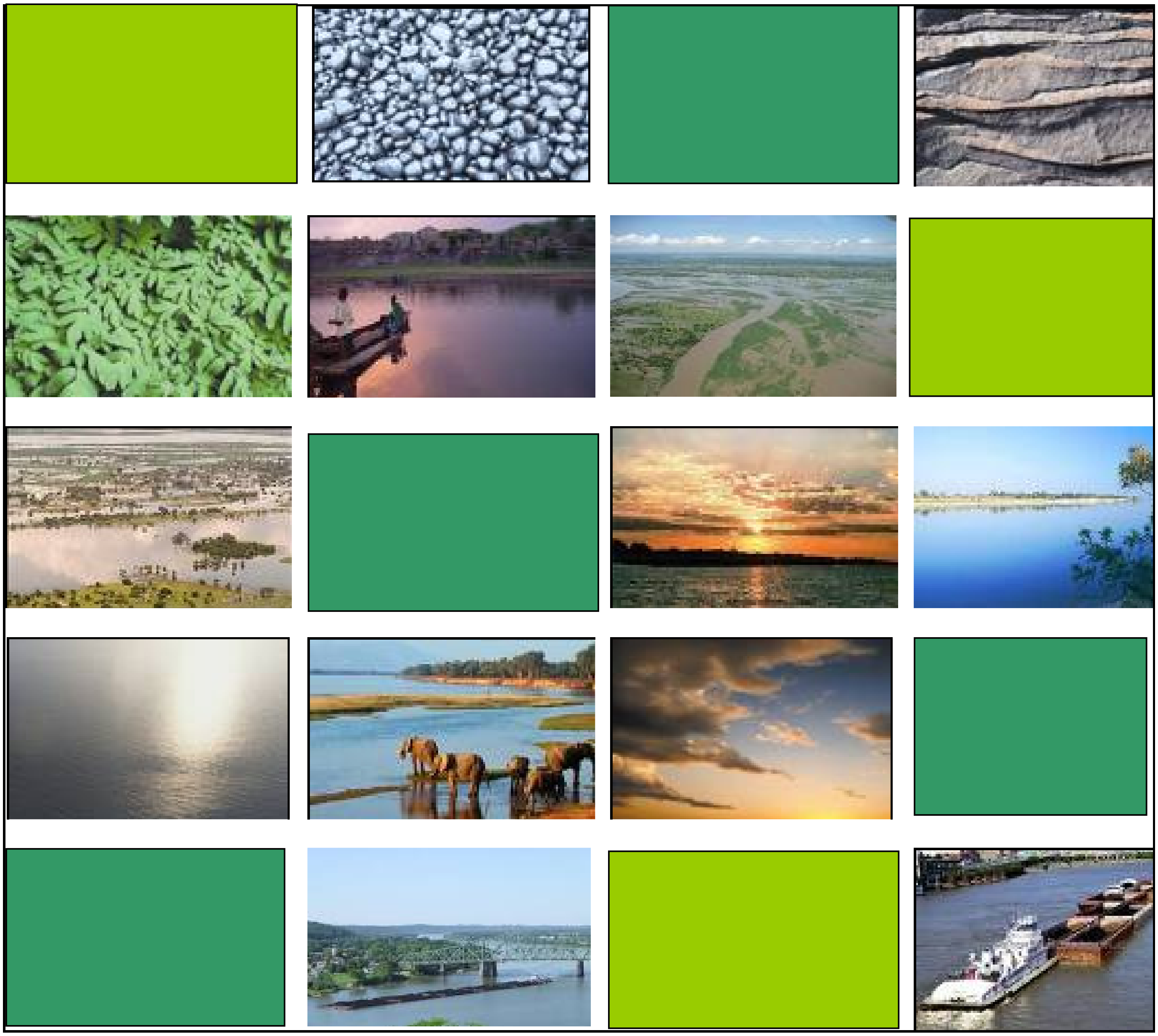

Riversdale's Zambezi River Barging Project, Zambezi River, Mozambique

Final Environmental and Social Impact Assessment Report

August 2011

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NON-TECHNICAL SUMMARY

INTRODUCTION

An Environmental and Social Impact Assessment (ESIA) has been compiled for the proposed Zambezi River Coal Barging Project, on behalf of Riversdale Mozambique Limitada (hereafter referred to as RML). RML is a 65%-owned subsidiary of Riversdale Mining Limited, a mining company listed on the Australian Stock Exchange, with operations in South Africa and Mozambique. The other 35% of RML is owned by Tata Steel, a major Indian steel producer.

An ESIA is a systematic process that predicts and evaluates the potential impacts a proposed project may have on aspects of the physical, biological, socio-economic and human environment as determined by specialist studies and analyses of the specific environment. Mitigation measures, as set out in the approved environmental management plan, are then developed and incorporated into the Project execution plan to eliminate, minimise or reduce adverse impacts and, where practicable, to enhance benefits.

RML have appointed Environmental Resources Management Southern Africa Pty Ltd (ERM) in partnership with Impacto Associados Lda (Impacto) as the independent consultants to undertake the ESIA for the Zambezi River Coal Barging Project, the main results of which are presented in this non-technical summary.

EIA Process

The ESIA process followed was designed to comply with the relevant Mozambican environmental legislation. Accordingly, the ESIA process comprised of a number of key steps, namely:

- Project Registration
- EPDA Phase (also known as Scoping Phase, and culminating in an EPDA Report)
- Specialist Studies
- Impact Assessment Phase (culminating in an ESIA Report).

PROJECT OVERVIEW

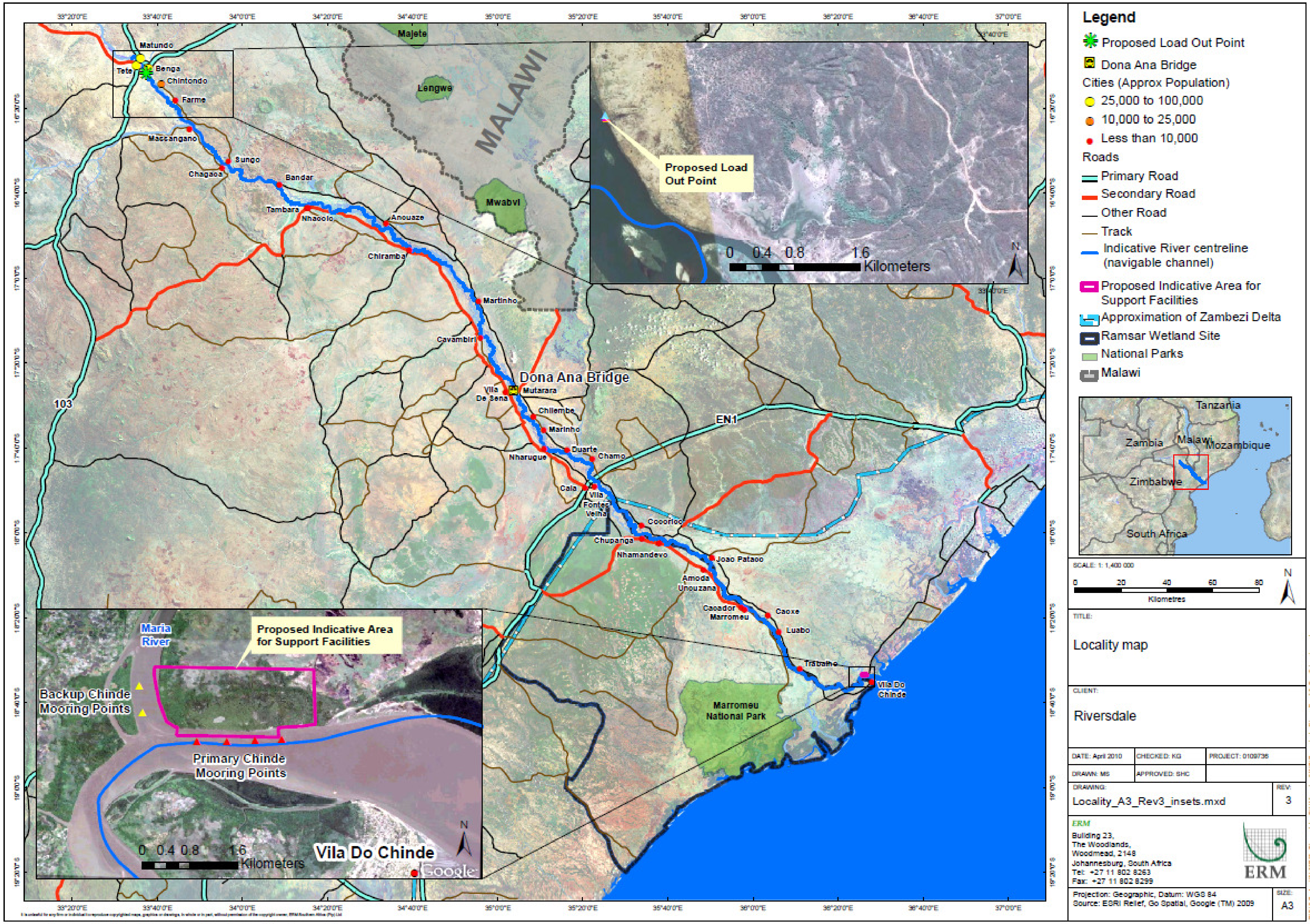
The Zambezi River Coal Barging Project (the Project) provides one of the means of transporting coal from the Riversdale's Benga mine in Tete to international markets.

The proposed Project begins with the barge coal loading facilities at the point where coal is received from the overland conveyor line from the Benga Mine and ends when the coal is loaded onto ocean-going vessels via a transloader located offshore at Chinde. Barging will be undertaken using specially designed shallow draft boats pushing between four and eight unpowered hopper barges, similar to barging operations currently being used on other rivers like the Mississippi River in the United States of America.

The Project comprises the following elements (illustrated in *Figure.1*):

- loading coal onto barges to be pushed downriver using pushboats (from the loadout point at Benga to Chinde);
- some land based support facilities at the load out point;
- initial capital and maintenance dredging in certain locations (about 180km in the approximately 540km stretch of river) to have a navigable channel for barging down the river;
- mooring points and fenders (if required) on either side of the Dona Ana Bridge;
- mooring points and support facilities at Chinde; and
- pullboats (also called shuttle tugs) pulling single barges from the mooring points at Chinde out to a transloader approximately 15km to 20km offshore.

Figure.1 *Locality Map*



Construction Phase

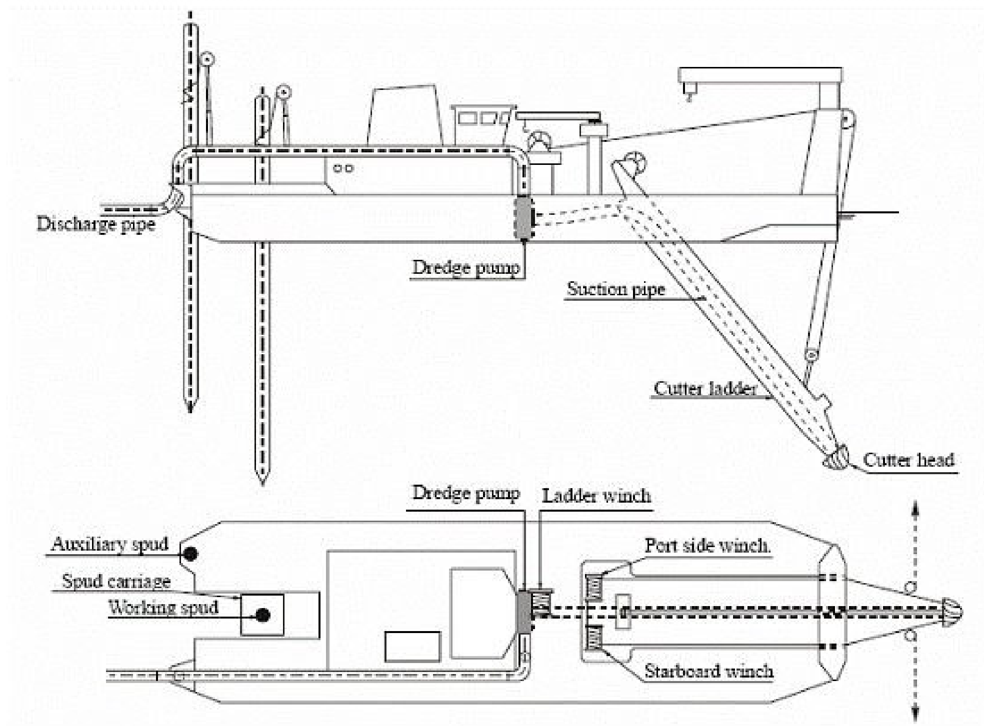
The construction phase activities consist of capital dredging and the construction of various components of infrastructure along the reaches of the Zambezi River. These are highlighted below.

Capital Dredging

Capital dredging refers to the initial dredging required to ensure the navigable channel is wide and deep enough to allow the proposed coal barging Project to proceed. Dredging will need to take place at various locations (totalling approximately 180km) along the river from Benga to Chinde, a distance of approximately 540km.

The "ideal" channel is one that, when the flow is low, has a minimum depth of 3.0 to 3.5m. The dimensions of the channel have been designed based on recognised guidelines for barge convoy and tugboat movement. Capital dredging within the river would be undertaken by cutter suction dredgers (CSD). This type of dredger is very common and comprises a suction pipe fitted with a cutter head supported below a floating barge, and a discharge pipeline. The dredger is anchored in position in the river and swivels around a rear pivot, sweeping the cutter head and suction pipe in a horizontal arc through the sediment on the river bed. The cutter head is designed to separate and breakdown the sediment to pass through the suction and discharge pipelines to prevent clogging. The dredged material is then disposed of via the discharge pipeline. The figure below illustrates a typical CSD.

Figure.2 *Diagram of Typical CSD*



Currently the base case is for dredged material to be deposited alongside the dredged channel (on the side with the greatest distance to the river bank). Mitigation measures proposed by the ESIA team suggest that it would be environmentally desirable (1) to deposit the dredged material in the lees of islands or sand bars wherever possible. This approach has been adopted. It is expected that approximately eight CSDs will be required, distributed along the river.

Capital dredging is also required across the bar at the entrance to the Zambezi River at Chinde in order to achieve adequate depth for the barging operation out to the transloading locations. At the entrance bar, the wave conditions are too rough for use of a cutter suction dredger. Here the capital dredging would be performed by a side casting trailer dredger or trailing suction hopper dredger (TSHD). The TSHD is a self propelled ship with an internal hopper. Material is removed from the seabed much like a vacuum cleaner and placed in the hopper of the dredger. The side casting trailer dredger is similar to a TSHD but has no hopper. Accordingly, the side casing trailer does not store the material before disposal but simply pumps it to the side of the vessel back onto the seabed. A typical side casting trailer dredger and TSHD are shown below.

(1) Deposition in the lees is may reduce the rate of infill of the navigable channel and may create a bit more braiding, which is a move toward more "natural" conditions, prior to the construction of the Cahora Bassa and Kariba dams.

Figure.3 *Typical Side Casting Trailer Dredger*

Figure.4 *Typical TSHD (material stored on board for disposal at appropriate location)*

The time period for capital dredging of the entrance bar is expected to require less than two months to complete. All capital dredging operations would take place 24 hours a day, 7 days a week (weather and flow conditions permitting).

Construction of River Infrastructure

The river infrastructure to support the barging operation comprises mainly the barge loading facilities at the loadout point in Benga, floating repair and maintenance facilities for push boats and barges at Benga ,mooring points upstream and downstream of Dona Ana Bridge, a floating transloader downstream of Dona Ana Bridge, if required fendering at the two bridges (Dona Ana and Caia), and a range of facilities at Chinde; including, mooring points, a floating dry dock, shuttle tug base, and floating transloader. RML is also considering establishing some facilities on land on the north side of the river opposite Chinde for the barging operations. These include:

- Administrative and communication office.
- Ablution facilities.
- Wastewater treatment plant.
- Generator.
- Fuel storage and fuel dock.
- Emergency floating dry dock repair facility.
- Heliport
- If land on the northern bank is available and proves suitable, equipment storage areas.

RML is investigating locating some of the administrative and support facilities in Chinde Town.

Operational Phase

Barging is planned to be a 24 hour, 7-day a week, year-round operation. This all year operation will however be subject to suitable weather and river conditions. It is expected that convoys in the upper half of the river (above Dona Ana Bridge) will comprise four barges initially, with the number of barges increasing to a maximum of eight once sufficient experience has been gained on the river. Downstream of the Dona Ana Bridge, eight barge convoys will be run.

Barge traffic intensity will be low. It is anticipated that the frequency of barges travelling to Chinde will commence at several per week and grow to several per day. When return traffic is taken into account, it is anticipated that the maximum average number of convoys passing a point on the riverbank per day will be seven. This figure includes convoys heading both downstream and upstream. Lighting will be required at all loading, offloading and changeover points.

A detailed discussion on the operational activities is presented below.

Convoy Assembly

Full barges will be towed by assist tugs to mooring points a short distance downstream of the loader. There they will be assembled into convoys of either four or eight barges, depending on river channel conditions at the time, and a push boat attached for the journey downstream. An example of barge loading is shown in the figure below.

Figure.5 Typical Barge Loading Facility

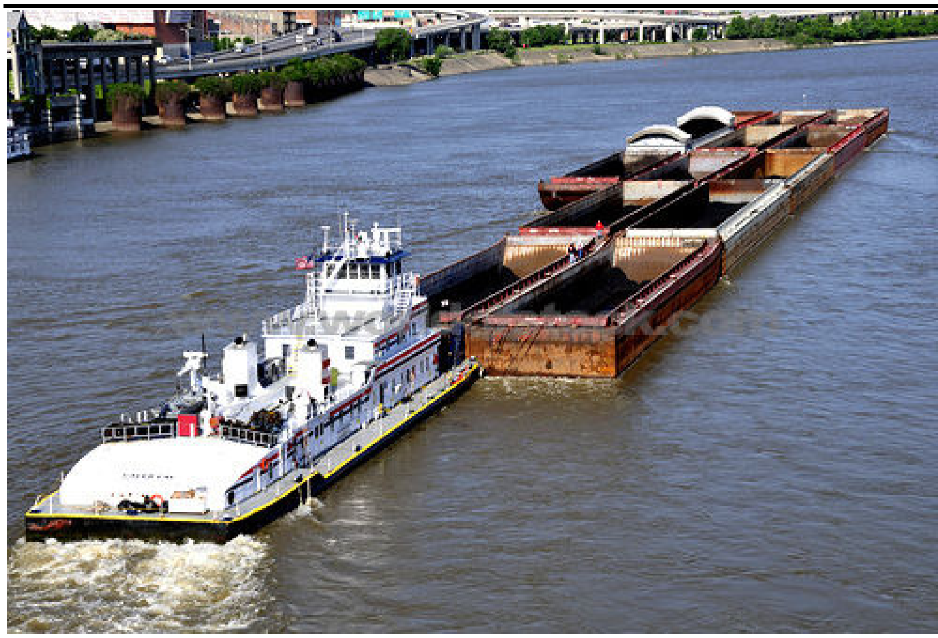
Barging of Coal down the Zambezi River

For the purpose of operations, the river will be divided into two sections of approximately equal lengths. The division of the river into two halves for operational purposes is due to the differing river characteristics above and below Dona Ana Bridge. Reflecting the different river characteristics, different push boats and convoy sizes will be used. Depending on the outcome of a navigation safety investigation, the convoy may be "fractured" at the Dona Ana Bridge. Fracturing entails mooring the convoy before the bridge and breaking it up to allow one or two barges at a time to be pushed under the bridge. The convoy will then be reassembled at a mooring point on the other side of the bridge. Subject to the results of further investigations and consultation with relevant authorities, consideration will be given to providing fendering around the bridge supports at the navigation spans to prevent collisions between the barges and the bridge supports. This approach will also apply at the Caia Bridge.

'Topping up' of barges just downstream of Dona Ana Bridge via a barge-to-barge floating transfer station (FTS) may also be undertaken should it be necessary to run convoys lightly loaded in the upper half of the river due to difficulties in maintaining a deeper channel, as described earlier. The FTS would comprise a barge mounted crane fitted with a grab. Transfer rates would be in the range of 500 to 1,000 tph.

The round trip per convoy (Benga terminal to Chinde and return to Benga) is estimated to take approximately six days. Thus if six convoys are in operation, on average, one convoy will be dispatched from Benga each day. The number of convoys passing any one point on the river would then average two per day – one going downstream and one going upstream. The anticipated maximum average number of convoys dispatched per day is three to four, and the maximum average number of convoys passing any one point on the river is seven. An example of a barge convoy is shown in the image below.

Figure.6 Example of a Barge Convoy



Operations at Chinde

The loaded convoys would arrive and be moored at Chinde (north bank). The push boat that transported the convoy down the river would then release the loaded convoy and immediately pick up a convoy of unloaded barges for the return trip upstream. Until such time as the larger special purpose ocean-going barges are introduced, the river barges would be towed offshore one or two at time by the ocean shuttle tugs to the offshore transloading location.

Following unloading at the transloading location the river barges would be towed back to Chinde by the shuttle tugs and assembled into empty barge convoys by the assistant tugs in readiness for the push boats to engage them on the return journey upstream. The assembly point would be primarily along the left hand bank opposite Chinde township.

Mooring points would also be provided in the Maria River near its confluence with the Zambezi River. After the larger special purpose ocean-going barges are introduced (around 10,000 t capacity) it will be necessary to introduce a barge-to-barge transfer operation at Chinde. This would take place by means of a floating transfer station (FTS) comprising barge mounted cranes fitted with grabs. The larger ocean-going barges would either be towed to the transloading location by the shuttle tugs (if unpowered) or, travel under their own power (if self-propelled).

Offshore loading of coal for export overseas

Transloading would take place 15 to 20km offshore of Chinde depending on the size of ship being loaded. The transloading operation will involve use of a FTS. The FTS would be moored to the ship once it is at anchor, and typically winch itself along the ship in order to access all the ship's hatches. The barges would come alongside the FTS on the opposite side to the ship and, where required subject to weather, in the lee of the ship. The FTS will be equipped with up to four cranes for unloading barges. These cranes will operate 25 – 35 tonne capacity grabs with throughput capacities of 1000 - 1500 tph. Grabs will transfer coal from the barges and into a hopper. If an ocean-going vessel is alongside, coal from the hopper will be fed to a conveyor system that transfers this coal directly into the ship. If no ship is alongside, the grabs will drop the coal into the hold of the FTS for storage. In the initial stages of the barging operation when river barges are towed offshore, the FTS will include floating storage capacity in the order of 60,000t. An example of transloading at sea is shown below.

Figure.7 Example of Transloading at Sea

Maintenance Dredging

The annual maintenance volumes to be dredged will not be as significant as the volumes for the initial dredging operation. Based on current information, it has been estimated that annual maintenance dredging quantities could, on average, represent some 25 percent of the initial capital dredging volume, i.e. average of approximately 5 million m^3 per year. Localised areas of chronic shallowing could be subject to higher maintenance dredging volumes. The location of maintenance dredging requirements is expected to reflect the pattern of initial capital dredging areas, i.e. within the river mostly upstream of Dona Ana Bridge, and at the entrance bar at Chinde.

In addition to using CSDs for maintenance dredging within the river, it is also proposed to utilise water injection dredging equipment and a sweep bar for maintenance dredging purposes. At the entrance bar, a side casting trailer or TSHD would be used for maintenance dredging. The methods of disposal of maintenance dredging material would be the same as the methods employed for the capital dredging material.

Emergency and upset conditions

Convoys will pass under two bridges – Dona Ana railway bridge and the new road bridge at Caia. Spans between pylons at the Dona Ana and Caia bridges are 70m and 137.5m respectively. Spans at both bridges are wide enough for convoys to pass safely. River current directions are also favourable. RML will, as a precaution, place moorings above and below the Dona Ana bridge to enable convoys to be fractured (split up) before passing under the bridge. Convoys will be fractured until experience is gained by boat pilots. Speeds under the bridges will be reduced at all times. RML will also consider fendering the bridge pylons to help protect the bridges.

Risk of barges capsizing in the river is very low. The barges meet international guidelines for stability and have been designed to safely handle marine as well as river conditions. Should an accident occur, it is very unlikely that a barge would capsize in the river. In addition to the stability of the barge design, the barges are too large (75m long and 17.5m wide) relative to typical river depths (generally less than 6m in the main channel) to allow a barge to overturn. If a barge did overturn, coal would fall into the water and the barge would fill with water. However, it would not sink due to buoyancy from the double skinned compartments.

The risk of major fuel spills is low. The largest quantity of fuel will be in fuel barges running between Chinde and Beira, and possibly between Chinde and Benga. These barges, which will hold 3,180 cubic metres of fuel, will be double hulled and marine certified, with the fuel contained in 4 to 6 separate compartments. These barges will be strong and will not rupture easily. Should a very severe accident occur and a barge be ruptured, the double-hulled design and use of multiple separate fuel tanks is likely that the rupture would be confined to one tank and result in a slow leak. While some diesel would escape into the river, action can quickly be taken to prevent all of the fuel in the ruptured tank emptying into the river. Pushboats and tug boats will be equipped with fuel containment equipment, which would be deployed. This containment equipment will slow the spread of fuel, but may not contain the entire leak, particularly if the incident occurred in a strong current. Once containment equipment was deployed, fuel would be pumped into another barge including, if required, an empty coal barge. While a strong current may hinder containment, it will assist the dispersion of the diesel fuel.

Fuel tanks in boats and dredgers will be well protected. Pushboats will be double hulled, and fuel will be stored in a number of separate tanks in a compartment inside the inner hull. Fuel will be therefore be protected by at least three steel walls.

DESCRIPTION OF THE EXISTING ENVIRONMENT

The study area comprised the stretch of river from the loadout point at Benga to the transloading zone offshore from Chinde. The biophysical environment within the study area comprises the Zambezi River and riparian habitats, the Zambezi Delta and the marine environment. The socio-economic environment includes the people who live within 2km of the river banks, the artisanal and semi-industrial fishing activities, agricultural activities and the local and national economy. A detailed description of the existing environment can be found in Chapter 5 of the ESIA Report.

PUBLIC PARTICIPATION PROCESS AND KEY ISSUES RAISED

The overarching objective of this consultation process was to ensure that key stakeholders were informed of the proposed Project and provided with an opportunity to provide comments, ask questions, or raise concerns.

The specific objectives included: (i) provide the identified stakeholders with clear information on the project; (ii) collect feedback regarding the overall design of the project or potential environmental and socio-economic issues related to the potential implementation of the Project; (iii) collect information for the development of the Terms of Reference for the EIA. A report detailing the public participation process that was followed as well as all issues and comments raised to date is included in *Annex B* of the ESIA Report. Key issues raised to date include:

- Changes to the river hydrology.
- Safety of current river users.
- Bank erosion.
- Impacts of dredging and sediment deposition on river biota and habitats.
- Impacts on artisanal and semi-industrial fishing due to Project activities.
- Impacts of coal dust or accidental spills of coal or fuel on water quality and on river biota
- Impacts on the delta and the Ramsar wetland.
- Cumulative impacts with other proposed projects (primarily the construction and operation of new dams on the river).

These key issues are described in more detail below. The full range of impacts investigated is described in Chapters 7 to 9 of the ESIA Report.

Changes to River Hydrology

Issue

Deepening parts of the river to form a navigable channel could result in more water flowing in that channel and less outside that channel. From an environmental and social perspective, the most significant issue to understand is how the creation of a navigable channel might affect the water flows and water levels in different parts of the river system under different flow regimes (eg wet season high flow and dry season low flows).

The outcomes of the Environmental Flow Study have informed many of the biophysical and social impacts assessed in the ESIA Report. The discussion below summarises the main findings of the Environmental Flow Study.

Impact Assessment

This study presents the expected flow changes as a result of the Project. This has then been used by the remaining specialists to inform their impact assessments; ie to determine the impacts on bio-physical and socio-economic receptors as a result of the expected physical change. As such, there is no significance rating for this study.

Discussion

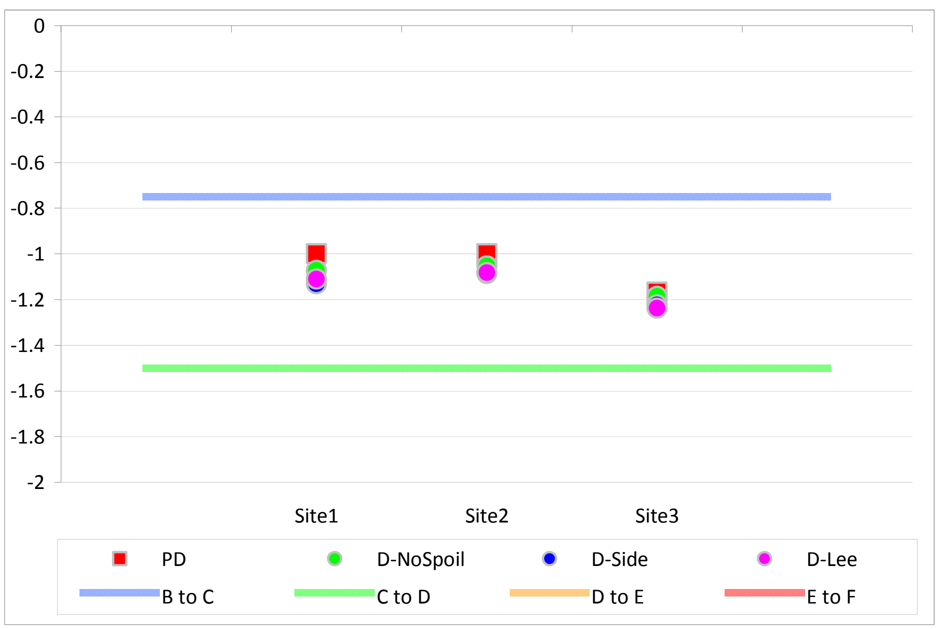
It is important to note that the navigable channel follows the naturally deepest part of the river. Dredging is used to link up the naturally deep locations which are often separated by shallower underwater sand bars. Dredging is not used to cut an entirely new channel, nor does it attempt to straighten the natural water course. Rather, the navigable channel will follow the natural river meander. No islands or river banks will be dredged.

The Environmental Flow Study investigated how the river water level would change as a result of the dredging and maintenance of a navigable channel in the river. This is an important question because changes in flows can potentially affect habitats (eg riparian habitats or wetlands) or communities living or farming adjacent to the river. A detailed hydraulic model of the river system from Tete to Chinde was prepared to investigate the impact of dredging. The model contains data from numerous sources including ARA-Zambeze and Riversdale. Details of the navigable channel were entered into the model and the results with and without the channel were compared. The modelling methodology, assumptions, and outcomes were reviewed by an independent expert.

The outcome of the Environmental Flow Study predicts that the impacts of the proposed dredging on the hydraulics of, and habitats in, the lower Zambezi River are expected to be muted by the large size of the Lower Zambezi ecosystem relative to the area of proposed dredged channel and spoil. During periods of high flow, which are critical for recharging the wetlands, the impact of the navigable channel on water levels is predicted to be negligible. This means that during the wet season, ecological services that require flooding of the floodplain will not be noticeably affected by the proposed navigable channel. Thus wetlands, flooding of ecologically important distributaries like the Salone Channel and flooding of floodplain agricultural areas are predicted to be unaffected.

The Environmental Flow Study also determined that the present-day habitat condition would not be significantly altered by the proposed Project. The present-day habitat condition is rated as a C, meaning that the habitats are moderately modified. A loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged. The proposed Project will not result in the habitat condition dropping to a D (where ecosystem functions start to become impaired). The following diagram shows that, for the three study sites investigated, and for the three dredged sediment deposition scenarios considered (no sediment deposition in river, sediment deposited in a linear fashion adjacent to the dredged channel, and sediment deposited behind (downstream) of islands and sandbars), the habitat integrity remains firmly in the C category. The blue and green lines indicate the boundary between Category B and C and between Category C and D respectively.

Figure.8 ***Habitat Integrity at the Three Study Sites***



The primary measures to manage potential impacts on river flow are to follow the dredging specifications as described in the ESIA Report, to follow the natural meandering of the river (ie not to straighten the river), to ensure sediments are deposited in the river and not on river banks so as to maintain the sediment balance in the river, to deposit sediments behind (downstream) of islands and sandbars and to ensure that the deposition of sediments does not block tributaries or distributaries.

Safety of Current River Users

Issue

Safety of current and future river users could be affected due the potential risk of collisions (especially at night) as well as by wakes caused by passing convoys (wakes could affect people on small boats or at the river's edge).

Impact Assessment

The residual impact is determined to be Minor with the implementation of mitigation measures including barge speed restrictions, disseminating convoy timetables to local communities and equip the barges with sound and light signals to warn river users of approaching convoys. In addition convoys will have someone on watch and all vessels will be equipped with safety equipment (life vests, first aid kits, life rings and rope, etc).

Discussion

While there is a risk of collision between the convoys and other river boats, the probability is low as most canoes and water taxis stick to the shallow river margins while the convoys will be in the deeper channels and the convoy traffic is not intense (approximately seven convoys are likely to pass a point on the river every 24 hours) . In addition, the convoys will be lit, with sound signalling systems as well, further limiting the probability of collisions. It is envisaged that the risk of collisions will decrease over time as people get used to the barging operations

Capsizing of small boats due to wake effects is another risk . RML has done extensive modelling of barge wakes to determine the size of wakes produced and also how to reduce the impact of wakes. These studies have shown that speed is the most important factor in wave generation and that light convoys moving upstream have the potential to generate larger waves than the loaded downriver convoys. The proposed speeds of the convoys have been reduced to achieve an acceptably small wave height. The key to mitigating the impacts of wakes and convoy traffic is through maintaining speed restrictions, disseminating convoy timetables to local communities and to use sound and light signals to warn river users of approaching convoys. In addition convoys will have someone on watch and all vessels will be equipped with safety equipment.

Impacts on Bank Erosion

Issue

Waves generated by the wake of passing convoys could result in an increase in the rate of erosion of sandy bank with associated impacts on riparian habitats and riverbank agriculture.

Impact Assessment

The residual impact is determined to be Minor with the implementation of mitigation measures, namely convoy speed restrictions.

Discussion

RML has done extensive modelling of barge wakes to determine the size of wakes produced and how to reduce the impact of wakes. These studies have shown that speed is the most important factor in wave generation and that light convoys moving upstream have the potential to generate larger waves than the loaded downriver convoys. The key to mitigating the impacts of wakes and convoy traffic is through maintaining speed restrictions. Therefore speed restrictions will be imposed to reduce waves to acceptable heights.

Impacts of Dredging and Spoil Deposition on River Biota and Habitats

Issue

Dredging and deposition of spoils could disturb river and riverbed biota (eg fish, hippos and riverbed invertebrates), and habitats (eg riparian vegetation and islands). In addition, dredging could affect the submerged habitats within the active channel where hippos remain submerged during the day.

Impact Assessment

The residual impact is determined to be Minor with the implementation of mitigation measures including the deposition of sediments downstream of islands and sandbars and the avoidance of sediment deposition in distributaries.

Discussion

The area affected directly by the dredge path is estimated to comprise 7.1 to 11.7 percent of the active channel. The area affected by deposition of sediments is estimated to comprise 17 percent of the active channel. With the deposition of sediments downstream of islands and sandbars, the total area drops to between 11 to 15 percent of the active channel. This means that the dredging and sediment deposition physically affects a relatively small percentage of the active channel.

Dredging and sediment deposition will have detrimental impacts on invertebrates found on the riverbed, such as the burrowing caddisflies, gomphid dragonflies and thiarid snails. Deposition of sediments could have detrimental impacts on sensitive invertebrates found in marginal vegetation, such as prawns, shrimps and heptageniid mayflies. Once created, the navigable channel is unlikely to host a wide array of invertebrate species. Re-colonisation of dredged sediments is likely to be rapid, however, dredging is expected throughout the construction and operational phases, extending the disturbance over the life of the Project. In order to mitigate impacts on riverbed organisms, RML will deposit sediments downstream of islands and sandbars away from the channel. This reduces the area of disturbance and is expected to keep maintenance dredging to the minimum. In addition, distributaries will be kept clear of sediment deposition, allowing riverbed organisms to remain relatively undisturbed in these areas.

In terms of water depths in the active channel, the Environmental Flow Study predicts that there will be a 1.3 to 1.7 percent decrease in the number of different depth classes (range of varying depths within the river channel). This means that the availability of different depths in the active channel is expected to remain largely unaffected. It should be noted that this calculation is in the context of a very dynamic river where depths change frequently over time as material is naturally eroded and deposited.

Some stakeholders were concerned about the project increasing hippo interactions with people. Hippos remain in the river during the day and emerge at night to graze on river banks. Their feeding behaviour is nocturnal and they are able to hide in narrow channels and reed beds during the day where they are relatively safe from human predation and stay cool in the heat of the day.

As indicated above, the Environmental Flow Study predicts minimal decrease in the availability of submerged habitat which means that hippos would have other deep areas within the active channel to move to when convoys pass by. In addition, it is expected that hippos will move into and out of the navigable channel depending on convoy movements. This was noted during the fieldwork when hippos moved out of the way of the boat well in advance of the boat's passage. This means that the probability of increasing human/ hippo interactions is unlikely.

Impacts on Artisanal and Semi-Industrial Fishing due to Project Activities

Issue

The dredging and barging operations could result in changes to fish populations or physically disrupt fishing activities.

Impact Assessment

The residual impact is determined to be Minor with the implementation of mitigation measures including implementing good practice with respect to fuel/ coal handling and loading, emergency response procedures, measures to minimise turbidity and by ensuring that sediments do not block tributaries and distributaries.

Discussion

The specialist Fish Study investigated the potential impacts of dredging, turbidity, accidental spills, changes to flow and changes to flooding on fish. In summary, given the proposed Project mitigation and management measures, and the adaptability of the fish species in the Zambezi River, the study predicts that fish populations will remain largely unaffected. The primary reason for this relates to the Environmental Flow study which shows that the wet season flood patterns will not be affected. This means that fish access to and breeding in the tributaries and distributaries of the Zambezi will not be affected. Thus fish populations are not expected to change. In addition fish species are adapted to the naturally changing river environment and natural turbid conditions. Impact on fish populations can be mitigated by implementing good practice with respect to fuel/ coal handling and loading, emergency response procedures, measures to minimise turbidity and by ensuring that spoils do not block tributaries and distributaries.

Physical disruption of fishing activities could occur during dredging and barging activities or as a result of safety zones around mooring points and the offshore transloader. Dredging and barge activity may disturb fishing operations in the vicinity of the dredging operations due to noise or may inhibit fishermen from fishing in certain areas of the river at certain times. An exclusion area will be maintained around the dredging operations – this is intended to prevent damage to fishing equipment. The impact will be localised and felt intermittently for the duration of the Project. Good communications with local communities, replacement of any damaged fishing equipment, enforcing appropriate speed limits and implementing a grievance mechanism are recommended to mitigate this impact.

Impacts of Coal Dust or Accidental Spills of Coal or Fuel on Water Quality and River Biota

Issue

Accidental spills of fuel and/ or coal could result in a deterioration of water quality in the Zambezi River.

Impact Assessment

The residual impact is determined to be Minor with the implementation of mitigation measures including defining boundary limits for coal handling sites and continual monitoring of the river bed; good operational procedures to minimise dust during coal handling..

Discussion

Coal does not usually cause pollution in water. Coal currently enters the Zambezi River when coal at the surface in the Moatize geological basin erodes and is washed into the river from numerous streams and tributaries. Nonetheless, measures will be taken to lower the chances of coal spilling during loading and unloading operations. Coal handling sites will be defined by limits and the river bed monitored. In the marine environment, any coal spillage will have a negligible impact on water quality due to the naturally low availability of pollutants in the coal and as marine water has a high buffering capacity with respect to pH. In the river environment, tests are being undertaken to confirm whether river water quality could be affected. These tests will include consideration of the substances added during processing of raw coal to achieve the coking coal product. Based on the nature of the substances being added during processing and the fact that coal is entering the river through natural processes, it is expected that these tests will demonstrate the low risk of water quality changes in the event of minor coal spillages.

The risk of barges capsizing in the river and spilling coal is very low. The barges meet international guidelines for stability and have been designed to safely handle marine as well as river conditions. Should an accident occur, it is very unlikely that a barge would capsize in the river. In addition to the stability of the barge design, the barges are too large (75m long and 17.5m wide) relative to typical river depths (generally less than 6m in the main channel) to allow a barge to overturn. If a barge did overturn, coal would fall into the water and the barge would fill with water. However, it would not sink due to buoyancy from the double skinned compartments.

Coal dust, if allowed to spread, could affect the environment at the load out point in Benga, during coal handling at the Dona Ana Bridge and at Chinde. Of these three locations, the mangroves at Chinde represent the most sensitive natural habitat as habitats at Benga and the Dona Ana Bridge are heavily disturbed by human activity. Coal dust can coat mangrove tree leaves reducing light levels and thereby affecting tree growth (Naidoo and Chirkoot, 2004). There is no evidence that coal dust is toxic to mangroves or that acute effects may be generated by exposure to coal dust (Ahrens and Morrisey, 2005). The smooth leaves typical of *Rhizophora* and *Bruguiera* do not generally retain coal dust whereas the hairy leaves of *Avicennia* do. Hence there could be stunting in the latter species at Chinde. In addition, artisanal fishermen dry portions of their catches on exposed sand areas near Chinde town and coal dust, if allowed to spread, may compromise fish quality or the perception of fish quality.

Chronic levels of deposition in mangroves may generate negative effects through alteration of mangrove species distributions via the reduction in *A. marina* and the associated implications for use of mangroves by especially white shrimp *Penaeus indicus* juveniles (Ronnback *et al.*, 2002). This may affect recruitment to the semi-industrial and industrial fishery. Coal dust could thus affect a localised area within the full extent of in the delta (a small percentage of the approximately 180ha at Chinde could be affected relative to the total mangrove area of approximately 100,000ha in the delta).

Impacts of coal dust are mitigated through good operational procedures to minimise dust during coal handling. Coal dust suppression procedures are straight forward and simple to implement for this project. Dust suppression measures include the use of water spray.

The risk of a major fuel spill is low. Pushboats and fuel barges will be double hulled with fuel stored in separate double-walled compartments. This means there are four walls between the fuel and the river. Boats will be equipped with fuel containment equipment, which would be deployed in the event of a spill. The containment equipment will slow the spread of fuel, but may not contain the entire leak, particularly if the incident occurred in a strong current. Once containment equipment is deployed, fuel would be pumped into another fuel barge or, if required, an empty coal barge. While a strong current may hinder containment, it will assist the dispersion of the diesel fuel. Diesel spills pose a risk for mangroves at Chinde if a fuel leak were to occur during refuelling. To mitigate this risk, fuel tanks will be equipped with automatic shutoff valves and spill containment shields. Should a leak occur during refuelling the spill should be contained. In the worst case scenario, the amount of fuel that could escape will be low and area affected small due to the automatic shutoff valves, and containment barriers.

Impacts on the Delta and the Ramsar Wetland

Issue

Dredging a navigable channel has the potential to modify water level and flood patterns, which in turn has direct implications for the Zambezi delta and Ramsar wetland. The delta and Ramsar wetland provide valuable ecologically services to an array of biological and social receptors. .

Impact Assessment

The residual impact is determined to be Negligible due to the fact that wet season high flows will not be changed as a result of the proposed Project. To ensure that the Environmental Flow Study modelled predictions are correct, the main mitigation measure is to ensure that the modelling is re-done should the design of the dredged channel change significantly. The design of the dredging channel includes channel dimensions, volume of sediment dredged or following the river's natural meander.

Discussion

As indicated earlier, the Environmental Flow Study predicts that water levels during the high flows will be negligibly affected. Thus the wet season overtopping of banks and subsequent flooding of distributaries and wetlands will remain unchanged. Thus the suite of ecological services (including provision of habitat and food sources) provided by the delta and wetland will not be affected by the Project. Discharges from Cahora Bassa remains as the primary influence on the flooding of the delta and wetlands.

Cumulative Impacts

Cumulative impacts occur when a Project activity acts together with other activities (other projects) to impact on the same environmental or social receptor. For purposes of this report, cumulative impacts have been defined as "the changes to the environment caused by an activity in combination with other past, present, and reasonably foreseeable future human activities". By definition, the impact assessments in the ESIA Report consider the cumulative impacts of past and present project in that all impacts are assessed against the present day baseline. The present day baseline includes impacts of past and present projects that have shifted the original natural, pristine conditions to the present day modified conditions. Thus, this cumulative impacts section considers potential future projects that could act together with the proposed Project to impact on common receptors.

The following "reasonably foreseeable" activities could act together with the Project to cumulatively affect the lower Zambezi environment:

- The construction and operation of the Mphanda Nkuwa Dam and Hydropower Plant.
- The expansion of Cahora Bassa Dam.
- The construction and operation of the Lupata Dam and Hydropower Plant.
- The construction and operation of the Boroma Dam and Hydropower Plant.
- Use of the river by other coal companies or projects as a transport route.
- Ongoing development.

Cumulative Impact of Dams and the Barging Project

<u>The Issue</u>
The dams identified above could act together with the Project to modify river and sediment flows, exacerbating environmental and social impacts on the Zambezi River and delta, on the Ramsar and other riparian wetlands/ habitats, on riparian agriculture and on artisanal and semi-industrial fishing.

The lower reaches of the Zambezi River have been altered significantly by the development of the Kariba and Cahora Bassa Dams. These large dams have resulted in an attenuation of the flows in the Zambezi River; largely eliminating the large flood events and very low dry season flows. The flows are now more stable to support hydropower generation. This has led to the river downstream of Cahora Bassa being more geomorphologically stable, with a narrower active channel, less braiding and less sediment transport than was historically the case. The result is that the river's geomorphologic and ecological systems downstream of the dams have been dramatically modified from their natural state. Inundation of the delta is now reliant on regional rain run-off and/ or releases from Cahora Bassa (Beilfuss and Brown, 2006).

Assessment and Mitigation

Because specific dam operating scenarios are unknown at this stage, quantifying the potential cumulative impact is not possible. The Environmental Flow study for this proposed Project shows that the Project will have a negligible incremental effect on water level and flood patterns in the river relative to present day conditions and the Project will not remove any sediment from the river system. Thus, in light of these results, it is reasonable to assume that the Barging Project's contribution to potential cumulative impacts on river flow and sediments is likely to be very low compared to that of the proposed dams. By their nature, dams are the primary influence on river and sediment flows.

In line with international good practice, RML's mitigation should be commensurate with its level of contribution to the cumulative impact. In this regard, the appropriate mitigation is for RML to share data and information with third parties to facilitate a regional strategic assessment of development on the lower Zambezi River. There is a strong need to foster collaboration among the mining and power sectors as well as between these sectors and the Mozambican government and NGOs.

Cumulative Impact of River Transport by other Coal Companies and Projects

Issue

The creation and maintenance of the navigable channel for the proposed Project could result in other companies and projects (including coal companies, transport companies or even tourist companies) using the river as a means of transport. This has the potential to result in cumulative impacts on environmental and social aspects like water quality, safety of current river users, riparian habitats and riparian agriculture.

Assessment and Mitigation

As with the dams, there is insufficient information available to quantify the potential future use of the river by other companies or projects. Should these future users comply with RML's channel design parameters (ie utilise RML's channel without additional dredging or widening) and operational parameters (speed of vessels, safety standards, pollution prevention measures, emergency response procedures etc), then the cumulative impacts on the river environment and those communities using the river is likely to be low. However the cumulative impact on river safety due to increased traffic on the river will be higher, depending on the number of additional vessels using the river and depending on the level of intervention by the appropriate authority.

The main mitigation measure is for RML together with future users to work with the Mozambican government in complying with regulatory requirements for river transport. As a minimum all users should comply with standards of operation described in this ESIA Report, ESMP and any regulations defined by the appropriate government authority.

Cumulative Impact of Ongoing Development

Issue

In addition to the specific reasonably foreseeable projects listed above, development in the Tete area (primarily throughmining) is resulting in an increase in population and increasing pressure on infrastructure and services. These population and development pressures may lead to further investigation of the river as a transport route or as a source of water. This in turn could cumulatively affect the ecological functioning, and dependent socio-economic activities, of the lower Zambezi.

Assessment and Mitigation

While these developments will add significantly to the economic growth of Tete Province and Mozambique as a whole, it is likely the functioning of the lower Zambezi, as an important source of livelihood and economic development in its own right, will be impacted and changed. The government of Mozambique needs to consider the trade-offs of growth in the mining, industrial and energy sectors and the associated benefits to the economy and the people of Mozambique against the potential long term and cumulative impacts on the functioning of the Zambezi Basin. This is important considering the role that the Zambezi River plays in economies outside of its catchment, namely its contribution to the fishing and prawn industry (through provision of breeding areas, food and shelter and linkages to the Sofala Bank), to marginal and island agriculture and potentially to ecotourism in the future.

While the cumulative impacts are difficult to quantify, ongoing monitoring will be key to provide the government of Mozambique with information to inform its strategic planning for the lower Zambezi River. In this regard collaboration among the mining and power sectors as well as between these sectors and the Mozambican government and NGOs will promote a more comprehensive understanding of the lower Zambezi River system.

SUMMARY OF IMPACTS

The table below summarises all the impacts assessed. As can be seen, the proposed Project would predominantly have a relatively minor impact on the status quo of the Zambezi River. The primary reason for this is that the impacts of the proposed dredging on the hydraulics of, and habitats in, the lower Zambezi River are expected to be muted by the size of the Lower Zambezi ecosystem relative to the proposed dredged channel and influence of spoil. Should the magnitude of the Project's dredging remain unchanged from that described in the ESIA report, and should the proposed mitigation measures be implemented, there are unlikely to be any fatal flaws from an environmental and social perspective.

SUMMARY OF IMPACTS AND MITIGATION

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Impact of dredging and spoil deposition on the Zambezi delta and Ramsar wetland	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of dredging and spoil deposition on benthic habitat	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Routine Coal Spillage on Freshwater Aquatic Invertebrates	Operation	**Minor**	**Negligible**
	Decommissioning & Closure	**Minor**	**Negligible**
Impact of accidental fuel spills on aquatic invertebrates	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of bank collapse on aquatic invertebrates	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Dredging on Turbidity and Fish	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Accidental Fuel Spills on Fish	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of accidental Coal Spills on Fish	Operation	**Negligible**	**Negligible**
Impact of Changes in the Hydrology and Flooding Pattern on Fish	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of Dredging on Injuries to Fish	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact on Depth Classes due to Dredging	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Benga land based facilities on terrestrial ecology and habitat	Construction, ,	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
	Decommissioning & Closure	**Minor**	**Negligible**
Impact of Chinde land based facilities on mangroves	Construction,	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
	Decommissioning & Closure	**Minor**	**Minor**
Disturbance to riparian habitats due to dredging and spoil deposition	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of accidental fuel spills on riparian habitats	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Increase in rate of erosion of riparian habitats due to wakes from barges and push boats	Operation	**Moderate**	**Minor**

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Changes to hippopotamus behaviour and an increase in human animal conflict	Construction	**Minor**	**Negligible to Minor**
	Operation	**Minor**	**Negligible to Minor**
Impact of human and vehicle traffic on salt marsh habitat	Construction a	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Noise on River and Estuarine Fauna	Construction	**Minor**	**Negligible**
Impact of dredging of the offshore sand bar on sea bed benthic organisms	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of dredging of the offshore sandbar on seawater quality	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of Anchoring of Transloaders and OGVs on the Sofala Bank Sea Bed	Operation	**Minor**	**Negligible**
Impact of coal dust on vegetation and water quality in the estuary	Operation	**Minor**	**Minor**
Impact of operational coal spillage on the estuary environment	Operation	**Minor**	**Minor**
Impact of coal dust and operational coal spillage on the marine environment	Operation	**Negligible**	**Negligible**
Impact of operational discharges from OGVs on the marine and estuarine environment	Operation	**Minor**	**Minor**
Impact of accidental discharge of liquid hydrocarbons during fuel transfers	Operation	**Minor**	**Low**
Impact of ballast water discharges on the marine environment	Operation	**Minor**	**Minor**
Impact of groundings and/or collisions of barges and/ or tugs in the River	Construction	**Minor**	**Minor**
	Operation	**Moderate**	**Minor**
	Decommissioning & Closure	**Minor**	**Minor**
Impact of collisions of barges and/ or tugs in the marine environment	Operation	**Minor**	**Minor**
Impact of salinity intrusion on the estuary due to dredging of the offshore sandbar	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of dredging the offshore sandbar on littoral drift sediment dynamics and beach erosion	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Land-based Facilities on Bird Habitat	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Noise on Birds	Construction	**Minor**	**Minor**
Impact of Disturbances on Island Bird Habitats due to Dredging	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Accidental Fuel Spills on Birds and Bird Habitats	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Bird Hunting by Workers during the Construction and Operational Phases	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Spoil Deposition on High Flow Distributaries and Bird Feeding and Breeding	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Impact of Dredging on Bird Food Sources	Construction	**Minor to Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Groundwater Impact on Gorongosa National Park	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of the project on Mozambican national economy (Cost Benefit Analysis)	The Project	**Major**	**Major**
Impact of the project on the macro-economy	Construction	**Major**	**Major**
	Operation	**Major**	**Major**
Noise impact of barging on riverside communities	Operation	**Minor**	**Minor**
Noise impact of dredging on riverside communities	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Noise impact at the loadout point at Benga	Construction	**Moderate**	**Moderate**
	Operation	**Negligible**	**Negligible**
Noise impact at the barge mooring areas at Dona Ana Bridge	Construction	**Moderate**	**Moderate**
	Operation	**Minor to Moderate**	**Minor to Moderate**
Noise impact at the barge mooring areas at Chinde	Construction	**Moderate**	**Moderate**
	Operation	**Minor**	**Minor**
Impact of dredging on artisanal and semi-industrial fishing activities in the river	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of barging operations on artisanal and semi-industrial fishing activities	Operation	**Minor**	**Minor**
Impact of safety exclusion zones on artisanal fishing at Chinde	Construction	**Minor**	**Negligible**
	Operation	**Moderate**	**Minor**
Impact of safety exclusion zone on offshore semi-industrial and industrial fishing	Operation	**Negligible**	**Negligible**
Impact of changes to flows on agricultural activity on river margins and islands	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of barging on river safety	Operation	**Moderate**	**Minor**
Impact of convoy wakes on river margin activities (washing, bathing, water collecting)	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of accidental fuel spills on river margin activities (washing, bathing, water collecting)	Construction	**Negligible**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact on community health	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Increase in social ills (crime, prostitution) on Chinde population	Construction	**Minor**	**Minor**
	Operation	**Moderate**	**Moderate** **Minor**
Impact of the project on social infrastructure in Chinde	Construction	**Negligible**	**Negligible**

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)		Residual Impact (Post Mitigation/ Enhancement Measures)	
	Operation	**Minor**		**Minor**	
Potential loss of Property in Benga and in Chinde North bank	Construction	**Minor**		**Negligible**	
	Operation	**Minor**		**Negligible**	
Impact of the project on river-centered tourism	Construction	**Minor**		**Negligible**	
	Operation	**Minor**	**+Minor**	**Minor**	**+Minor**
Impact of barging operations on sense of place	Operation	**Minor-Moderate**	**+Minor - Moderate**	**Minor-Moderate**	**+Minor - Moderate**
Impact of the project on direct job creation	Construction	**Moderate**		**Moderate - Major**	
	Operation	**Moderate**		**Moderate - Major**	
Impact of skills transfer on local Mozambicans	Operation	**Moderate - Major**		**Moderate - Major**	
Impact of development at Benga, Mutarara and Chinde	Operation	**Moderate - Major**		**Moderate – Major**	
Impact of creating a navigable channel on business opportunities and indirect jobs	Operation	**Moderate**		**Moderate**	

Framework Environmental and Social Management Plan

The ESMP is a delivery mechanism for environmental and social mitigation measures made in the ESIA Report. The purpose of the ESMP is to ensure that recommendations are translated into practical management actions which can be adequately resourced and integrated into the project phases. The ESMP also outlines roles and responsibilities, reporting cycles and measures for corrective actions (*Chapter 10* of the ESIA). The framework ESMP can be found in *Annex D* of the ESIA Report.

Conclusion

Should the Project be approved, it is recommended that RML works closely with the Mozambican government to monitor the ongoing activities to assist with strategic planning for the river, particularly focussing on cumulative impacts.

CONTENTSNON-TECHNICAL SUMMARY *I*

ACRONYMS

ADI	Area of Direct Influence
BCR	Benefit Cost Ratio
BID	Background Information Document
CBA	Cost Benefit Analysis
CD	Chart Datum
CLO	Community Liaison Officer
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSD	Cutter Suction Dredgers
dB	Decibel
DEM	Digital Elevation Model
DRIFT	Downstream Response to Imposed Flow Transformation
EF	Environmental Flow
EIS	Environmental Impact Study
ESIA	Environmental and Social Impact Assessment
EIR	Environmental and Social Impact Report
EMC	East Madagascar Current
EPDA	Estudo de Pré-viabilidade Ambiental e Definição de Âmbito
EPSS	Environmental Pré-feasibility and Scoping Study (EPDA)
ERM	Environmental Resources Management Southern Africa (Pty) Ltd
ESMP	Environmental and Social Management Plan
FTS	Floating Transfer Station
GDP	Gross Domestic Product
GIS	Geographic Information System
GLIS	US Geological Surveys Global Land Information System
Hp	Horsepower
Hz	Hertz (cycles per second)
IMO	International Maritime Organisation
IPCC	International Panel on Climate Change
I&AP	Interested and Affected Parties
IEM	Integrated Environmental Management
IFC	International Finance Corporation
IMPACTO	Impacto Associados Lda
JA	Justiça Ambiental
km	Kilometres
km^2	Kilometres Squared
LAT	Lowest Astronomical Tide
l/s	Litres per Second
m	Meters
m^3	Cubic Meters
m^3/s	Cubic Meters per Second
MAE	Ministry for State Administration (Ministério da Administração Estatal)
Mamsl	Meters Above Mean Sea Level
MAR	Mean Annual Runoff
Mcm^3	Million Cubic Meters
MICOA	Ministry for Coordination of Environmental Affairs / Ministério para a Coordenação da Acção Ambiental

mtpa	Million Tons Per Annum
MZM	Mozambique Meticais
NPV	Net Present Value
NO_x	Nitrite (NO_2) and Nitrate (NO_3)
PPP	Public Participation Process
PV	Present Value
RAP	Resettlement Action Plan
ROM	Run of Mine
RML	Riversdale Mining Limitada
SADC	Southern Africa Development Community
SAM	Social Accounting Matrix
SASS	South African Scoring System: A rapid method of water quality assessment, based on the composition of aquatic macro-invertebrates
SEC	South Equatorial Current
SO_2	Sulphur Dioxide
STDs	Sexually Transmitted Diseases
TDS	Total Dissolved Solids
ToR	Terms of Reference
TPH	Tons Per Hour
TSHD	Trailing Suction Hopper Dredger
WBC	Western Boundary Current
WGS84	World Geodetic System 1984 (revised 2004)
WOCE	World Ocean Circulation Experiment
WWF	World Wildlife Fund

GLOSSARY

Alluvium: Loose, unconsolidated soil or sediments eroded and deposited by water in a non-marine environment

Alternative: A possible course of action, in place of another, that would meet the same purpose and need (of the proposal). Alternatives can refer to any of the following but are not limited to: alternative sites for development, alternative projects for a particular site, alternative site layouts, alternative designs, alternative processes and alternative materials.

Aquifer: Defined as a saturated geological unit that is permeable enough to yield economic quantities of water to wells.

Ballast water: Ballast water is held in tanks on ships to improve trim and aid in navigability. Unladen vessels carry large volumes of ballast water and vice versa

Barge: A long, large, usually flatbottom boat for transporting freight that is generally unpowered and towed or pushed by other craft.

Baseflow: Baseflow is the groundwater component contributing to stream flow for gaining streams (water level intercepts the stream).

Benthic: Bottom dwelling

Biodiversity: The structural, functional and compositional attributes of an area, ranging from genes to landscapes.

Biotope: The place in which a certain assemblage of organisms live.

Discharge: Flow rate in cubic metres per second.

Dredging: Excavation activity associated with shallow seas and natural channels.

Endemic: Occurring in a specified locality, not introduced.

Estuary: A partly enclosed coastal body of water with one or more streams or rivers flowing in to it with a free connection to the open sea.

Environment: The surroundings within which humans exist and that are made up of:

i. the land, water and atmosphere of the earth;
ii. micro-organisms, plant and animal life;
iii. any part or combination of (i) and (ii) and the interrelationships among and between t them; and
iv. the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being. This includes the economic, social, cultural, historical and political circumstances, conditions and objects that affect the existence and development of an individual, organism or group.

Environmental Assessment: The generic term for all forms of environmental assessment for projects, plans, programmes or policies. This includes methods/tools such as environmental impact assessment, strategic environmental assessment, sustainability assessment and risk assessment.

Exotic: Introduced from elsewhere: neither endemic nor indigenous.

Habitat: An ecological or environmental area inhabited by a particular species or that which supports a typical community of species

Impact: The positive or negative effects on human well-being and / or on the environment.

Indicator Taxa: Taxa that are commonly associated with and characteristic of a specific instream habitat type.

Interested and Affected Parties: Individuals, communities or groups, other than the proponent or the authorities, whose interests may be positively or negatively affected by the proposal or activity and/ or who are concerned with a proposal or activity and its consequences.

Macroinvertebrate: Invertebrates larger than 1 mm. This excludes most zooplankton.

Natural Habitat: Land and water areas where (i) the ecosystems' biological communities are formed largely by native plant and animal species, and (ii) human activity has not essentially modified the area's primary ecological functions. All natural habitats have important biological, social, economic, and existence value.

Mitigate: The implementation of practical measures to reduce adverse impacts or enhance beneficial impacts of an action.

Permeability: Is a measure of the ability of a porous material (often, a rock or unconsolidated material) to transmit fluids.

Proponent: Riversdale who is applying for an environmental authorisation in terms of the relevant environmental legislation.

Public Participation Process: The process of engagement between interested and affected parties (the proponent, authorities and other stakeholders) during the planning, assessment, implementation and/or management of proposals or activities.

Salinity: Salinity refers to the dissolved salt content in seawater.

Salt marsh: An environment in the coastal upper intertidal zone between land and salty (brackish) water dominated by dense stands of halophytic plants such as herbs, grasses and low shrubs

Scoping: The process of determining the spatial and temporal boundaries (i.e. extent) and key issues to be addresses in an environmental assessment. The main purpose of scoping is to focus the environmental assessment on a manageable number of important questions.

Scoping should also ensure that only significant issues and reasonable alternatives are examined.

Significance: Significance can be differentiated into impact magnitude and impact significance. Impact magnitude is the measurable change (i.e. intensity, duration and likelihood). Impact significance is the value placed on the change by different affected parties (i.e. level of significance and acceptability). It is an anthropocentric concept, which makes use of value judgements and science-based criteria (i.e. biophysical, social and economic).

Suspended Solids: Suspended solids refer to particulate inorganic and organic matter that are in suspension in the water column. The presence of suspended solids is usually attributed to a reduction in the clarity of water, i.e. light penetration or visibility.

Thalweg: Longitudinal flow path connecting lowest bed elevations.

Transmissivity: The transmissivity is a measure of how much water can be transmitted horizontally, such as to a pumping well (measured in m^2/day).

Turbidity: Turbidity is caused by colloidal suspensions (particle size between 0.001 µm and 0.1 µm) which usually give water a 'murky' appearance, while colour is caused by substances which dissolve in water and as a result the colour of the water changes. Both turbidity and colour, together with suspended solids, influence the clarity of water, i.e. the depth of light penetration or visibility in water.

1 *INTRODUCTION*

1.1 *PURPOSE OF THIS ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT*

This Environmental and Social Impact Assessment Report has been compiled as part of as part of the Environmental and Social Impact Assessment (ESIA) process for the proposed Zambezi River Coal Barging Project, on behalf of Riversdale Mozambique Limitada (hereafter referred to RML or the Company). RML is a 65%-owned subsidiary of Riversdale Mining Limited, a mining company listed on the Australian Stock Exchange, with operations in South Africa and Mozambique. The other 35% is owned by Tata Steel limited, a major Indian steel producer.

This ESIA Report summarises the EIA process followed to date, outlines the legislative framework, and provides a description of the project and the biophysical and socioeconomic conditions of the study area. It also provides an assessment of the impacts of the proposed project activities on the surrounding biophysical and social environment and detailed recommendations on how negative impacts can be mitigated and positive effects enhanced. The report will be used by the Mozambican Ministry for the Coordination of Environmental Affairs (MICOA) as part of the information required to make a decision as to whether the proposed development may proceed.

1.2 *BACKGROUND TO THE PROJECT*

RML controls one mining concession (the "Benga Mine Project") and an exploration licence covering a combined area of approximately 25,000ha in Tete Province. The Environmental Impact Study (EIS), Environmental Management Plan (EMP) and Environmental Licence 2/2010 for Riversdale's Benga Mine Project, comprising a large opencut coal mine and associated mining, processing and logistical infrastructure in Benga, Moatize District, was recently approved by the Ministry for the Coordination of Environmental Affairs (MICOA). The Zambezi River Coal Barging Project provides one of the means of transporting coal from the mine to international markets.

1.3 *NEED AND PURPOSE OF THE PROPOSED PROJECT*

There are several coal companies currently prospecting in the Moatize area. The potential coal resource is very large (the Benga Mine Project alone has a coal resource of approximately 4 billion tonnes), which has resulted in a need for coal companies to explore various means of transporting coal to markets. Accordingly, there are three routes that are currently being investigated for transporting coal:

- Export via the Sena Railway Line to Port of Beira (direct loading or barging to a transloader).
- Export via Nacala Corridor from Benga.
- Export via barging down the Zambezi River from Benga.

It should be noted that, given the large coal resources in the area and that other mining companies also need to transport coal, *all* three routes are likely to be utilised by RML to ensure that they are able to optimise the export potential from their current and future mining operations. Thus the three routes are complementary and not alternative options.

RML have appointed Environmental Resources Management Southern Africa Pty Ltd. (ERM) in partnership with Impacto Associados Lda (Impacto) as independent consultants to undertake the ESIA for the Zambezi River Coal Barging Project. The Ministry for the Coordination of Environmental Affairs (MICOA) has classified this project as a Category A Project (Reference No. 233/GDN/DNAIA/MICOA/10 dated 15/03/2010). This requires that a comprehensive ESIA process be undertaken.

The Project comprises the following elements and is described in detail in *Chapter 4*.

- Loading coal onto barges to be pushed downriver using pushboats (from the loadout point at Benga to Chinde).
- Capital and maintenance dredging in certain locations to have a navigable channel for barging down the river.
- Mooring points on either side of the Dona Ana Bridge.
- Fenders to protect bridges that cross the river, if required.
- Mooring points and support facilities at Chinde.
- Pullboats (also called shuttle tugs) pulling single barges from the mooring points at Chinde out to a transloader approximately 15km to 20km offshore.

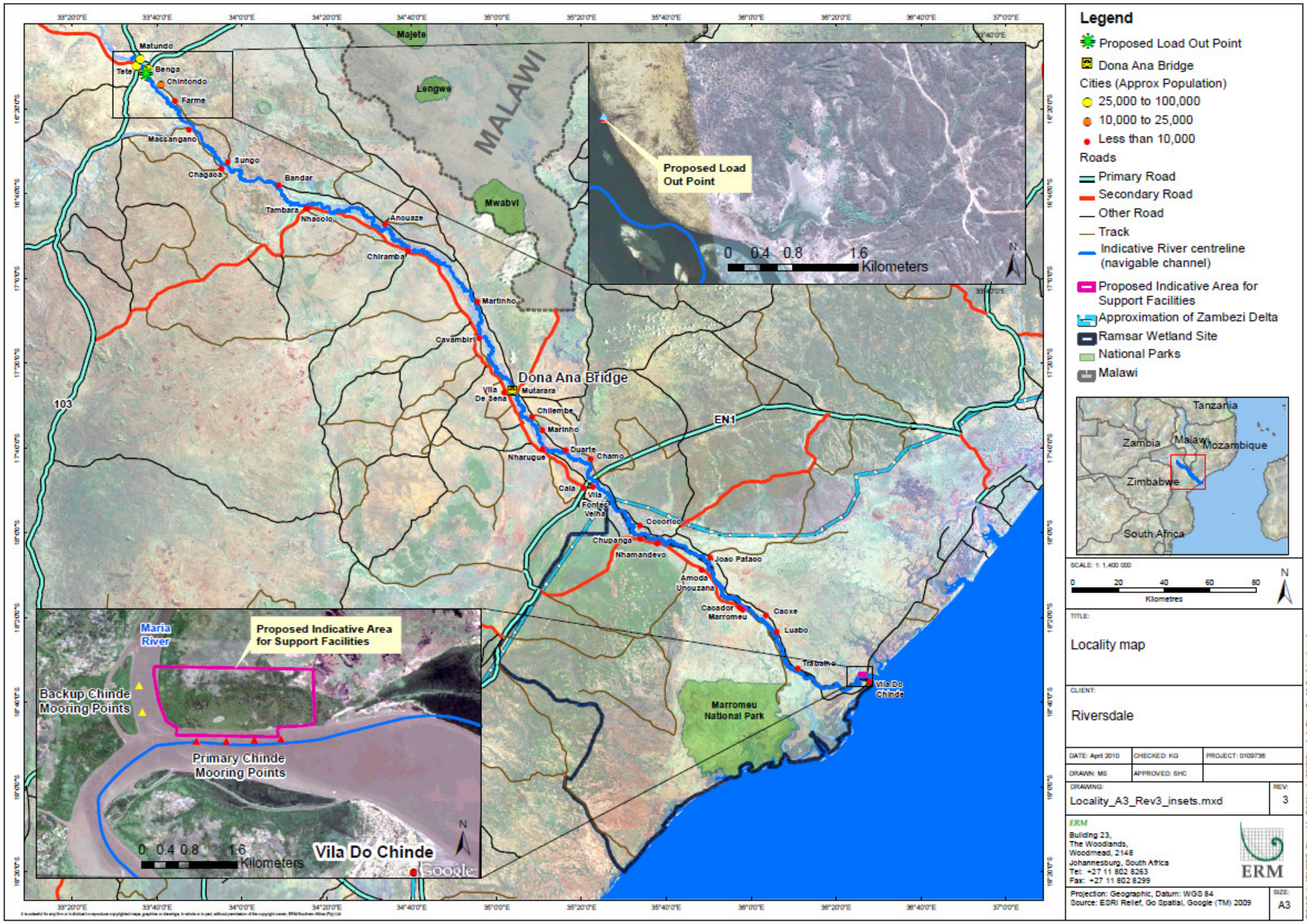
Figure 1.1 shows the project area and key project elements.

1.4 *ASSUMPTIONS AND LIMITATIONS*

The study area is defined as the location of the barge loading facilities at Tete, the river environment (river channel and immediately adjacent floodplain) from the loadout point to Chinde, the support facilities on the northern side of the river, across from Chinde, the river mouth at Chinde and the site of the transloader in the ocean.

The point of departure for this ESIA process excludes the consideration of alternative means of transporting coal from the Benga Mine Project. In terms of alternatives, this ESIA will focus on alternative site layouts, processes or technologies within the proposed Zambezi River Coal Barging Project and not on complementary routes or methods for exporting coal.

Figure 1.1 Locality Map



1.5 *STRUCTURE OF THIS REPORT*

This Report comprises eleven chapters, as described in *Table 1.1* below.

Table 1.1 Structure of Environmental Impact Report

Chapter	Description
Chapter 1	**Introduction**
Chapter 2	**EIA Approach & Methodology** Describes the EIA phases undertaken thus far and describes the remaining phases.
Chapter 3	**Legal Framework** Describes the legal and regulatory framework for the ESIA, including relevant international conventions.
Chapter 4	**Project Description** Provides a description of the proposed project and the rationale behind it. Also provides a brief discussion on the alternatives to be considered.
Chapter 5	**The Receiving Environment - Biophysical** Describes the existing biophysical environment that could be affected by the project.
Chapter 6	**The Receiving Environment - Socio-Economic** Describes the existing socio-economic environment that could be affected by the project.
Chapter 7 and 8	**Impact Identification and Assessment** Provides an assessment of the identified impacts of the proposed project activities on the biophysical and socio-economic receiving environment. Proposed mitigation measures are outlined for each impact assessed.
Chapter 9	**Cumulative Impacts** Qualitative Assessment of potential cumulative impacts
Chapter 10	**Framework Environmental and Social Management Plan** Provides management measures (mitigation and enhancement) to address the identified negative and positive impacts.
Chapter 11	**Conclusion** Provides conclusions to the ESIA study.
Chapter 12	**References** Provides a list of the sources used to compile this report.

1.6 *CROSS REFERENCE OF ISSUES RAISED*

All issues, comments, questions and concerns raised to date have been recorded. *Table 1.2* and
Table 1.4 below facilitate easy cross referencing to various sections in this report that address a particular issue.

Table 1.2 Cross Reference of Issues Raised during Stakeholder Engagement for the EPDA Phase

Issue/Impact Raised by Stakeholders to date	**Reference in the ESIA**
Issues / Concerns/Comments raised related to Dredging	
Possible impact of dredging on the Zambezi effluents and on sedimentation patterns at the delta.	Section 5.8.1 Section 7.4 Section 7.28 Section 7.29 *Annex C (Marine and Estuarine Ecology Report, Sediment Dynamics Report)*
The impact of dredging on the erosion patterns must be investigated. Erosion is a huge problem in the Zambezi valley. Dredging and traffic can further aggravate the problem. Machambas on the banks and margins can be affected.	Section 5.10.2 Section 7.7 Section 7.13 Section 7.14 Section 7.29 Section 8.15 *Annex C*
Need to assess increase on water turbidity due to dredging operations.	Section 5.6.3 Section 7.18 *Annex C*
The "behaviour" of the Zambezi must be taken into consideration. It's a very errant river, and the main channel shifts its position. This will make dredging a very difficult and expensive operation.	Section 4.2 Section 4.6 Section 5.6
Need to guarantee ecological flows, bearing in mind that dredging has the potential to interfere with flows. Current ecological flow plus dredging will probably no longer be an ecological flow.	Section 5.8.1 Section 7.2 Section 7.3 *Annex C* (Environmental Flow Assessment)
Strategic Plan for Zambezi Delta specifies that dredging is not allowed in the delta (Plan submitted to Government perusal but not yet approved)	Noted. RML will keep open lines of communications with all decision making authorities.

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Need to define how many spots will be dredged and quantities of sediments to be removed Volumes to be dredged should be made clear. Dredging should be minimized as possible	Section 4.1 Section4.2 Section4.4.1 Section4.5.3 Section 4.5.6 Section 4.7.1 Section 4.7.3 Section 7.3.1 *Annex C* (Environmental Flow Assessment) While the Project concept is well defined, detailed design is ongoing, with technical investigations into river flow variations, channel depths, convoy configurations, barge mooring requirements, **<u>dredging requirements</u>**, and coal transport volumes amongst others continuing
The dumping of dredged material must be carefully considered, especially with respect to affects on benthic fauna and riverine species reproduction	Section 7.3 Section7.4 Section 7.11 Section 7.14 *Annex C* (Environmental Flow Assessment, Benthic Fauna Assessment)
Issues / Concerns/Comments raised with regard to noise	
Noise produced by passing convoys can be a disturbing factor not only for humans but also for several species inhabiting the river who can feel compelled to abandon their current habitats.	Section 7.16 Section 8.5 Section 8.7 Section 8.8 Section 8.9
Issues / Concerns/Comments raised with regards to public consultation process	
Need to involve more entities (such as universities, research institutions and the National Directorate of Water – DNA in technical stakeholders meetings. Need to ensure transparency of the process and release relevant technical information for public scrutiny. The National Institute for Natural Calamities Management (INGC) has implanted Risk Management Committees along the Zambezi Valley. Those Committees must be involved in the project. The Project can have an impact on the Marromeu reserve. The Director of Marromeu reserve must be involved in the search for measures to ensure the protection of this important conservation area.	Section 2.6.1 *Annex B* (PCDP)
Issues / Concerns/Comments raised with regards to cumulative Impacts	
Need to maintain open communication channels between Riversdale and the Mphanda Nkuwa consortium.	Section 4.6.1 Chapter 9

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Need to consider impact of future hydropower projects on the river flow, namely on dredging requirements.	
Need to take into account other river uses and other projects to be developed on the Zambezi, namely hydropower projects. Possible conflict with hydropower projects	
There is an ongoing work of rehabilitation of the Zambezi delta from the negative impacts provoked by Cahora Bassa; this work can be hampered by the cumulative impact of the barging project.	
Barging project can be conflicting with hydropower projects, irrigation projects and water supply projects. Thus there needs to be an agreement between RML, Cahora Bassa and Mphanda Nkuwa, to prevent future conflict induced by possible reduction in flows due to climate change.	
Cumulative impacts must be considered.	
MICOA and UEM, in partnership of WWF, are preparing a Zambezi Delta Management Plan. Need to coordinate the Project with Plan, after Plan is approved by relevant authorities.	
Cumulative impacts must be considered.	
Compatibility of the barging project with other possible projects, namely the building of Lupata Dam, downstream Benga.	
Issues / Concerns/Comments raised with regards to social and economic aspects	
Possible environmental and socio-economic impacts of coal dust generated during Project operations.	Section 7.20 Section 7.22
Benefits to be granted to riverine populations affected by the Project. Local populations will not benefit from the project. Support and compensation measures must be studied.	RML will develop a Social Responsibility Initiatives
Need to observe not only social responsibility policies but also environmental responsibility policies	
Impacts of the project on the livelihoods of riverine communities, especially on fishing activity.	Section 7.8
The river is a vital resource for the livelihood of riverine communities and must be left undisturbed.	Section 8.10 Section 8.11 Section 8.12 Section 8.13
Impact of the project on river-based tourism activity.	Section 6.7 Section 8.23
Socio-economic impacts of the Project in the Zambezi valley must be investigated. Micro-economic studies must be carried out.	Section 8.3 Section 8.4 *Annex C* (Macro Economic Impact Assessment)
Need to define what kind of measures will be implemented to compensate riverine communities for disruptions of their river-related activities Fishing communities along the river will be severely affected. Need to study alternatives for those who might be forced to stop fishing.	The SIA does not conclude that subsistence fishing will be affected to the degree where alternatives need to be provided by RML. However the ESMP does note that in the event of any grievance RML has a responsibility to address all valid grievances.
The convoys will mean more people (the convoy crews) sailing along the river and stopping in some points (Dona Ana, Chinde). There is thus a need to engage in AIDS awareness and prevention programmes.	Section 8.19

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
When building infrastructure at Chinde, mangroves need to be preserved. Also, measures to prevent a population influx to the northern margin, opposite Chinde, must be contemplated.	Section 4.5.4 Section 7.10 Section 8.20 Section 8.21 Section 8.26
Issues / Concerns/Comments raised with regards to Safety	
Risk of accidents involving convoys and existing river traffic. Signage must be provided. Need to implement navigation safety rules and procedures, in order to avoid accidents with other river traffic.	Section 7.26 Section 7.27 Section 8.16
Issues / Concerns/Comments raised with regards to fauna	
Need to carefully assess the impacts of the project on river fauna. Specific study of possible impacts in hippo and crocodile populations is needed.	Section 7.4 Section 7.5 Section 7.6 Section 7.7 Section 7.14 *Annex C*
Projects' impact on migrating birdlife must be evaluated	Section 7.30 *Annex C (Avifauna Specialist Study)*
Issues / Concerns/Comments raised with regards to alternatives to barging on the Zambezi	
Three alternatives were presented for the coal transport: Sena line, Nacala and the barging project. Other options should be considered, such as a new railway line and a new port in Zambézia Province. Need to further exploit the railway option, which is perceived as less disruptive from an environmental perspective. The impact of the railway option is less significant than the impact of barging. Investment in railway structure should be viewed as a preferred solution, instead of investment in barging. Economic viability studies must be produced for all options.	Section 1.2
Issues / Concerns/Comments raised with regards to pollution caused by coal spillage/dust/ash	
Coal dust emissions during loading, transport and transloading as a possible source of air pollution. The selected technology for transloading must be carefully evaluated. Grabs have a high risk of spillage. Vacuum methods should be considered. Possible contamination of river by coal, fuel and oil spillages. There needs to be adequate anti-spillage measures.	Section 7.21 Section 7.22 Section 7.24 Section 8.18
Need to define what kind of monitoring measures will be implemented to verify the projects' impact on water quality. Need to study how the river will be transformed by the project overtime, namely in terms of water quality	Annex D – Framework Environmental and Social Management Plan
Issues / Concerns/Comments raised with regards to Barging	
Technical inspections for the barges, pushboats and tugboats must be rigorously performed.	RML will develop plans for regular inspection and maintenance according to manufacturer specifications

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Clarify whether the channel is solely for RML's use or will it be open to other transporters.	Once the channel is open its expected that Government will be responsible for regulating its use
Possible inclusion of Mozambican technical personnel in a case-study visit to an operational barging project elsewhere in the world in order to enable them to verify in situ impacts of such projects.	This was not logistically feasible
Option for use of non-covered barges increases need to study wind regime in the Zambezi Valley, which is prone to cyclones and strong winds. Wind patterns must be studied	Chapter 5
Issues / Concerns/Comments raised with regards to political decision making	
Necessity of taking into account Mozambique's international obligations such as the SADC Protocols, since the Zambezi is an international river.	Chapter 3
Possible implications for political decision involving the Malawi Shire River project.	Government will be responsible for regulating its use
Need to contemplate the possible need of diverting water from the Zambezi to other river basins and the implication of that option on the project	Potential for significant volumes of inter-basin transfers do not appear to be part of the short to medium term planning for the Zambezi River. Should any such transfers be considered in future, they will be subject to comprehensive EIA and RML will participate in that process in order to determine cumulative impacts
Issues / Concerns/Comments raised with regards to ecological aspects	
Extreme caution must be exercised in preserving mangroves in the Zambezi delta, as they are important nurseries for shrimps captured in the Sofala bank.	*Annex D* (ESMP)
Acceptable levels of confidence in the hydrological model should be defined for decision making.	Peer review of EF Specialist study is being undertaken by Dr Ian King
Dredging and coal falling into the water can affect mangroves and the shrimp production of Sofala Bank, the country's most important fishing site.	Section 7.19
Issues / Concerns/Comments raised with regards to climate change	
Clarification is needed on how climate change could affect the Project and on whether coal will be stockpiled at Chinde	Section 4.6.3
Potential effects of climate change on the project must be taken into account, since extreme drought or extreme flooding situations might affect the Project's viability	

Table 1.3 Cross Reference of Issues Raised during Stakeholder Engagement for the Impact Assessment Phase

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Issues / Concerns/Comments raised related to Dredging	
Need to clarify effect of dredging in the main channel in water dynamics (speed, capacity to transport sediments, capacity for increased erosion, etc.)	Section 5.8.1 Section 7.4 Section 7.28 Section 7.29 *Annex C (Marine and Estuarine Ecology Report, Sediment Dynamics Report Environmental Flow Assessment)*
Decrease of fish and prawn captures could occur due to project impacts on mangroves, vital for maintaining fish and prawn stocks;	Section 5.10.2 Section 7.7 Section 7.13 Section 7.14 Section 7.29 Section 8.15 *Annex C*
Dredging may effect on the quality of water for bathing and drinking;	Section 5.6.3 Section 7.18 *Annex C*
The Project should be put on hold until Strategic Assessment for the Zambezi is finalized;	Noted. RML will keep open lines of communications with all decision making authorities.
Need to provide a list identified sites for deposition of dredged materials. Need to define maximum dredging limits, in order to ensure that river will not be over dredged.	*Annex C* (Environmental Flow Assessment) Given the natural river variation, it is difficult to pinpoint fixed sites for dredging and deposition. These will be identified according to the principles in the Project description and as defined in the Environmental Flow Assessment. The ESMP notes that should dredging volumes increase significantly from that described in the ESIA, the Environmental Flow Assessment would need to be amended accordingly.

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Impact on fisheries due to combined disturbance of traffic and dredging	Impacts on fish are considered in Chapter 7 and 8. *Annex C* (Fish and Fisheries Specialist Study)
Issues / Concerns/Comments raised with regard to noise	
Noise impacts on riverine communities need to be addressed	Section 7.16 Section 8.5 Section 8.7 Section 8.8 Section 8.9
Issues / Concerns/Comments raised with regards to public consultation process	
Need for Riversdale sharing information and data with relevant institutions such as ARA Zambeze	Noted. RML will keep lines of communications open with all relevant authorities
Issues / Concerns/Comments raised with regards to cumulative Impacts	
Need to ensure that the existing dams will not be requested to release additional flows for navigation purposes	Noted. Cumulative are considered in Chapter 9
Need to assess if barging and hydropower projects are compatible. The EIA draft report does not refer how the Barging Project and the building of Lupata Dam will be compatible The Proponent of Lupata Dam, indicated possible interference of the proposed dam with the Benga loadout facility and barge traffic Cumulative impacts of increased traffic in case other operators are given the go-ahead to use the navigable channel	RML has indicated that they would not request Cahora Bassa Dam to release additional flows to facilitate barging. Communications between RML and potential projects on the river (like Lupata Dam and Mphanda Nkuwa) are ongoing.
Issues / Concerns/Comments raised with regards to social and economic aspects	
Benefits of the Project are understated in the report. Local agriculture and transport possibilities will benefit from the Project.	Noted
Possible constraints on fishing activity induced by dredging.	Section 7.8 Section 8.10 Section 8.11 Section 8.12 Section 8.13 Section 7.12 Section 7.13 Section 7.14 *Annex C* (Fish and Fisheries Specialist Study) .
Need to contemplate the possibility of a limitation of the navigation period (as opposed to 24h/day navigation) to accommodate other river-cantered interests	Noted. Such limits are expected to be driven by government regulations regarding barging.

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
A recommendation to Riversdale to allocate funds to promote, thru NGOs, alternative development plans (not centred in fishing or in agriculture) for populations living up to 5-6 km from the river banks, in order to allow those populations to better cope with impacts on their river-centred livelihoods.	Noted. RML will develop Social Responsibility Initiatives
Need to ensure that dust emissions at Chinde will not affect mangroves and, thus, have a detrimental effect on prawn fishing	Section 4.5.4 Section 7.10 Section 8.20 Section 8.21 Section 8.26 *Annex C* (Fish and Fisheries Specialist Study)
Need to find compensation schemes to benefit fishermen who will have to temporarily interrupt their work due to project activities	The SIA does not conclude that subsistence fishing will be affected to the degree where alternatives need to be provided by RML. However the ESMP does note that in the event of any grievance RML has a responsibility to address all valid grievances.
Social issues insufficiently covered in draft EIA. No quantification of affected people	Noted. The types of communities or stakeholders that could be both positively and negatively impacted by the Project are considered in the SIA, the Macro-economic Study (*Annex C*) and in the ESIA Report. The specific number of affected people is difficult to quantify with any degree of confidence. Nonetheless, affected communities or stakeholders are identified and impacts assessed in detail.
Issues / Concerns/Comments raised with regards to Health and Safety	
Signage must be provided, mainly near meanders and areas where the channel shifts direction;	Section 7.26 Section 7.27 Section 8.16
Need to assess if the new Caia bridge needs protection against accidental impacts	This issue will be monitored and fenders will be considered if warranted.

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Need to define size of exclusion zones around main project activity areas (loadout point at Benga, Mutarara, Chinde and oceanic transloader site)	The size of the exclusion zone around the ship-loader is not yet specified but should be at least 500m radius. Similarly, if there are specified approach and departure routes safety zones these should also be ~500m wide but possibly ~1,800m long. The estimated total area of exclusion zones will therefore be 2.6km². Two possible positions have been specified for the offshore installation, one ~15 km and the other ~20 km from the coast. Both are located in active trawling areas and therefore there will be implications for fishing. According to this figure the level of interference will be less for the further offshore site especially if the navigation routes to and from the facility are oriented offshore (away from the coast) as opposed to long-shore.
Issues / Concerns/Comments raised with regards to fauna	
Increase of human-hippo conflict due to disturbance of dredging and barging on hippo populations. Need to contemplate possible Project impact on hippo population; it has been observed in other navigated African rivers that hippo populations have decreased Need to clarify potential project impacts on crocodile populations. The report does not address this issue;	Section 7.4 Section 7.5 Section 7.6 Section 7.7 Section 7.14 *Annex C* The relevant specialist studies do not identify impacts on crocodiles as being an issue of concern.
Issues / Concerns/Comments raised with regards to alternatives to barging on the Zambezi	
Need to consider construction of alternative ports, Macuse and Pebane being possible options	Noted. This issue is beyond the scope of this ESIA. All reasonable alternatives have been considered in this ESIA Report.
Issues / Concerns/Comments raised with regards to pollution caused by coal spillage/dust/ash	
Concerns related to dust emission should be considered since the barges will not be covered Need to ensure that accidental fuel leaks will be addressed in a prompt and effective manner Need to study how the river will be transformed by the project overtime, namely in terms of water quality	Chapter 4 Section 7.21 Section 7.22 Section 7.24 Section 8.18 The ESMP notes that an ERP will have to be developed by RML. In addition, water quality monitoring will be undertaken.

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Issues / Concerns/Comments raised with regards to Barging	
Conclusions extracted from modelling should be validated by observation of coal barging operations existing elsewhere	Noted
Need to contemplate alterations to the Project in case the building of Lupata dam goes ahead	Noted. RML will keep open lines of communications with all decision making authorities as well as with the proponents of Lupata Dam
Issues / Concerns/Comments raised with regards to ecological aspects	
Decrease of fish and prawn captures due to project impacts on mangroves, vital for maintaining fish and prawn stocks	*Annex D* (ESMP) Chapter 7
Possible damage on the Sofala Bank due to transloader presence and transloading activity	Section 7.25
Issues / Concerns/Comments raised with regards to Environmental Management during operations	
What monitoring plans will be in place and who will undertake the monitoring. Need for ongoing monitoring to verify possible environmental degradation induced by the Project Residual and wastewater produced in barges and pushboats must be treated. Need to prepare a comprehensive monitoring plan. Monitoring at Benga, Mutarara and Chinde only is insufficient	*Annex D* (ESMP) lists the various monitoring activities and notes responsibilities for monitoring. Wastewater will be treated.

Table 1.4 *Cross Reference of Comments by MICOA on the EPDA Report*

Issue/Impact Raised by Stakeholders to date	Reference in the ESIA
Figure 4.3 presents a map that indicates the point of loading. However, the same is not clear, which makes it difficult to visualize and evaluate its compatibility with other existing infrastructures;	Now Figure 4.9 in the ESIA Report.
The symbols ESIA (page iii) and EISA (page 10) are not included on the list of acronyms and abbreviations;	Please refer to the Abbreviations and Acronyms at the beginning of the report.
The document presents a few sentences in English, eg. Pages iii and iv.	The ESIA Report will undergo a quality control review before submission to MICOA.
Recommendations from MICOA	
Compliance with the Regulation on the Process for Environmental Impact Assessment approved by Decree 45/2004 of 29th of September from the General Directive for the Elaboration of Environmental Impact Studies and the General Directive for the process of Public Participation;	Chapter 2 – ESIA Approach The ESIA Report has been undertaken in accordance with the Regulation on the Process for Environmental Impact Assessment approved by Decree 45/2004 of 29th of September.
Submission of the methodology used in the identification of impacts;	Annex E
Further details of the physical and biotic descriptors of the location for project implementation.	Chapter 5 – The Biophysical Receiving Environment describes the existing biophysical environment that could be affected by the project.
Inclusion in the chapter on "other Regulations of interest to the Environmental Management", of the Regulation of Law on Territorial Planning, since some of the infrastructure of the project will be implemented on the ground and within a Territory;	Noted. This Law has been reviewed
Submission of the identified species in scientific names but also in vernacular and local names;	Annex C – Specialist studies do indicate the identified species in scientific names and common names.
Submission through a location map of infrastructures, of all components of the project to be built, including the exact location of the floating platform in geographical coordinates;	Figure 4.1 Figure 4.9
Submission of measures for minimizing dust during injection of coal into barges, including other safety measures so that the transport of coal can be made in environmentally sound conditions;	Annex D – Framework Environmental Management Plan
Evaluation of impacts of extreme events on the navigability of the river;	Chapter 7 and 8
Completion of an integrated study on the dynamics and hydrological, hydrogeological, geomorphologic and environmental implications including relevant experiments/studies from regions with similar characteristics;	Annex C – Specialist Studies
Submission of the results from the bathymetrical studies on the initial conditions of the river before the implementation of the project, which will also serve as a baseline for future monitoring;	Bathymetrical study results will be provided by RML on completion of the ESIA. Section 5.9 – Physical Characteristics of the Marine and Estuary

	Section 5.6 – Physical Characteristics of the Zambezi River System
Submission of the implications of dredging on wetlands and other ecological systems and groundwater flow, including its mitigation measures or minimization;	Section 9.4 – Impact of Dredging and Spoil Deposition on Benthic Habitat Section 9.11 – Disturbance to Riparian Habitats due to Dredging and Spoil Deposition Section 9.19 – Impact of Dredging of the Offshore Sand Bar on Sea Bed Benthic Organisms Section 9.20 – Impact of Dredging of the Offshore Sand Bar on Sea Water Quality
Submission and evaluation of disposal sites for dredged volumes and its implications for coastal dynamics;	Section 4.4.1 – Construction Phase
Submission of river water quality data before the implementation of the project, which shall serve as baseline for future monitoring;	Section 5.6.3
Evaluation of aspects from changes in flow regime associated with minimum water flows, as well as compatibility between the project for Transport of Benga Coal and the Lupata Dam, including solutions for passage through Lupata canyon, since its location is expected to be located downstream from the point of loading of Benga Coal.	Annex C – EF Specialist Study and Chapter 7 & 8 for those impact assessments that used the outcomes of the EF Specialist Study Section 4.6- Operating Scenarios
Evaluation of water requirements for navigation and other uses of water from the Zambezi (irrigation, fisheries, power generation, human consumption, industrial, etc.) and the mechanisms for managing potential conflict between different users.	Section 4.6.1 Chapter 9 Potential for significant volumes of inter-basin transfers do not appear to be part of the short to term planning for the Zambezi River. Should any such transfers be considered in future, they will be subject to comprehensive EIA and RML will participate in that process in order to determine cumulative impacts
A detailed assessment of cumulative impacts resulting from various actions planned for the project area, regardless of which entity is responsible;	Chapter 9 – Cumulative Impacts
A description of mitigation measures of increased water turbidity during dredging, which could reduce the growth and reproduction rate and survival of the species found there;	Impacts on fish are considered in Chapter 7.
Submission of the relationship between the effects of dredging and coastal erosion, especially at the mouth (Chinde);	*Annex C* – Sediment Dynamics at the River Mouth and other Specialist Studies
The consultation of the report "Country Situation Report - Water Resources - Volume 3, Zambezi River", since that contains information related to the management of the Zambezi River, particularly on the navigability on the river;	Unable to find a report with this particular title. However, the World Bank Report called "The Zambezi River Basin, Volume 3, State of the Basin was considered.
The description of the methodology to be used for determining the concentration of pollutants in the river from possible spillage of fuels and coal;	*Annex E* Chapter 7
Submission of impacts arising from spills of oil and fuel;	Section 9.5 – Impact of Coal Spillage on Aquatic Invertebrates Section 9.6 – Impact of Accidental Spills on Aquatic Invertebrates Section 9.12 – Impacts of Accidental Spills on Riparian Habitats

	Section 9.22 – Impact of Coal Dust on Vegetation and Water Quality in the Estuary Section 9.23 – Impact of Operational Coal Spillage on the Estuary Environment Section 9.24 – Impact of Coal Dust and Operational Coal Spillage on the Marine Environment Section 9.25 – Impact of Operational Discharges from OGVs on the Marine and Estuarine Environment Section 9.26 – Impact of Accidental Discharge of Liquid Hydrocarbons during Fuel Transfers Section 9.27 – Impact of Ballast Water Discharges on the Marine Environment.
The inclusion of measures to be taken in case of accidents during barge detachment at Dona Ana Bridge;	*Annex D* (ESMP notes that an ERP will have to be developed by RML)
Submission of the alternative for subsistence for families around the area of influence of the project during the course of dredging, since their main source of subsistence is the fishing activity;	The SIA does not conclude that subsistence fishing will be affected to the degree where alternatives need to be provided by RML. However the ESMP does not that in the even of any grievance RML has a responsibility to address all valid grievances.
Submission of measures for mitigation /compensation to be undertaken due to interruption of fishing activities from semi-industrial and artisanal fleets, during dredging and transport by barges.	Annex D – Framework Environmental and Social Management Plan
Submission of the plans for pollution control, response and emergency, which should be evaluated according to the Convention OPRC 90;	ESMP has measures for pollution Control. Response has to be developed by RML
The completion of public consultation meetings in all regions to be traversed by the project and at the central level;	Chapter 7 – Public Participation Process
Guarantee the dispatch of invitations for public consultation meetings to all interested and affected institutions by the project;	Chapter 7 – Public Participation Process
Consideration for the concerns raised by interested and affected parties during the public consultation meetings in all provinces traversed by the project;	Chapter 9 and 10 (Biophysical and Socio-Economic Impacts have been informed by concerns raised by interested and affected parties.
Improvement of the quality of pages printed in colour including the legend of some maps;	The ESIA Report will undergo a quality control review.
Submission of the program for following up and monitoring of impacts;	Annex D – Framework Environmental and Social Management Plan
Submission of the project investment value.	Annex C – Macro Economic Specialist Study

2 ESIA APPROACH

This chapter outlines the approach to the ESIA and the process that has been followed to date. The approach to the ESIA complies with the applicable Mozambican environmental legal requirements, as described in *Chapter 3*.

2.1 APPROACH TO THE EIA

The ESIA process followed was designed to assess potential environmental impacts of the Project to assist MICOA during the approvals process, and to comply with the relevant Mozambican environmental legislation.

Environmental impact assessment is provided for by the Mozambican Environment Law (*Law Nr. 20/97*) and is regulated by the EIA Regulation (*Decree Nr. 45/2004*, dated 29th September 2004). The EIA Regulations highlight the importance of public participation and public participation requirements are subsequently detailed in the Guidelines for Public Participation Process (*Decree Nr. 130/2006*).

2.2 THE ESIA PROCESS

One of the objectives of the ESIA process is to support decision making regarding the environmental licensing of a proposed activity and/or development. In achieving this, the ESIA process consists of the following four key phases:

- **Project Registration:** During this phase the project is registered with MICOA who categorise the Project based on the level of environmental assessment required.

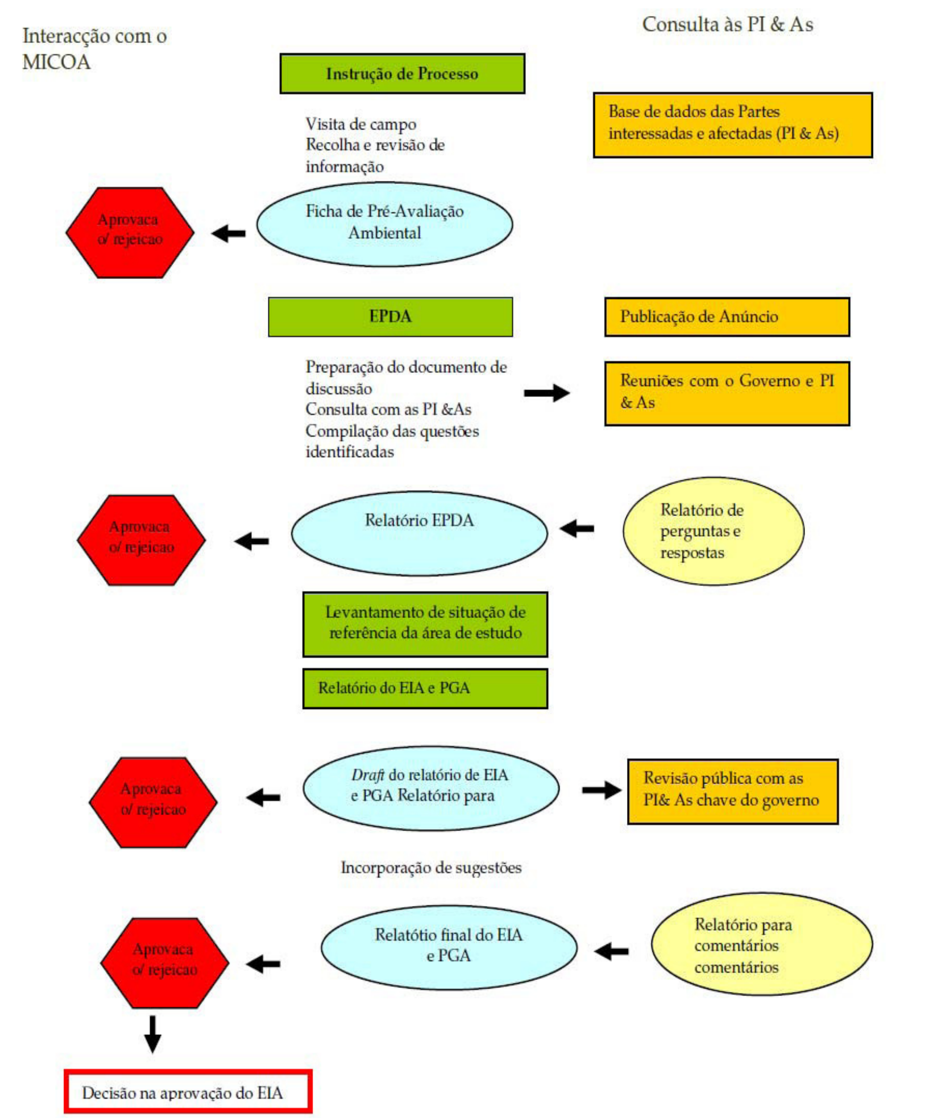
- **EPDA**: The EPDA phase aims to identify key issues and concerns associated with the proposed development. These could include project-related activities which may have the potential to contribute to or cause potentially significant impacts to environmental and socio-economic receptors and resources in the area. The EPDA Report also defines the Terms of Reference for the specialist studies and Impact Assessment phases to follow.

- **Specialist Studies**: Based on the above, specialist studies are undertaken to establish and review the existing conditions and legislative requirements pertaining to the Project and its surroundings, and also to highlight receptors and resources sensitive to potential impacts.

- **Environmental Impact Report and Environmental and Social Management Plan:** The ESIA Report aims to identify and evaluate the likely extent and significance of the potential impacts on identified environmental and social receptors and resources according to defined assessment criteria. The ESIA Report also details recommended measures to avoid, minimise, reduce or compensate for any potential adverse environmental effects, and reports the significance of the residual impacts that remain following mitigation. The ESIA Report informs the development of an Environmental and Social Management Plan (ESMP). The ESMP presents specific measures and commitments by RML to address identified impacts.

The phases of the ESIA process are illustrated in *Figure 2.1* and are described in detail below.

Figure 2.1 Flow Diagram of ESIA Process



2.3 *PHASE 1: PROJECT REGISTRATION*

The primary aim of the Screening phase is to initiate the ESIA by liaising with MICOA to identify the level of environmental impact assessment required.

The Project Registration documents were submitted to MICOA on 26 February 2010 for consideration. Written approval and permission to proceed with the EPDA Phase was obtained on 15 March 2010 from MICOA. Based on Annex 1 of the EIA Regulations, this Project was classified as a *Category A* Project, and is therefore subject to a comprehensive Environmental and Social Impact Assessment process.

2.4 *PHASE 2: EPDA PHASE*

The objectives of the EPDA Phase were to:

- gather baseline data about the project area in order to understand the sensitivity of the affected biophysical and social environment;
- present the proposed development to the Interested and Affected Parties (I&APs) and identify issues and concerns about the proposed development;
- identify potential significant positive and negative environmental and socio-economic impacts;
- develop the Terms of Reference for the specialist studies and Impact Assessment Phase
- compile Project information and results of the stakeholder consultation into an EPDA Report and submit to MICOA for decision-making.

The Final EPDA Report was submitted to MICOA on 19 July 2010
2010.

The activities undertaken as part of the EPDA Phase are described below.

2.4.1 *Preliminary Baseline Data Gathering*

A high-level analysis of baseline sensitivities was undertaken to inform RML's planning prior to commencing the ESIA process. The aim of the preliminary baseline sensitivity analysis was to highlight key baseline sensitivities, red flags, or fatal flaws from a socio-economic and biophysical perspective. This preliminary baseline assessment forms the basis for the baseline information gathered for EPDA Phase. In addition, baseline information was gathered via reviewing existing reports and studies and via public consultation during the EPDA Phase. A site reconnaissance was also undertaken by key members of the ESIA team to familiarise themselves with the affected environment.

2.4.2 *Stakeholder consultation during the EPDA Phase*

Public participation is a critical component of the EPDA phase, allowing for the identification of public expectations and concerns that need to be considered and addressed as part of the ESIA process. In this regard the objectives of the stakeholder consultation process undertaken during the EPDA Phase were as follows:

- consult with relevant government departments and key stakeholders;
- notify the public through advertisements, background information documents (BIDs) and letters of invitation;
- arrange and facilitate public meetings in key locations; and
- gather public comment on the EPDA Report.

The stakeholder consultation process undertaken to date is described in detail in the Public Consultation and Disclosure Plan in *Annex B*. Copies of all relevant documentation such as meeting minutes, attendance registers, letters of invitation and the Background Information Document (BID) are included in the Public Consultation and Disclosure Plan.

A summary of the activities undertaken during and after the EPDA Phase is presented in *Table 2.1.*

Table 2.1 Summary of Public Participation Process

Activity	**Purpose and discussion**	**Date of activity**	**Reference**
Initial Meetings	Tete, Beira, Quelimane and Maputo	21-24 September 2009	*Annex B*
Meeting with MICOA	To present the proposed project and the proposed EIA process	24 February 2010	
Compilation of stakeholder database	Identify stakeholders to be included in the consultation process	October 2009	*Annex B* - Stakeholders Database
Compilation and distribution of Background Information Document (BID)	Provide information on the ESIA process, the proposed development and dates of public meetings	22 March 2010	*Annex B* - Background Information Document (BID)
Distribution of invitations to public meetings	To invite stakeholders to public meetings	22 March 2010	*Annex B* - Invitation to public meetings
Press advertisements for public meetings	To invite stakeholders to public meetings	19 March 2010	*Annex B* - Advert for public meetings

Activity	Purpose and discussion	Date of activity	Reference
Public meetings: Maputo, Quelimane, Tete and Beira.	To present the proposed EIA process and project to the public and to allow the public to identify issues of concern	2 to 8 April 2010	*Annex B* - List of participants and minutes of the meetings
Written comments received	Written comments received during the scoping process	until April 20, 2010	*Annex B* – Comments received on the BID and at the public meetings
Updating of the Stakeholder Database	Registration of new I&APs	March 2010	*Annex B* - Updated Stakeholders Database
Scoping Report available for public review	For public review and comment	24 May- 18 June 2010	
Submission of Final Scoping Report and ToR to MICOA	For MICOA´s decision	19 July 2010	*Annex A* -Approved on September 13, 2010
Meeting with Technical stakeholder, Maputo, Tete, Quelimane	To provide an update to technical stakeholders on the ESIA process and provide an indication of upcoming activities in terms of the ESIA process	25-29 October 2010	*Annex B*- List of participants and minutes of the meetings
Public meetings: Maputo, Quelimane, Tete and Beira.	To present findings of the ESIA to stakeholders and to elicit comments on the draft ESIA Report	17- 20 May 2011	*Annex B* - List of participants and minutes of the meetings

2.4.3 *EPDA Report*

The results of the baseline data review and the public consultation activities was compiled into an EPDA Report, prepared in accordance with the requirements of Decree no. 45/2004. This EPDA Report was made available to registered I&APs and to MICOA for review for a period of 30 working days.

The Final EPDA Report was approved by MICOA on 13 September 2010 and a copy of the MICOA approval letter is included in *Annex A*

2.5 *PHASE 2: SPECIALIST STUDIES*

The issues raised during the Scoping phase were used to develop the Terms of Reference (ToR) for the specialist studies to be undertaken during the Impact Assessment phase of the ESIA. The outcomes of these studies formed the basis for the baseline description and impact assessment of the potential impacts on the affected environment.

The objectives of the specialist studies were to:

- Describe the existing environmental and socio-economic conditions;
- Identify those resources or receptors that may be affected by the Project;
- Assess the impact on the environment using predefined criteria; and
- Identify potential mitigation measures.

The specialist studies undertaken as part of the EIA process are listed in *Table 2.2*.

Table 2.2 Specialist Studies

Specialist Study	**Specialist**
Environmental Flow Study	Southern Waters
Peer Technical Review of the Environmental Flow Study	Dr Ian King
Sediment Dynamics at the River Mouth	PRDW
Benthic Fauna Study	Nepid Consulting
Terrestrial and Riparian Ecology Study	Impacto
Bird Study	Carlos Bentos
Fish and Fisheries Study	Jorge Mafuca
Marine and Estuarine Ecology Study	Lwandle Technologies
Socio-economic study	Impacto
Economic Study	Strategic Economic Solutions
Noise Study	JH Consulting
Groundwater Study	ERM

Because riverine ecological and socio-economic systems are influenced by the pattern of flow (seasonal variations, water level heights, inundation areas, etc.) in the river, the Environmental Flow (EF) Study was seen as one of the most important studies, outputs from which were used by almost all other specialists in order to identify and assess potential impacts within their respective areas of expertise. Given the importance of the EF Study and to provide assurance to both authorities and the public that the results of the study are defendable, an independent Peer Technical Review of the EF Study was commissioned. The purpose of the Peer Technical Review was to review the HEC-RAS hydraulic model on which the EF Study is based to determine if the model can be relied on to predict changes to the river hydraulics as a result of the proposed Project. All specialist reports, including the Peer Technical Review report can be found in *Annex C.*

As part of their Terms of Reference, the specialists undertook field studies to gather data to further assist them in defining the baseline so as to inform their impact assessments. The following table indicates their field works schedule.

Table 2.3 Specialists Fieldwork

Specialist Study	**Dates**

Specialist Study	Dates
ERM and Impacto Specialists	
Environmental Flow Study	
High flow fieldwork	26 to 29 March 2010
Mid-flow fieldwork	13 to 17 May 2010
Low flow fieldwork	16 to 28 August 2010
Sediment Dynamics at the River Mouth	Not required. Relied on fieldwork by Worley Parsons and Lwandle Technologies.
Benthic Fauna Study	30 April to 9 May 2010
Terrestrial and Riparian Ecology Study	30 April to 5 May
Bird Study	30 April to 5 May
Fish and Fisheries Study	30 April to 5 May
Marine and Estuarine Ecology Study	Meetings with local scientists in Maputo in July 2010
Socio-economic study	6 to 9 May 2010 14 to 16 June 2010
Economic Study	Not required.
Noise Study	15 to 26 April 2010
Groundwater Study	Desktop Study
Riversdale Specialists	
Riverbed sediment sampling	August 2010, November 2010

- The specialist reports are available for review in *Annex C.* They were reports were integrated into the impact assessment chapters and EMP in this ESIA Report.

2.6 *PHASE 3: IMPACT ASSESSMENT PHASE*

2.6.1 *Stakeholder Consultation during Impact Assessment Phase*

In October 2010 four focus meetings with relevant technical stakeholders where held in Quelimane (25 October 2010), in Maputo (26 October 2010) and in Tete (two meetings, 28 and 29 October 2010). In preparation for the meetings, invitations were sent to identified stakeholders via e-mail, fax and posts, followed by phone confirmations.

The Team included Victor Hugo Nicolau (Impacto) Kamal Govender (ERM) and Phil Tanner (RML). The overall structure of the meetings comprised a presentation updating the Project's technical detail and the Environmental and Social process to be followed. A plenary discussion and question and answer session followed, whereby attendees were allowed to ask questions of clarification, make comments and raise any concerns.

Technical stakeholders attending the meetings were as follows:

- Quelimane: Inahina, DPCA
- Maputo: DPCA, Inahina, Justiça Ambiental (JA), WWF, Centro Terra Viva.
- Tete: GPZ, DPCA, ARA Zambezi

All issues raised as well as responses can be found in *Annex B*.

During the public comment period for the Draft ESIA, public consultation meetings were held in Beira (17 May 2011), Quelimane (18 May 2011), Tete (19 May 2011) and Maputo (20 May 2011).

In preparation for the meetings, invitations were sent to key stakeholders via e-mail, fax and posts, followed by phone confirmations. Adverts were also published in line with legal requirements in national newspapers (Notícias and Diário de Moçambique). Copies of the draft ESIA report were sent to DPCA offices in Beira, Quelimane. Tete and Maputo. The report was also available for on Impacto´s website.

The Team compromised of Kamal Govender (ERM), Victor Hugo Nicolau (Impacto), Sandra Fernandes (Impacto) Alan Menton (Riversdale), Greg Britton (Riversdale), Phil Tanner (Riversdale) and Ivo Lourenço(Riversdale).

The overall structure of the meetings comprised a presentation prepared by the Consultants, presenting the main conclusions of the ESIA and addressing main concerns expressed by stakeholders during the previous consultation exercises. A plenary discussion and question and answer session followed, whereby attendees were allowed to ask questions of clarification, make comments and raise any concerns.

The presentation was provided in non-technical language and in Portuguese. Whenever necessary, the questions and answers would be translated between Portuguese and English to make sure that both stakeholder and Riversdale had a full understanding of the issues under discussion.

All issues raised as well as responses can be found in *Annex B*

2.6.2 Impact Assessment Methodology

During scoping, a preliminary analysis was undertaken of the ways in which the project may interact (positively and negatively) with environmental and socioeconomic resources or receptors. The impacts that were identified as potentially significant during the scoping process provided focus for the studies for the detailed ESIA. Each of these identified, potential impacts is assessed using the following methodology.

The assessment of impacts has proceeded through an iterative process considering four key elements, namely:

1. Prediction of the magnitude of identified impacts ie the consequences of the proposals on the natural and social environment;

2. Evaluation of the importance (or significance) of identified impacts taking the sensitivity of the environmental resources or human receptors into account;

3. Development of mitigation measures to avoid, reduce or manage the impacts; and

4. Assessment of any identified residual impacts after the application of mitigation measures.

Where significant residual impacts remain, further options for mitigation may be considered and impacts re-assessed until they are as low as reasonably practicable for the project.

The detailed methodology can be found in *Annex E*

2.6.3 ESIA Report and ESMP

The results of the specialist studies have been integrated into this ESIA Report and have informed the development of the ESMP.

This report provides an assessment of the impacts associated with the proposed Project and makes recommendations for the mitigation of adverse impacts and the enhancement of positive impacts. The ESMP is in a tabular format and will contain clear, practical management measures to be implemented during the construction, operation and decommissioning of the Project. Should the environmental licence be issued, the ESMP will form part of conditions of the license to ensure that the project is conducted and managed in an environmentally and socially responsible manner.

The ESIA Report and ESMP will be made available for public comment. Meetings will be held in Maputo, Quelimane, Tete and Beira to present the findings of the ESIA Phase and to elicit comment on the ESIA Report and ESMP. All comments received will be consolidated into the Comments and Responses Report which will be appended to the ESIA Report and submitted to MICOA for decision-making.

3 LEGAL FRAMEWORK AND INTERNATIONAL GUIDELINES

3.1 INTRODUCTION

The objective of this chapter is to present the environmental legal framework into which the proposed project fits; including both international and national legal instruments; the identification of those international conventions ratified by the Government of Mozambique, as well as the agreements established at regional level between Southern African countries. Also identified are the national legal framework specific to transport sector projects and those components related to environmental management and other aspects that are holistically integrated with the environment. Also addressed in this chapter are some international guidelines related to best practice in the development of studies and projects of this nature that, while not constituting formal legal imperatives, are important documents as they establish standards, guidelines or recommendations related to the activities under analysis. These were developed in part by international organizations of reference in an approach specific to the various issues, whether in terms of river transport projects, associated environmental studies, public participation, etc.

3.2 INTERNATIONAL AND REGIONAL LEGAL FRAMEWORK

3.2.1 International Environmental Conventions

The Government of Mozambique has signed and ratified a number of International conventions that would be relevant to the proposed project. These conventions are listed in *Table 3.1* below, along with their ratification status.

Table 3.1 Mozambique's participation in relevant International Conventions

Convention	Date Ratified
Convention concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972	1982
Convention on Biological Diversity, Rio de Janeiro, 1992	1996
Convention on Wetlands of International Importance Especially as Waterfowl Habitats (Ramsar Convention), Ramsar, 1971	2003
Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 1979	not signed
Convention on Migratory Birds, Bonn, 1991	not signed
Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region and related Protocols, Nairobi, 1985	1996
International Maritime Organisation Member since 1991	n/a
Organisation on the Indian Ocean Marine Affairs Cooperation-IOMAC, member since 1991	n/a
United Nations Convention on the Law of the Sea, Jamaica, 1982	1982

Convention	Date Ratified
Convention for the Suppression of Unlawful Acts Against the Safety of Maritime Navigation, 1988 (including the Protocol for the Suppression of Unlawful Acts Against the Safety of Fixed Platforms Located on the Continental Shelf)	Acceded 2003

The following environmental conventions and declarations are ratified by Mozambique deserve particular emphasis for the current study:

- **African Convention on the Conservation of Nature and Natural Resources, ratified by Resolution Nr. 18/81, of December 30**, in which the fundamental principle integrated into Article II guides States in the adoption of measures necessary to ensure the conservation, utilization and development of land, water, flora and fauna according to scientific principles and taking into consideration the interests of populations. In relationship to the conservation of water resources, the convention urges the various parties to take necessary measures for the development of conservation and use policies for surface and underground water resources and for the parties to make efforts to ensure the sufficient and continuous supply of quality water, taking appropriate measures with respect to: Execution of studies on hydrological cycles and research in each river catchment; Coordination and planning of development of hydro projects; Management and control of all forms of water use; Prevention and control of pollution.

- **United Nations Convention on Climate Change,** ratified by Resolution N 1/94, of the 24 of August, the objective of which is the promotion of reductions in greenhouse gas emissions to safe levels, minimizing in this way the negative environmental impacts of global warming.

- **Convention on Biological Diversity**, ratified via Resolution N 2/94, of the 24 of August, which has as its objective the conservation of biodiversity, the sustainable use of its components and the equitable and fair distribution if the benefits derived from genetic resources, including via adequate access to these resources and the appropriate transfer of relevant technologies.

- **Ramsar Convention (The Convention on Wetlands of International Importance),** ratified via Resolution N 45/2003, of the 5 of November. In ratifying the convention, the signatory governments committed to the designation of sites to be integrated into the List of Wetlands of International Importance and to work towards the sustainable use of wetlands through land use planning, the development of policies and the publication of legislation, as well as management and education interventions for the education of their populations. They also committed themselves to designate additional sites for the List of Wetlands of International Importance and to ensure the proper and effective management and to cooperate internationally in relation to cross border wetlands, the shared wetland systems, shared species and common development projects that may affect wetland. Recognizing the value of the economic, cultural and ecological complex at Marromeu in the Zambezi Delta, the government declared this area as the first wetland of international importance in Mozambique.

3.2.2 *International Maritime Conventions*

RML is obliged to ensure that its operations comply with International Maritime Conventions to which the Government of Mozambique is a signatory. International conventions relevant to the marine environment include the following:

- **MARPOL, 1973,** The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) contains a number of the provisions relevant to the project (*Table 3.2*). These include general requirements regarding the control of waste oil, engine oil discharges, grey and black waste water discharges as well as solid waste management and disposal. The MARPOL Convention initially comprised Regulations for the Prevention of Pollution by Oil (Annex I) and Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (Annex II). Another four annexes have subsequently been added. Ratified parties must accept Annexes I and II, but the other four are voluntary. Mozambique has ratified Annexes I and II only and a draft Marine Pollution Bill has been prepared to adopt the remaining four annexes of the MARPOL standards into Mozambican legislation. It is the intent of the project to comply with the relevant annexes that are not yet ratified. MARPOL Annex I also designates 'special areas' where there are stricter controls on discharge of oily wastes. No Mozambique offshore areas have been declared to be MARPOL special areas.

- **The OPRC Convention, 1990,** The International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) came into force in 1995 and requires Parties to establish measures for dealing with major incidents or threats to marine pollution, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan and to report incidents of pollution to coastal authorities. Offshore operators are required to have oil pollution emergency plans or similar arrangements which must be co-ordinated with national systems for responding promptly and effectively to oil pollution incidents.The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents. Parties to the Convention are required to provide assistance to others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided.

- **Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation, 1988,** This Convention was adopted on 10th March 1988, came into force on 1st March 1992 and was acceded to by

Mozambique in 2003. The convention requires governments to take measures to prevent unlawful acts which threaten the safety of ships as well as passenger and crew security.

- **The Nairobi Convention (formally known as the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region)** was adopted on 21 June 1985. The convention aims to provide a platform for collaboration between signatory countries in the management of the eastern African marine environment. The Comoros Islands; Reunion/France/European Union; Kenya, Madagascar; Seychelles and Somalia are original signatories to the convention. Mozambique, Tanzania and Mauritius signed the convention at a later date. Key aspects of the convention are listed below:

  - signatories may enter into bilateral or multilateral agreements for the protection and management of the marine and coastal environment of the convention area;

  - signatories shall cooperate in scientific research, monitoring, and the exchange of scientific information, and develop a network of national research centres to ensure sound scientific results;

  - signatories shall implement measures to ensure protection to endangered wild fauna species, as listed in an Annex II to the convention; and

  - signatories will establish protected areas in areas to conserve the natural resources of the Eastern African region, where necessary, consult with one another to reach agreement on contiguous protected areas and establish a regional program to co-ordinate the selection, establishment, and management of these protected areas.

Table 3.2 MARPOL 1973/1978 Provisions Relevant to Oil and Gas Developments

Environmental Aspect	Provisions of MARPOL 1973/1978	Annex
Drainage water	Ship must be proceeding en route, not within a 'special area' and oil must not exceed 15 ppm (without dilution). Vessel must be equipped with an oil filtering system, automatic cutoff and an oil retention system.	I
Accidental oil discharge	Shipboard oil pollution emergency plan (SOPEP) is required.	I
Bulked chemicals	Prohibits the discharge of noxious liquid substances, pollution hazard substances and associated tank washings. Vessels required to undergo periodic inspections to ensure compliance. All vessels must carry a Procedures and Arrangements Manual and Cargo Record Book.	II

Environmental Aspect	Provisions of MARPOL 1973/1978	Annex
Sewage discharge	Discharge of sewage is permitted only if the ship has approved sewage treatment facilities, the test result of the facilities are documented, and the effluent will not produce visible floating solids nor cause discoloration of the surrounding water.	IV
Garbage	Disposal of garbage from ships and fixed or floating platforms is prohibited. Ships must carry a garbage management plan and shall be provided with a Garbage Record Book.	V
Food waste	Discharge of food waste ground to pass through a 25-mm mesh is permitted for facilities more than 12 nautical miles from land.	V
Air pollutant emissions	Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances including halons and chlorofluorocarbons. Sets limits on emissions of nitrogen oxides from diesel engines. Prohibits the incineration of certain products on board such as packaging materials and polychlorinated biphenyls.	VI

3.2.3 Regional Protocols

As a member of the Southern Africa Development Community (SADC), Mozambique took the overall commitments enshrined in the SADC Treaty as well as specific commitments in the area of natural resource management. In this context, it is worth noting, in particular the need to respect the objectives and principles established in Articles 2 and 3 of the **SADC Protocol on Shared Water Resources**, also ratified by Mozambique, which aims to promote cooperation between Member States for the sustainable and coordinated management, protection and use of shared water resources in order to implement the agenda of SADC regional integration and poverty eradication. In July 2004 the ZAMCOM Agreement (Zambezi Watercourse Commission) was signed, which established the Zambezi River Commission. The ZAMCOM was signed by Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe, and established a joint institution for the management of the Zambezi River. This agreement, however, is not yet ratified, and Zambia shows some reluctance in the adoption of some of the principles enshrined in this. Thus, the states of the Zambezi Basin are currently subject only to the requirements of the SADC Protocol on Shared Water Resources. The new ZAMCOM agreement encourages the equitable use of Zambezi River resources, as a way to mitigate the conflicts within the basin. Other relevant protocols at the SADC include:

SADC Protocol on Gender and Development, Article 2; SADC Protocol on Wildlife Conservation, Article 3; SADC Protocol on Forest Management, Article 2.

3.3 NATIONAL LEGAL FRAMEWORK

The proposed project must comply with approved standards for project licensing, as regards the institutional aspects imposed for licensing, especially cross-sectoral consultation and coordination, as well as with regard to the evaluation of social and environmental aspects and impacts. Public participation, especially consultation with potentially affected parties, deserves emphasis in this kind of project. In general terms, the instruments and regulations applicable to the following sectors are relevant to this type of project.

3.3.1 Environmental Management

The **National Environmental Management Policy** (approved by Council of Ministers Resolution Nr.5/95, 3 August), adopts the principle that "Man is an important component of the environment and is the principal beneficiary of its proper management." In point 2 of its introduction, the text of the policy states that environmental policy is the basis for the sustainable development of Mozambique, aimed at the progressive eradication of poverty and improving the quality of life of Mozambicans as well as reducing environmental damage. As general objectives, the following are indicated:

a) Ensure an adequate quality of life for citizens;
b) Ensure the management of natural resources and the environment in general in order to maintain their functional and productive capacity for present and future generations;
c) Develop the environmental awareness of the population, to enable public participation in environmental management;
d) Ensure the integration of environmental considerations into socio-economic planning;
e) Promote local community participation in planning and decision making about the use of natural resources;
f) Protect essential ecosystems and ecological processes;
g) Integrate the regional and global efforts in finding solutions to environmental problems.

The **Framework Law on the Environment** (Law Nr. 20/97 of 1st October), contains the fundamental principles of environmental management and natural resources in the country, with the prescribed objective of defining the legal basis for sustainable use and correct management of the environment and its components, in order to implement a system of sustainable development in the country. This law, as stated in Article 3, applies "to all public and private activities that may directly or indirectly influence the environmental components", including water, air, soil, sub-soil, flora, fauna and all the socio-economic and health conditions that affect the communities." The Law adopts the following fundamental principles for environmental management (Article 4):

- Rational use and management of environmental components;
- Recognition and appreciation of traditions and local community knowledge;
- Caution;
- Overview and integrated environment;
- Broad participation of citizens;

- Equality;
- Accountability (polluter pays principle);
- International cooperation.

Due to its importance, attention is drawn to the need for observance of all principles included in Article 4, of which are emphasized here; the principle of accountability, since the responsibility for preventing and / or compensating for damages must be interpreted with reference to a broad definition of environment (ecological and socio-economic aspects) contained in the Law. This requires the project proponent and the government in general, the need for strict and total observance of all prescriptions for the prevention and mitigation of social and environmental impacts and the careful assessment of costs /benefits and of alternative options. The law prohibits pollution in its various forms (Article 9) including the generation, disposal and / or the release of any toxic substances and pollutants in the soil and subsoil, water or atmosphere, as well as the importation of hazardous waste into national territory, except in cases covered by specific legislation. The law also prohibits all activities that work against conservation, reproduction, quality and quantity of biological resources, especially those threatened with extinction (Article12). In order to prevent environmental damage, the law establishes the Environmental License, based on a process of Environmental Impact Assessment (Article 15).

3.3.2 Environmental Impact Assessment

Although all the provisions of the Environmental Law and its regulations are relevant to this project, particular attention should undoubtedly be given to the provisions of the law on environmental licensing, detailed in the **Regulation on the Process of Environmental Impact Assessment - REIA** (Decree 45/2004, of 29 September as amended by Decree 42/2008 of 4 November). Ministerial Diploma 198/2005 of 28 September provides that Category A EIAs are submitted and administered at the national level of MICOA while other categories are handled at the provincial level). Note also the General Guideline for Environmental Impact Studies (Ministerial Diploma 129/2006 of 19 July) prescribes guidelines and parameters for the overall implementation of the Environmental Impact Studies in order to standardize procedures inherent to these. This Guideline provides a detailed enumeration of the aspects that should be part of the EIA. Under the REIA and as confirmed by MICOA in response to the registration of the Project, the proposed Project falls in *Category A* activities in accordance with Annex I, and the EIA process thus must follow the provisions for this category. For activities in *Category A* a full Environmental Impact Assessment is required, preceded by the preparation of an Environmental Pre-Feasibility and Scoping Study (EPDA/EPSS), which establishes the Terms of Reference for Environmental Impact Assessment. Public participation is mandatory for Category A activities (Article 14) to be conducted in accordance with the **General Guidelines for Public Participation in the Environmental Impact Assessment Process** approved by Ministerial Diploma 130/2006 of 19 July. Upon submission to MICOA both the EPDA/EPSS and EIA are reviewed by a

Technical Evaluation Commission specifically constituted for this purpose which will justify its decision on the approval of the reports and environmental licensing.

3.3.3 *Other Regulations of Interest to Environmental Management*

It is important to also consider the following regulations, to the extent that they prescribe standards applicable to different aspects for consideration:

- **Decree Nr.11/2006 of 15 June -** Approves the Regulation on Environmental Inspection, the objective of which is to regulate the activities of supervision, control and compliance with environmental protection standards at national level.

- **Decree Nr.18/2004 of 2 June -** Approves the Regulations on Environmental Quality Standards and Wastewater Emissions, which aims to ensure an effective control and monitoring on the quality of the environment and Mozambique's natural resources. Furthermore it provides water quality, atmospheric emission and noise standards.

- **Decree Nr.13 / 2006 of June 15** - Regulation on Waste Management, which establishes rules for the waste production, storage in soil and subsoil, and the release into water or atmosphere. It also addresses polluting activities that accelerate environmental degradation, with the aim of preventing or minimising negative impacts on health and the environment. Classifies the waste into hazardous and non-hazardous and sub-divides them into categories set out in its Annex IV.

- **Order of the Minister for Coordination of Environmental Action of 28 September 2005** - Concerning the issuance of Environmental Licences.

- Decree 45/2006 of 30 November – Regulations on the Prevention of Coastal & Maritime Pollution.
- Decree 32/2004 of 18 August – Charter of INAMAR National Maritime Institute which has competence over use of territorial waters for navigation
- Resolution 64/2004 of 31 December – ratification of Agreement for the Establishment of the Zambezi Watercourse Commission.

3.4 *WATER RESOURCES*

Water resource management is defined, in Mozambique, by the National Water Policy, the Water Law (Law 16/91, of 3 August) and the Water Law Regulations (Decree 43/2007 of 30 October. These legal instruments are based on the principle of the primacy of common or public water supply access rights and contain rules and procedures for water basin management, the issuance of licences and concessions for private water extraction and water extraction infrastructure and the protection of ecological balance and the environment including rules for payment of water extraction and public infrastructure and prohibition of any effluent without licence. It is important to take note of the following provisions in the Water Law (Law 16/91 of 3 August):

- Article 7, containing the Principles of Water Management, in which line (b) refers to the need for institutional coordination and participation of the people in major decisions concerning the water management policy;

- Article 16 concerning the need for intersectoral cooperation in implementing the National Water Policy. This provision is complemented by Article 17, establishing the National Water Council and to which assigns responsibility to provide opinions on water programs and projects before they are submitted to international funding or for funding from the state budget.

- Article 18 provides for the establishment of the regional water administrations and calls for the following competencies: participation in the preparation, implementation and review of the hydrological basin uses, administration and monitoring of public water domain, the creation and maintenance of a water registry; the registration and licensing of private water uses as well as the setting and recovery of charges for water use; the approval and review of hydraulic works to be undertaken; and reconciliation of conflicts arising from the use and enjoyment of water. In this context, the ARA-Zambezi was established, and is responsible for managing the Zambezi River Basin, the authorisation of the extraction of underground and surface water and of materials from the riverbed and the construction and use of water supply infrastructure. Further ARA-Zambezi authorises the uses within special protection zones such as the 50 metre river coast strip for the purposes of water extraction and supply (See Decree 26/91 and Ministerial Diploma 70/2005 of 23 March). Conversely, the use of the river watercourse, its channel and coastline for navigation purposes as such and as partial protection zones is subject to the oversight and authority of INAMAR (see Decree 32/94 of 18 August and Decree 37/2007 of 14 August)

3.4.1 Fisheries

The **Fisheries Law** (Law Nr.3/90, of 26th of September) is relevant in the sense that in Article 9 the state is made responsible for the promotion of small-scale fisheries, including fishing, an activity which occupies a large number of riparian communities. Particular reference to its Article 8, on fisheries development plans.

3.4.2 Land

Under the Mozambican Constitution and as reflected in the Land Law, ownership of land is vested in the State, however rights to use and occupy the land acquired through inheritance or occupancy are recognised. No

documentary title is required for such rights to be recognised and given the protection of the Law.
The derogation or expropriation of existing land use and occupancy rights requires the consent of the party in interest and compensation paid for tangible and intangible assets, loss of community and productive assets, including a substitute land plot and costs of resettlement, that places the damaged party in as good as or better position than enjoyed previously (Law 19/1997 of 1 October, DM 29-A of 17 March, and Article 20 of Law 19/2007).

In this context, the **Land Law** (Law Nr.19/95 of 1st of October) provides legal guidelines in respect of:

- Procedures for the acquisition of Right to Use and Benefit from Land (DUAT) (Article 24);

- pre-existing rights of use and benefit of land, especially of local communities (loss of rights + resettlement);

- zoning and planning of land use for other economic and social purposes;

- agriculture, natural resource use and other; and

- The National Land Policy of 1995 promotes the facilitating of socio-economic development without, however, creating environmental imbalances. One of the fundamental principles of Land Policy (paragraph 17) is the sustainable use of natural resources to ensure the quality of life for present and future generations, ensuring that the areas of total and partial protection maintain environmental quality and the special purposes for which they were created.

3.4.3 Forestry and Wildlife

Article 3 of the **Forestry and Wildlife Law - LFFB** (Law Nr.10/99 of 7 July) defines the principles for managing forest and wildlife resources, and in particular for recognizing and valuing the traditions and knowledge of local communities (line (e); private sector involvement in the management, conservation and exploitation of forestry and wildlife resources (line (f); liability of those who cause damage to forest and wildlife resources with the obligation for the restoration or compensation of degradation and damage caused to third parties, regardless of other legal consequences.

Another relevant provision relates to the protection of areas of historical and cultural use and value to local communities defined and protected by Article 13. Article 3 of LFFB Regulation (Decree 12/2002 of 6 June as amended by Decree 11/2003 of 25March) also deserves consideration, which requires the implementation of environmental impact studies for any exceptional activities undertaken in protection zones. Also consider Decree Nr.12/2002 of June 6th, as amended by Decree Nr.11/2003 of March 25th, which regulates the

Forestry and Wildlife Law, as well as Decree Nr.25 / 2008 of July 1st, which approves the **Regulation for the Control of Invasive Alien Species.**

3.4.4 The Law of the Sea

Since the barging Project includes transhipment at sea, this Law is relevant. The Law of the Sea (Law No. 4/96 of 4 January 1996) covers mainly aspects related to maritime traffic, but also refers to activities concerning the conditions of security and the control of the pollution of the marine environment.

The Law applies to:

- The sea and all waterways and the corresponding seabed and subsoil under maritime jurisdiction, in accordance to the terms of the applicable law, as well as the public domain adjacent to those waters;

- Vessels and other maritime objects, including cables, pipelines, facilities and maritime structures under Mozambican jurisdiction;

- National vessels, wherever their location;

- Individuals and collective entities connected to vessels or with navigation in Mozambique;

- All maritime activities taking place within the limits of specific jurisdiction.

As regards the area adjacent to territorial sea:

1. The area adjacent to territorial sea is defined as the strip of sea adjacent to territorial sea that extends up to 24 nautical miles as of the baseline.

2. In the area adjacent to territorial sea, the State exercises the necessary control to:

    a. prevent breaching of customs, tax, migration and sanitary laws and regulations for the protection and conservation of the maritime environment, in force in the Mozambican territory;

    b. Prevent infractions against laws and regulations referred to in the previous line.

As regards the Exclusive Economic Zone:

The exclusive economic zone of the Republic of Mozambique encompasses the strip of sea adjacent to territorial sea up to 200 nautical miles as of the baseline where the territorial sea is measured.

Article 11 of the Law of the Sea refers to the sovereign rights in the exclusive economic zone. The jurisdiction of the State over the exclusive economic zone will be exercised in accordance to the terms of the present law, as regards:

a. Scientific maritime research;
b. Protection and preservation of the maritime environment.

The regulatory measures (Article 33) include:

a. All issues regarding safety of commercial vessels, investigation of accidents or maritime events in Mozambican jurisdictional waters
b. Control of maritime traffic, as well as pilotage and towing in Mozambican waters;
c. Issues regarding maritime pollution;
d. Issues regarding maritime commerce and industry.

It is also the responsibility of the Government to regulate and administrate all sea use activities within the Mozambican jurisdiction waters, in accordance to international laws, namely:

a. Scientific maritime research;
b. Exploration and use of all natural marine resources, living and otherwise;
c. Protection and preservation of maritime environment;
d. Protection of archaeological objects in the sea;
e. Maritime sports and maritime recreational activities;
f. General management of territorial sea, adjacent area; exclusive economic zone and Mozambican continental platform.

3.4.5 Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment

Decree 45/2006 of 30 November (1) approved the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment.

The first chapters of this Regulation transpose general provisions included in several Conventions on the subject-matter into the domestic legal order, adjusting them to the Mozambican reality. Among these are the International Convention for the Prevention of Pollution from Ships (MARPOL 1973/1978), the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) and the International Convention on Oil Pollution Preparedness, Response and Cooperation 1990 – OPRC 90.

As established in its article 1, the objective of this Regulation is to determine the appropriate measures to prevent and limit pollution resulting from illegal discharges carried out by ships, platforms or by land-based sources, off the Mozambican coast as well as the establishment of legal bases for the

(1) Decree 45/2006 is published in the Boletim da República N.º 48, 1st Series, Supplement of 30 November 2006.

protection and conservation of the maritime, lacustrine and fluvial public domain areas, of beaches and of fragile ecosystems.

The Regulation applies to all national or foreign natural or legal persons, performing activities susceptible of causing negative impacts on the environment, in maritime, lacustrine and fluvial public domain areas, including all fragile ecosystems bordering the coast and inland waters. In addition, the Regulation applies to discharges of harmful or dangerous substances by ships, in ports, harbour facilities, emission facilities along the coast, platforms or by other land-based sources, namely:

a. In inland waterways, including ports and wetlands;
b. In the territorial waters of the Mozambican State;
c. In the Mozambique Channel, when used for international navigation subject to the transit passage regime, established in Part III, Section 2, of the Convention of the Law of the Sea, ratified by Resolution 21/96, of 26 November, insofar as the Mozambican State exercises jurisdiction over the Channel;
d. In the exclusive economic zone, established in agreement with international law; and
e. In the international waters.

The regulation also applies to all domestic and foreign ships navigating the jurisdictional waters of the Republic of Mozambique as well as to facilities situated off the Mozambican coast, regarding any discharge or dumping occurred under its terms. Regarding the classification of harmful or dangerous substances, the Regulation refers to the waste management legislation in force (1) .

Heading II of this Regulation deals with ships and platforms. In the scope of pollution prevention and control systems, the Regulation stipulates that all ports, port facilities, platforms, emission facilities along the coast as well as their support facilites, have the obligation to have adequate facilities or means for the collection and treatment of the various types of waste and for pollution control at their disposal. Their owners must prepare a procedures manual for the management of the various types of waste produced by or deriving from the movement and storage of oil and harmful or dangerous substances. This procedures manual shall be approved by the entity supervising the area of the environment. The owners must also have contigency plans available for fighting oil pollution and pollution by harmful or dangerous substances[2]. Ships have furthermore the obligation to store all waste produced onboard, before leaving the port, respecting, however, the conditions under which this may not be done[3]. The Regulation also stipulates the obligation to provide data about this waste[4].

(1) Article 3 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment.

(1) [2] Articles 5, 6 and 7 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment

(2) [3] Article 8 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment

(3) [4] Article 9 of the Regulation for the Prevention of Pollution and Protection of the Marine and Coastal Environment

In Chapter II (articles 11 to 14), the Regulation deals with issues related to the transport of oil, hydrocarbons and harmful or dangerous substances, stipulating obligatory Record Books and the data that should be entered, and the obligation to inform about their onboard location as well as the data that the packing of harmful or dangerous substances should provide.

Chapter III (articles 15 to 25) deals with aspects related to oil and harmful or dangerous substance discharges, prohibiting their occurrence in waters of national jurisdiction, and defines the exceptions to this prohibition. Furthermore, in Chapter III the obligation is laid down to communicate incidents occurred in ports, ships, platforms and support facilities liable to cause pollution of waters of national jurisdiction.

Chapter IV (articles 26 to 32) defines the competences of the maritime authority to avoid pollution, among which the possibility to demand that the ship master and/or owner:

a. Carry out transhipment to another ship available or discharge to a specific part of the same ship or to a port depot, within a given time frame;
b. Move the ship under his command to a specific location;
c. Retain the ship at a given location, until a contrary order is given according to the ship's specific conditions and its actual position;
d. Abstain from any unloading or transhipment of hydrocarbon or part of it until a contrary order is given by the maritime authority;
e. Carry out operations for sinking or destroying the ship or its load or part of it, in agreement with Government decisions;
f. Follow a given route, in the event that the ship is navigating in territorial waters or in the contiguous zone;
g. Seek to obtain help from one or more vessels adequate to support the maritime authority in the measures that turn out to be necessary;
h. Take other measures in relation to the ship or its load to impede the hydrocarbon discharge or the continuation of this discharge.

Regarding facilities' masters, the maritime authority may demand the suspension of the facilities' operation or that the above-mentioned measures are taken.

Chapter V (articles 33 to 42) deals with the investigation of incidents, sanctions and compensation for damages.
In addition to the pecuniary sanctions, the Regulation stipulates other punitive measures, particularly the seizure of the ship and the product's destruction or rendering it unusable.

Heading III (articles 43 a 86) of this Regulation deals with the prevention of marine and coastal pollution by land-based sources.

3.5 *INTERNATIONAL BEST PRACTICE GUIDELINES*

In addition to compliance with the standards prevailing in the country, whether these are derived from strictly national legal instruments or international and regional legal instruments adopted by the country by virtue of ratification; the proposed project is subject to observe internationally established guidelines, to orientate some of the project activities.

3.5.1 *Equator Principles*

International lending institutions provide guidance on their requirements for the EIA process and place emphasis on achieving sustainable environmental, social and health outcomes. They also provide environmental standards and limits for emissions and discharges. A number of key project impact mitigation measures such as resettlement (if necessary) are also specified.

The Equator Principles are a voluntary set of guidelines developed by leading financial institutions for managing environmental and social issues in project finance lending. The guidelines are based on the environmental and social standards of the IFC, and apply globally to development projects with a capital cost of US$10 million or more in all industry sectors. These principles are intended to serve as a common baseline and framework for the implementation of participating institutions' individual, internal environmental and social procedures and standards for project financing activities across all industry sectors globally. Additional detail can be found on their website *www.equator-principles.com*.

The first set of Equator Principles was launched in 2003 and was ultimately adopted by over 40 financial institutions during a three-year implementation period. A subsequent updating process took place in 2006 leading to a newly revised set of Equator Principles that were released in July 2006. The new, revised set of Equator Principles is fully consistent with recently revised IFC Performance Standards (see discussion below).

The Equator Principles aim is to ensure that prior to agreeing to provide financing, (a) a project has been subject to an appropriate level of environmental and social assessment in accordance with the requirements of the International Finance Corporation (IFC) Performance Standards (2006) and (b) that the project will implement appropriate measures for the management of environmental, social and health issues during construction, operation and decommissioning phases. By adopting the Principles, financial institutions undertake to review carefully proposals for which their customers request project financing. They commit not to provide loans to projects where the borrower will not, or is unable to, comply with the requirements of the IFC Performance Standards.

3.5.2 *International Finance Corporation Performance Standards*

The overall project design and this ESIA are based on relevant guidelines published by the International Finance Corporation (IFC) and therefore are expected to meet the environmental requirements of potential lending institutions.

The Project is aligned with the April 2006 version of IFC Performance Standards on Social and Environmental Sustainability. The eight Performance Standards are what IFC applies to manage social and environmental risks and impacts and to enhance development opportunities in its private sector financing. Further information can be found at their website *www.ifc.org*.

The eight standards are:

- Performance Standard 1: Social and Environmental Assessment and Management Systems;
- Performance Standard 2: Labour and Working Conditions;
- Performance Standard 3: Pollution Prevention and Abatement;
- Performance Standard 4: Community Health, Safety and Security;
- Performance Standard 5: Land Acquisition and Involuntary Resettlement;
- Performance Standard 6: Biodiversity Conservation and Sustainable Natural Resource Management;
- Performance Standard 7: Indigenous Peoples; and
- Performance Standard 8: Cultural Heritage.

Social and Environmental Assessment and Management Systems establish the importance of: (i) integrated assessment to identify the impacts, risks and opportunities of social and environmental projects, (ii) community participation through the dissemination of project related information and consultation with local communities about the project, and (iii) the management of social and environmental performance made by the investor throughout the project cycle. Performance Standards 2 to 8 establish requirements to prevent, reduce, mitigate or offset the impacts on people and the environment, and to improve conditions where appropriate. Although all relevant risks and potential social and environmental impacts should be considered as part of the assessment, the Performance Standards 2 through 8 describe the impacts that require particular attention in emerging markets. When social or environmental impacts are anticipated, the investor must manage them through a system of socio-environmental management, in accordance with Performance Standard 1. In addition to meeting the requirements of the Performance Standards, investors must comply with national laws, including those involving the country's obligations under international law.

4 *PROJECT DESCRIPTION*

4.1 *OVERVIEW*

The proposed Project begins with the barge coal loading facilities at the point where coal is received from the overland conveyor line from the Benga Mine and ends when the coal is loaded onto ocean-going vessels via a transloader located offshore at Chinde (*Figure 4.1*). Barging will be undertaken using a Mississippi-style operation. This will comprise of specially designed shallow draft boats pushing between four and eight unpowered hopper barges. The barges will be sufficiently light and shallow enough draft for use in the river while strong enough to be taken offshore. The barges, which will be certified for marine use, will have raked bows designed to assist them handle the sea conditions expected to be encountered at Chinde.

While the Project concept is well defined, detailed design is ongoing, with technical investigations into river flow variations, channel depths, convoy configurations, barge mooring requirements, dredging requirements, and coal transport volumes amongst others continuing. In order to inform the impact assessment, upper estimates for channel depths, barge design etc have been used. The technical design team is liaising with the environmental team so as to reduce potential impacts by incorporating changes into the detailed design. A few changes to the project description (primarily the operational phase of the Project) have been made subsequent to the submission of the EPDA Report. These changes are described in detail in this Chapter.

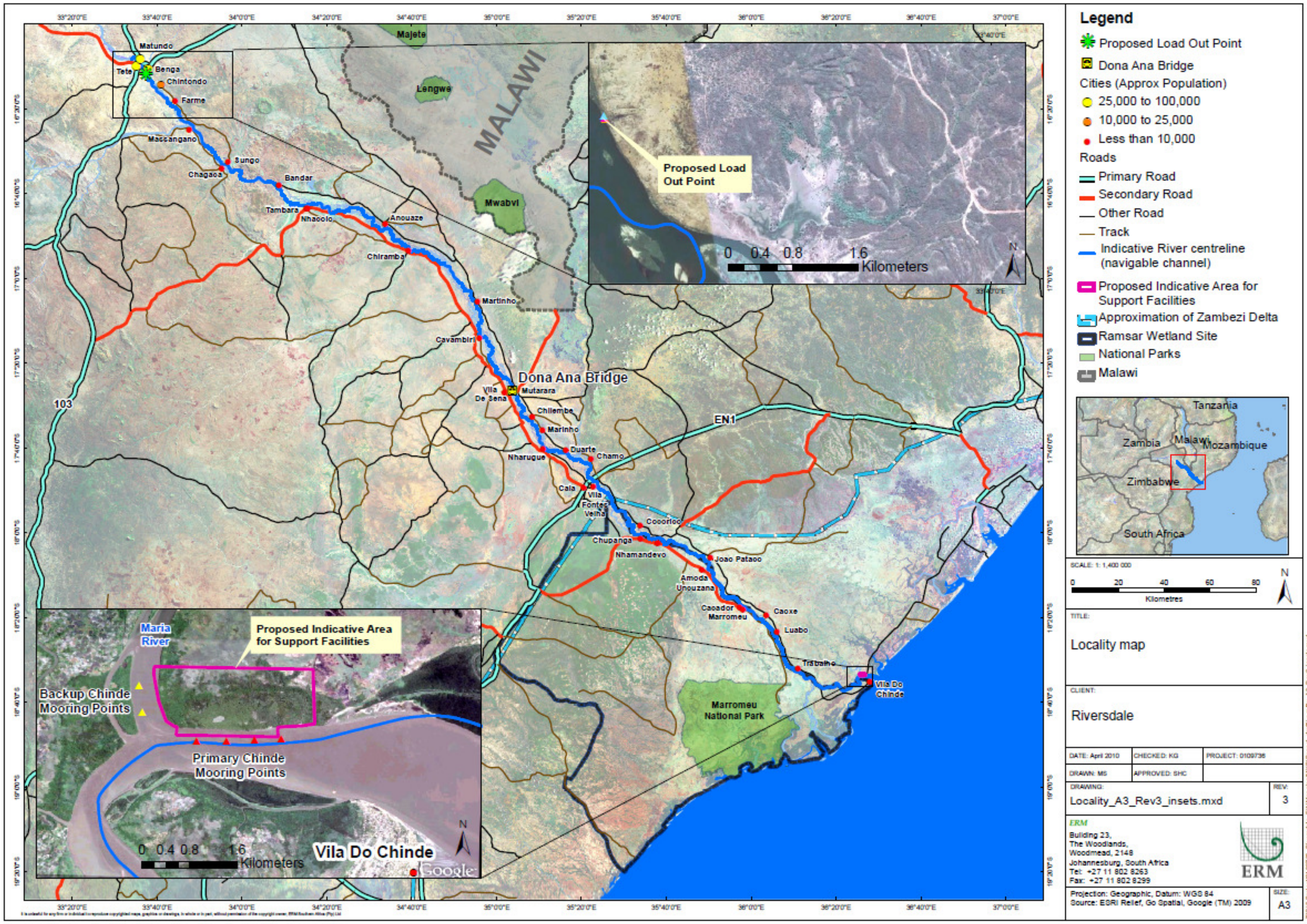
The main activities associated with this project include:

Construction Phase:

- Capital dredging of the river at certain locations between Benga and Chinde to the optimal depth for coal transportation of between 3.0 and 3.5m with provision to increase depth at specific locations to up to 5.5m. These deeper dredged locations are to provide localised buffers for channel infill at specific sites. The channel depths referred to in this Chapter relate to a depth relative to typical dry season river heights which, for the purpose of this report, is based on a river height at the Tete gauge of 2.8m.

- Capital dredging, across the river sand bar at Chinde river mouth to a depth of approximately 4m below Chart Datum (CD). Chart Datum is approximately the level of Lowest Astronomical Tide (LAT) and is some 2m below Mean Sea Level at Chinde.

Figure 4.1 *Locality Map*



- With respect to dredging, Riversdale is investigating the possibility of initially dredging a shallower channel of approximately 3m. The channel would then be deepened once experience was gained as to the extent and rate of channel infill. Studies show that approximately 60 percent (depending on desired channel depth) of dredged sediment volumes will be in the upper half of the river between the loadout point and the Dona Ana Bridge, with the remaining ~40 percent being in the lower half of the river from Dona Ana Bridge to Chinde. Depending on the rate of channel infill actually found to occur, it may be decided to either deepen the channel along the entire river or alternatively maintain a shallower channel upstream of the bridge and to deepen the channel downstream of the bridge only. Under this latter scenario, barges in the upper part of the river would run partly loaded from Benga to just below Dona Ana Bridge and then be topped up with coal at Dona Ana for the second half of the trip. While the possibility exists that the navigable channel in some sections of the river may ultimately be maintained at less than 3.5m, approval is sought to create a channel with a minimum depth of 3.5m along its entire length, with provision to deepen the channel to up to 5.5m at select high infill sites.

- Construction of coal loading facilities and mooring points on the Zambezi River at Benga.

- Construction of support facilities at or close to the load-out point at Benga.

- Construction of mooring points on either side of the Dona Ana Bridge.

- Construction of fenders at Dona Ana Bridge to protect bridge piers should investigations show this to be necessary or advisable.

- The Dona Ana floating transfer station (FTS), if installed, would consist of a crane and grab mounted on a floating platform. The grab would pick up coal from one barge (unloading barge) and place it into another (loading barge).

- Construction of mooring points and floating platforms at various locations at Chinde. These will be on the left hand bank (looking downstream) of the Zambezi River downstream from the point of confluence with the Maria River, within the Maria River, and on the right hand bank of the Zambezi River approximately two kilometres upstream from the point of confluence with the Maria River.

- Establishment at Chinde of one or more floating transfer stations to transfer coal from river barges to larger ocean going barges. It is expected that the transfer stations will be phased in as coal volumes increase.

- Construction of support infrastructure and associated facilities on the northern side of the river at Chinde, with the potential to locate some facilities in or near Chinde township.

- Anchoring a transloader 15km to 20km offshore of Chinde.

Operation Phase:

- Maintenance dredging to maintain the navigable channel along the river during the life of the Project of between 3.0 or 3.5m, and 5.5m, and to maintain the navigable channel over the river entrance bar at approximately 4m below Chart Datum.

- Loading of barges at the Benga barge loading terminal;

- Assembly of convoys adjacent to the Benga barge loading terminal;

- Transport of coal in convoys of four to eight barges, with each convoy pushed by a shallow draft push boat. Convoys may comprise four (or less) barges at the beginning of the Project while experience is gained on the river. The frequency of convoys will depend on various factors such as the volume of coal to be transported, the number of barges per convoy and the channel depths available at the time of dispatch (for example the river height is subject to change by changes in releases from Cahora Bassa dam and weather conditions) . While it is anticipated that the frequency of convoys will be no more than two a day initially, this is likely to increase as coal production increases and familiarity with navigation improves.

- If it becomes necessary to run lightly loaded barges on the upper half of the journey, the barges would be topped up using a floating transfer station (FTS) which would be moored downstream of the Dona Ana Bridge. As partly loaded convoys arrive at the transfer station, coal would be transferred from some of the lightly loaded barges into others in the convoy. The now fully loaded barges would then resume the journey to Chinde while the newly emptied barges would be formed into a convoy and returned to Benga.

- In terms of convoy configuration, approval is sought for convoys of up to eight barges each over the entire river from Benga to Chinde. It is proposed that smaller convoys of two or four barges will be run initially, with the convoy size increasing as experience is gained. It is likely that in the initial years shorter convoys will be used upstream of the Dona Ana Bridge with convoys being combined downstream of the bridge.

- There may be possible fracturing of the convoys at Dona Ana Bridge (disassembly of the convoys) to facilitate safe movement of barges under the bridge;

- Mooring and fractioning of the river convoys at Chinde prior to the transfer of the river barges to the transloading location offshore or prior to transfer of coal from the river barges onto larger ocean-going barges (see below);

- Towing of loaded river barges one or two at a time across the Chinde bar to the transloading location by shuttle tugs (depending on weather conditions);

- Transfer of coal at Chinde from river barges to larger ocean going barges by means of a floating transfer station (FTS). The river barges are designed for marine use and are capable of safely taking coal to the transloader offshore from Chinde. However, as volumes of coal transported increase, a point is reached where it becomes more feasible to transfer the coal from river barges into larger special purpose marine barges for the shuttle from Chinde to the transloader. The larger marine shuttle barges will be phased in so as to increase the volume of coal that can be transported efficiently across the Chinde sand bar. Studies indicate that the optimum phasing-in point corresponds to a volume of coal of approximately 5mtpa. However, approval is sought to introduce the larger marine shuttle barges at any throughput volume.

- Towing of barges one or two at a time from Chinde to the transloader by ocean-going tugs.

- Transfer of coal from the barges onto the transloader. The transloader will unload barges by way of grabs and store coal in its hatches until it is ready to be loaded into customers' ocean-going vessels.

- Transfer of coal from the transloader into ocean going export vessels. Where ocean going export vessels have their own grabs, such vessels may unload barges directly into their own holds.

- Some maintenance and operational activities at Chinde and Benga (routine maintenance at Benga and only emergency repair at Chinde).

- Major maintenance and periodic dry docking of ocean-going tugs at Beira.

- Return of empty barges from Chinde to the Benga load-out facilities

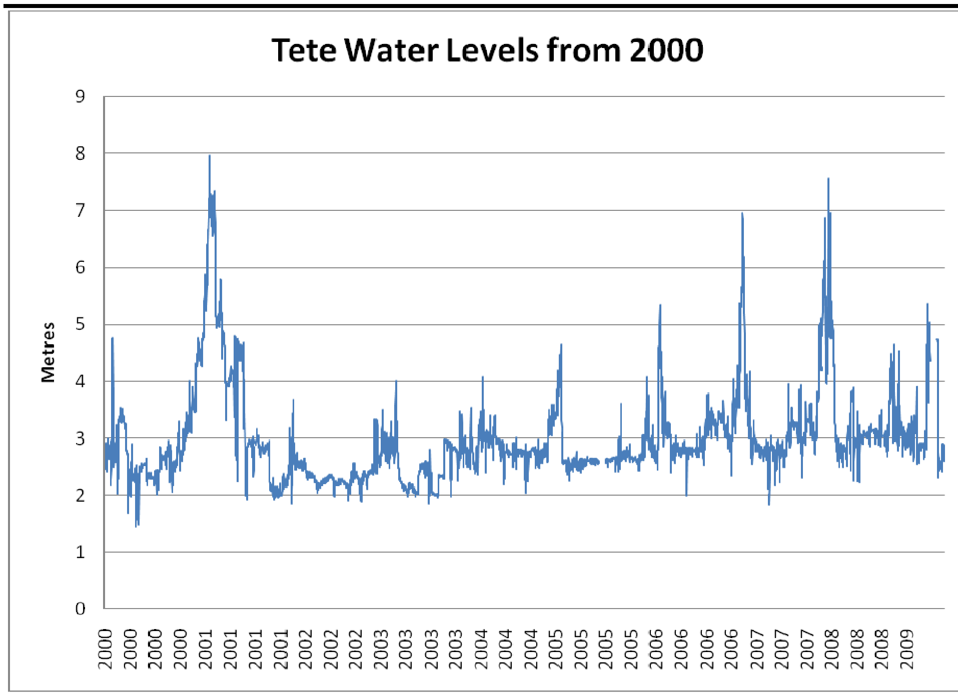
It is proposed to investigate potential land stockpile areas at Chinde and, in addition, the feasibility of construction of an offshore loading jetty, as part of further studies by the barging team. The construction of land stockpiles or any offshore jetty would be subject to separate environmental approvals should Riversdale subsequently wish to proceed with these initiatives. Approvals are not sought these facilities under this ESIA.

4.2 REFERENCE RIVER HEIGHT FOR DREDGING

Channel depths referred to in this Chapter relate to a depth relative to typical dry season river heights which, for the purpose of this report, is based on a river height at the Tete gauge of 2.8m.

Since the construction of the Cahora Bassa Dam in 1975, river flow patterns downstream of the dam have been modified. Over the past few years, power demand has increased resulting generation-related discharges becoming more prominent. While flows are still variable, in recent years they are generally at a rate that keeps the water level at the Tete gauge above the reference level of 2.8m. Rarely in recent years has the level dropped much below 2.4m (see *Figure 4.2*).

Figure 4.2 ***Water level at Tete since 2000***



Riversdale's boat and barge convoys have been designed to accommodate the river height patterns associated with the Cahora Bassa's more recent style of operations. Riversdale does not require river flows to be further stabilised. However, it should be noted that the barging operation is predicated on flow patterns not changing materially from recent historic patterns.

4.3 *PROJECT MOTIVATION*

Construction of Stage 1 of the Benga Mine Project is underway. It will initially produce approximately 2 million tonnes per annum of coal for export. It aims to commence with coal production in mid 2011. RML will export Stage 1 coal by rail through the Port of Beira. Benga Mine Project is a staged development. At full production, the mine will produce 10 – 12 million tonnes of export coal per year. This production rate greatly exceeds the rail capacity likely to be available to RML in the foreseeable future. Without a secure and stable means of transporting coal from the Benga Mine Project, the value and viability of the upstream business is compromised. In this regard RML is currently evaluating barging as a complementary solution for the export of its coal in addition to transport via the Sena Railway and Nacala transport corridor. Barging will facilitate the expansion of mining activities in the Moatize Basin and allow RML to export product (coal) that may otherwise not be economical to transport through the other two transport systems.

The coal to be mined at the Benga Mine Project comes from numerous different seams with different qualities. Approximately one third of the coal mined is high grade metallurgical coal which is expected to achieve a premium product rating in the export market, once the coal has been fully tested and has established its position in the market.

Up to another one third of the coal mined is suitable for use as a thermal coal in power stations (the remainder is a combination of stone bands and very low quality coal that is not saleable in the export market). However, the thermal coal is not a premium product. It has relatively high raw ash content, and is suitable for select export markets only. The price received for this coal will be much lower than for the high grade metallurgical product. The key to being able to sell this lesser grade thermal coal is to deliver it cheaply and in large volumes. RML is investigating the use of barging as a means of developing and supplying a market for this lesser quality product which would otherwise be uneconomic to transport and so would be wasted. While barging is seen as critical to developing and supplying a market for lower quality coal, approval is sought to barge any coal product type.

Several direct and indirect economic benefits associated with the creation of the transport route along the Zambezi River are expected, including the provision of substantial opportunities for increased local and regional economic development.

4.4 *PROJECT DESCRIPTION*

4.4.1 *Construction Phase*

The construction phase activities consist of capital dredging and the construction of various components of infrastructure along the reaches of the Zambezi River.

Capital dredging

Capital dredging refers to the initial dredging required to ensure the river channel is wide and deep enough to allow the proposed coal barging Project to proceed. Dredging will need to take place at various reaches along the river from Benga to Chinde, a distance of approximately 540km.

The "ideal" channel is one that, when the flow is low, has a minimum depth of 3.0 to 3.5m. The channel design also needs to allow convoys to negotiate bends with safety. Required channel widths vary according to radii of bends, length of bends, length of convoys and whether or not the channel at particular locations needs to accommodate one-way or two-way traffic. The dimensions of the channel have been designed based on recognised guidelines such as the "Inland Navigation and Canalization", *Pamphlet No 1110-2-14*, Engineering and Design Monograph, CECW-EH, Department of the Army, US Army Corp of Engineers, Washington DC, 30 November (Peterson, Margaret Sara (1997)).

A range of studies has been conducted to optimise the design alignment, width and depth of the navigation channel, including navigation studies and economic studies taking into account capital and operating costs. Based on these studies, the channel has an initial design depth below the reference water level of 3.0 m (laden barge draft of 2.5 m) and width generally ranging from 60 m to 110 m depending on convoy size and bend radius (the channel needs to be wider in bends than on straight sections). In one instance, between chainages (1) 21.87km and 23.37km, the navigable channel needs to be 220m wide to accommodate bends

As a guide, straight or gently bending channels need to be at least 50m wide to accommodate one-way traffic. Channel widths increase as bends get tighter. For eight barge convoys, bends of up to 900m radius can be readily navigated in a single manoeuvre and without fracturing the convoy. The minimum channel width required for an eight barge convoy to pass through a 900m radius bend that turns 90 degrees or more is 110m (one-way traffic). For less tight bends or bends that turn for less than 90 degrees, required channel width reduces. For shorter convoys, the minimum turn radius reduces. The minimum turn radius for a four barge convoy is 450m (for a bend turning through 90 degrees or more).

In this regard the estimated total dredging volume to create the design channel is approximately 19 million m^3. The nature of the river is such that for a channel design that is common for both halves of the river, about 75 percent of the total capital dredging volume is situated above the Dona Ana Bridge (this section of the river is generally shallower and also has tighter bends necessitating a wider channel on average), and about 25 percent below the Dona Ana Bridge. By reducing the size of the convoys in the upper half of the river, it has been possible to reduce the average width of the channel upstream and hence dredging volumes, while also providing flexibility to widen slightly the channel in the lower half of the river to aid navigation. The final breakdown of dredging volumes is about 60 percent above the Dona Ana Bridge and 40 percent below.

The channel described above will facilitate one-way traffic. For convoys to pass each other safely, the channel needs to be at least 90m wide on straight or gently curving sections. Given the frequency of convoy movements envisaged coupled with the fact that there are many locations where the natural channel exceeds 90m there is little need to create passing locations by dredging. Passing will be undertaken where the channel is naturally wide. Convoys will

(1) The chainage refers to the distance (in km) from the sand bar at the river mouth (0km) to the loadout point (540km).

be in constant communication with each other and a central communications centre. This communications system will be used to co-ordinate and control barge traffic including passing.

Capital dredging within the river would be primarily undertaken by cutter suction dredgers (CSD). This type of dredger is very common and comprises a suction pipe fitted with a cutter head supported below a floating barge, and a discharge pipeline. The dredger is anchored in position in the river and swivels around a rear pivot or spud, sweeping the cutter head and suction pipe in a horizontal arc through the sediment on the river bed. A variation on the CSD is a dustpan dredger. These operate in a similar manner to a CSD, the main difference being employment of a wide suction head at the end of the suction pipe (as wide as the dredger) as opposed to a cutter suction head. A dustpan dredger is particularly suited to dredging thin layers of material.

The CSD may be supported by auxiliary water injection dredging (WID) equipment. This equipment would be used to locally remove and redistribute any highspots and ridges left by the CSD.

The material dredged by CSD (and dustpan dredger) would be disposed of via a discharge pipeline and spreader barge. The location and method for disposal of the dredged material will be determined by both technical and environmental factors. It is planned for all dredged material to be deposited back within the river system for environmental reasons (due to sediment budget considerations) within a distance of about 300 to 700m of the dredging locationThe pipeline would be arranged so that larger, heavier, particles when encountered could be selectively pumped a shorter distance, e.g. by use of valves in the pipeline. Currently the base case is for dredged material to be deposited alongside the dredged channel (on the side with the greatest distance to the river bank). Mitigation measures proposed by the ESIA team suggest that it would be environmentally desirable (1) to deposit the dredged material in the lees of islands or sand bars wherever possible. Accordingly, this approach will be adopted as a preference wherever practicable, eg where islands and sand bars exist near the dredging and it is feasible to deploy the pipework within the distance limits referred to above..

In certain locations along the river it may be feasible to utilise dredging equipment that incorporates hoppers which temporarily store dredged material prior to disposal. In this case disposal of material would again be in the lee of islands and sand bars where practicable, either by using a discharge pipeline and spreader barge as for the CSD or by direct transport of the hopper to the disposal area.

Due to the relatively high quantity of dredging, the long length of the river, and schedule requirements (dredging period less than 18 months), it is expected that up to approximately eight CSDs will be required, distributed

(1) Deposition in the lees may reduce the rate of infill of the navigable channel and may create a bit more braiding, which is a move toward more "natural" conditions, prior to the construction of the Cahora Bassa and Kariba dams.

along the river. As the CSDs are not self propelled, small work boats/tugs will be required for towing the dredgers between dredging locations. These vessels would also be employed in positioning the anchors for the CSDs.

Preliminary sediment investigations have shown that the material to be dredged comprises a fine to medium to coarse grained sand with some localised gravel and cobble size particles. As one moves further downstream and into the delta area fine particles begin to show in the sediment samples. Further sediment investigations are planned to gather additional information along the river and with depth below the existing river bed level.

Capital dredging is also required across the bar at the entrance to the Zambezi River at Chinde in order to achieve adequate depth for the barging operation out to the transloading location. The estimated quantity of capital dredging across the bar is approximately 350,000 m^3. At the entrance bar, the wave conditions are too rough for use of a cutter suction dredger. Here the capital dredging would be performed by a side casting trailer dredger or trailing suction hopper dredger (TSHD). The TSHD is a self propelled ship with an internal hopper. Material is removed from the seabed via a drag arm(s) suspended (trailed) below the dredger, much like a vacuum cleaner and placed in the hopper of the dredger. The side casting trailer dredger is similar to a TSHD but has no hopper. Consequently this type of dredger does not store the material before disposal but simply pumps it to the side of the vessel back onto the seabed.

TSHDs vary in size. A vessel size would be selected for the Zambezi River entrance dredging based on a range of technical and environmental factors but would be expected to have an overall length of approximately 70m. The material to be dredged on the bar is expected to be fine to medium grained sand. Due to environmental reasons (sediment budget considerations) material would be disposed of within the active coastal system, by pumping onto the nearshore seabed or bottom dumping in the nearshore zone.

The TSHD would achieve this by one of two means after sailing to the disposal area:

- by bottom dumping the dredged material onto the seabed through the hopper doors; or

- by ‘rainbowing’ the dredged material (pumping it over the bow of the vessel onto the water surface).

Of these methods, bottom dumping is the most straightforward. As the side casting trailer has no internal hopper, it must, as noted above, pump the material over the side of the dredger (via a discharge pipeline on an extended boom) as it undertakes the dredging process. Hence the material is deposited within about 50 m from the dredging area. The specialist study addressing sediment dynamics at the river mouth recommends depositing dredged sediment in the nearshore coastal system so as to maintain the nearshore sediment budget. RML will follow this recommendation.

The time period for capital dredging of the entrance bar would not be expected to exceed two months. All capital dredging operations would take place 24 hours a day, 7 days a week (weather and flow conditions permitting).

Figure 4.3 below provides examples of dredging operations from other parts of the world

Figure 4.3 Showing examples of dredging operations from other parts of the world

Photographic example of Dredging Operation from other parts of the word	Description
	Photo showing CSD dredging sand in Botany Bay, Sydney, Australia. This is right in the heart of Sydney, International Airport. There are also, adjacent residential areas and a RAMSAR wetland nearby.
	Photo showing CSD dredging sand to maintain a channel in the entrance reach of Tuggerah Lakes, New South Wales, Australia. The Lakes have significant ecological and recreational values. ***Note proximity to development including residential.***
	Photo showing a side casting trailer dredger maintaining the navigation channel through the entrance sand bar at Lakes Entrance, Victorian coastline, Australia. This is indicative of what could take place at the entrance to the Zambezi.
	Photo showing a side casting trailer dredger maintaining the navigation channel in the estuary at Lakes Entrance. This is indicative of what could take place at the Lower Zambezi.

4.4.2 *Construction of Infrastructure*

The historic loadout point, approximately 10km downstream of the Tete Bridge, on the northern bank, will be refurbished to incorporate the barge loading facility. A typical barge loading facility is shown in *Figure 4.4*

Figure 4.4 Example of Barge Loading Facility

The river infrastructure to support the barging operation comprises mainly the barge loading facilities adjacent to the mine, the repair and maintenance facilities for push boats and barges at Benga comprising a floating dry dock (*Figure 4.5*), mooring points upstream and downstream of Dona Ana Bridge, an FTS downstream of Dona Ana Bridge, if required, fendering at the two bridges (Dona Ana and Caia) (*Figure 4.6*), and a range of facilities at Chinde; namely, mooring points, a floating dry dock, shuttle tug base, and FTS (*Figure 4.7* and *Figure 4.8).*

Mooring points will be constructed at the following areas:

- Along the left hand bank (looking downstream) at the loadout point at Benga.
- Before and after the Dona Ana Bridge
- At various locations at Chinde:
    - Left hand bank of the Zambezi downstream of the point of confluence with the Maria River;
    - Within the Maria River;
    - Right hand bank of the Zambezi River approximately two kilometres upstream from the point of confluence with the Maria River.

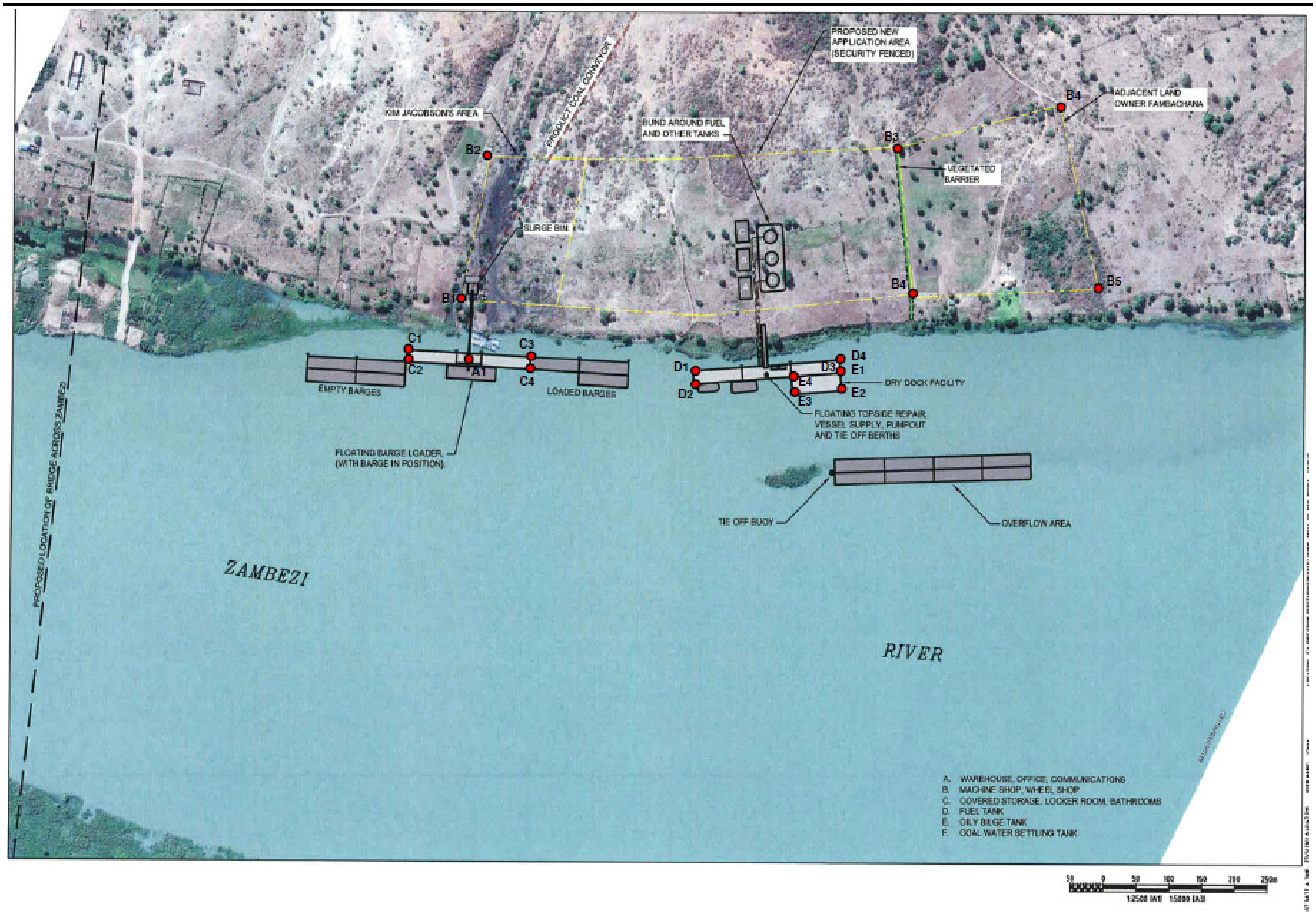
The river infrastructure itself would largely comprise piling and floating pontoons/barges (at the loadout point). Piling would consist of tubular steel piles driven into the river bed from a floating barge (or possibly jack-up barge), typically in clusters of 3 or 4 piles to form a 'dolphin'. The height of the piles would need to be sufficient to accommodate the range of river water levels experienced at the various sites. The pontoons/barges would be fabricated from steel plate, with multiple compartments. They would be designed to have adequate freeboard when subjected to dead and live load, including eccentric loads.

At the river mouth, RML will establish some support facilities which will be primarily located on floating structures attached to piles driven into the river bed near Chinde. RML is also considering establishing some facilities on land on the north side of the river opposite Chinde (refer to location of indicative areas for support facilities in *Figure 4.7)* for the barging operations. RML is currently investigating the suitability of this site and the final site may change. RML is also interested in establishing some facilities, such as offices and workshops in the Chinde township if this is acceptable to the local people and administration. Discussions on possible use of sites in Chinde town are to be conducted in the near future. Any change relating to the location of facilities will be reported on and assessed in the EIA Report. The following infrastructure is likely to be established at or in the vicinity of Chinde:

- Administrative and communication office.
- Ablution facilities.
- Wastewater treatment plant.
- Generator.
- Fuel storage and fuel dock.
- Emergency floating dry dock repair facility (as an alternative, a floating platform may be used).
- Heliport
- If land on the northern bank is available and proves suitable, equipment storage areas.

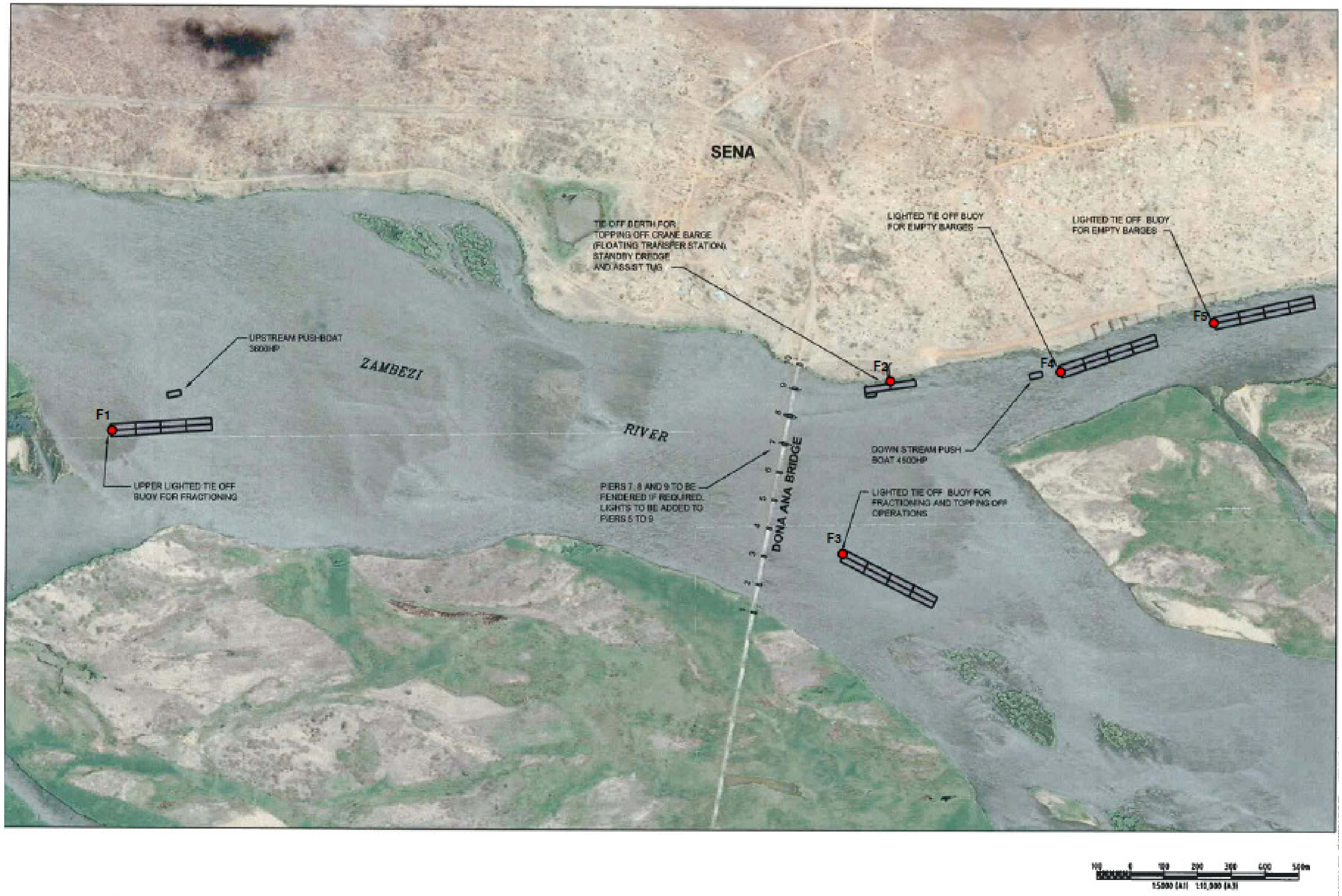
The support facilities will not include any land-based coal storage or handling. Should this be required in future, RML would need to undertake a separate ESIA prior to commencing with this activity, as noted earlier.

Figure 4.5 Layout of Mooring Points and Support Facilities at the Loadout Point



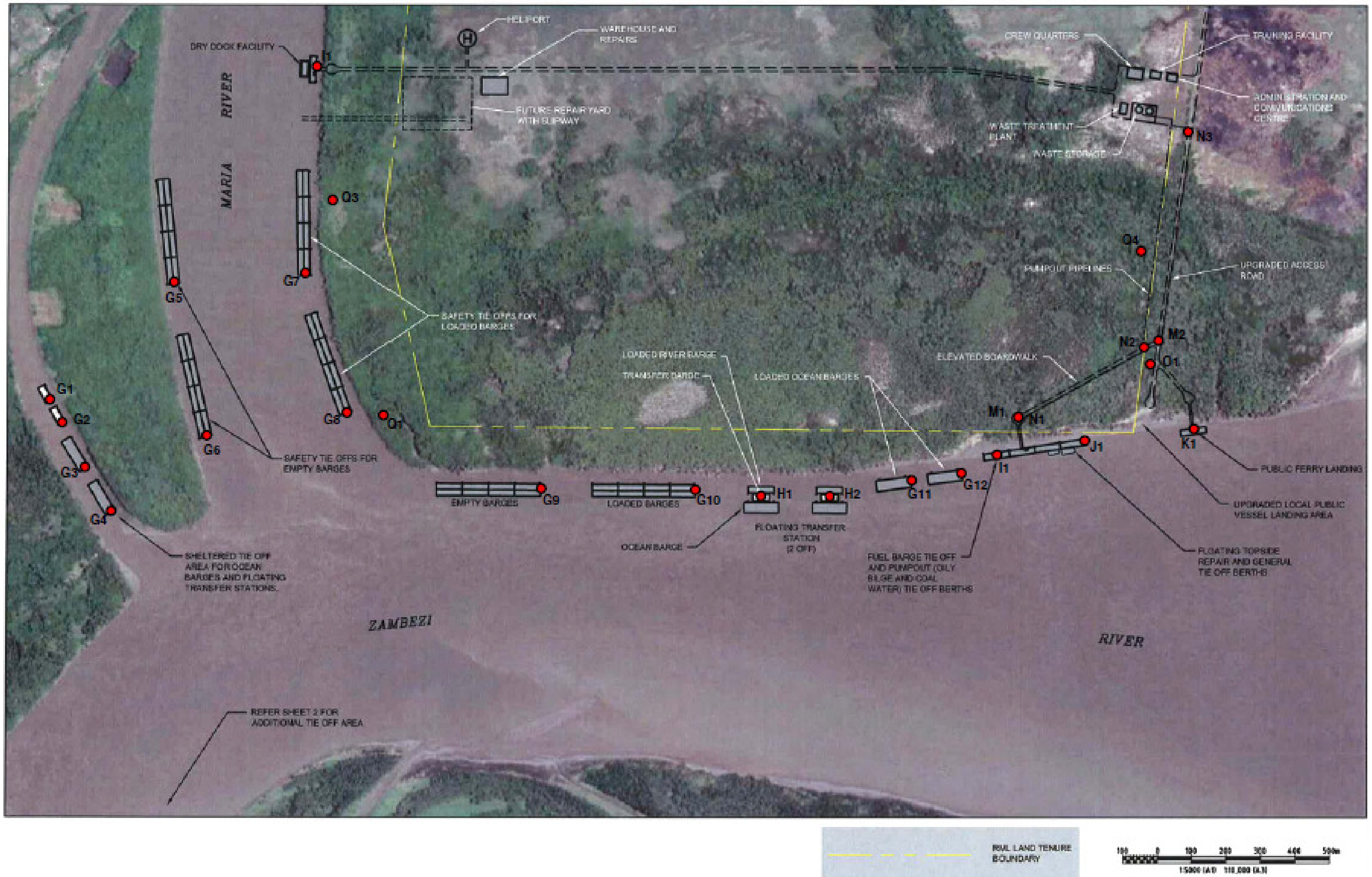
Source: Worley Parsons

Figure 4.6 Layout of mooring points at Dona Ana Bridge



Source: Worley Parsons

Figure 4.7 Indicative layout for support facilities at Chinde



Source: Worley Parsons

Figure 4.8 Layout of barge mooring points at Chinde

Source: Worley Parsons

The coordinates for the infrastructure illustrated above are as follows:

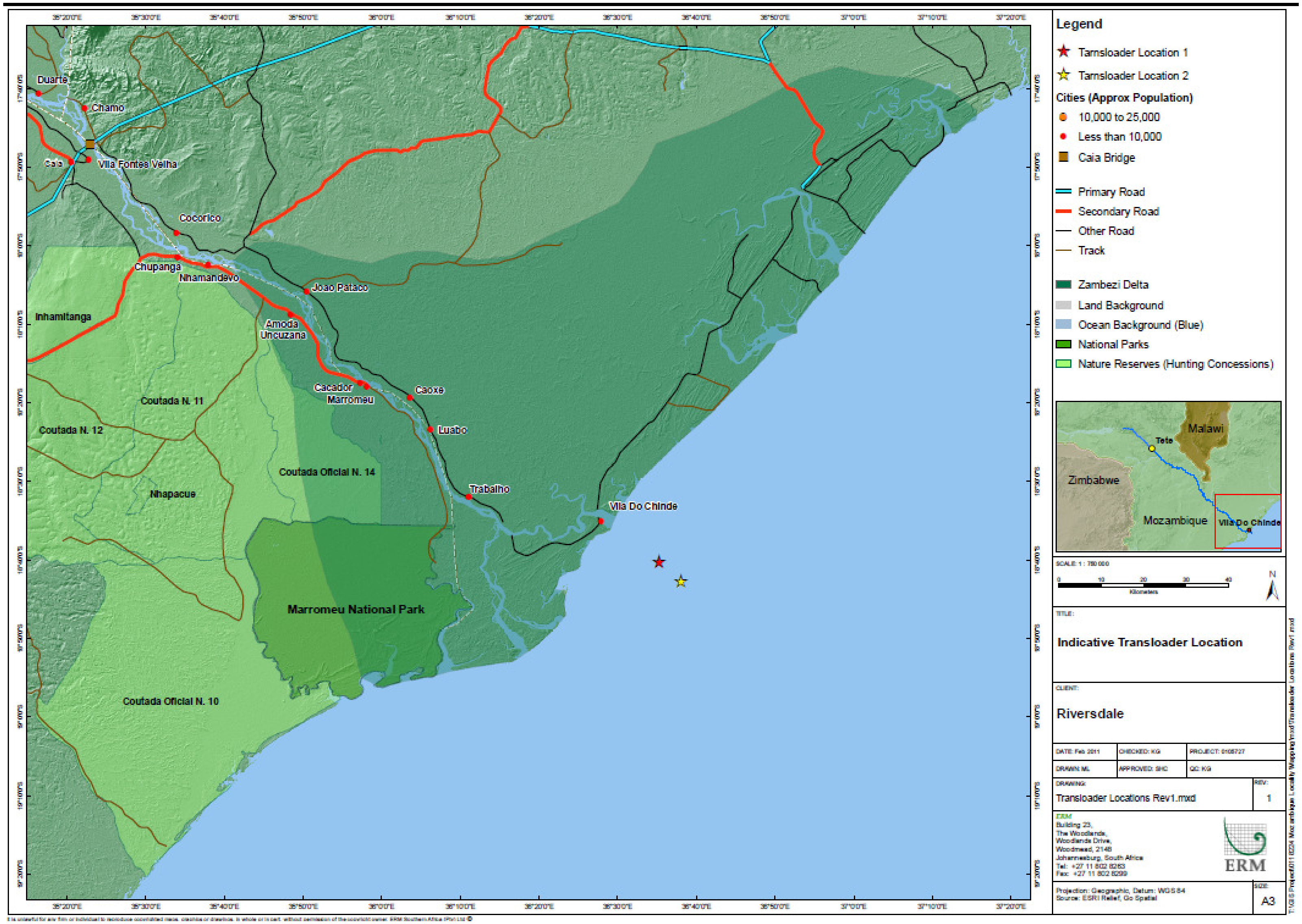
Table 4.1 Infrastructure Coordinates

Point	Latitude	Longitude
A1	-16.195575	33.623719
B1	-16.195119	33.624272
B2	-16.194617	33.626103
B3	-16.199544	33.628983
B4	-16.201261	33.630544
B5	-16.202842	33.628714
B6	-16.200575	33.627361
C1	-16.194817	33.623367
C2	-16.194819	33.623197
C3	-16.196325	33.624083
C4	-16.196394	33.623953
D1	-16.198378	33.625042
D2	-16.198469	33.624900
D3	-16.200178	33.626003
D4	-16.200106	33.626114
E1	-16.200178	33.626003
E2	-16.200308	33.625797
E3	-16.199731	33.625447
E4	-16.199622	33.625711
F1	-17.422536	35.055119
F2	-17.440661	35.066181
F3	-17.441611	35.061450
F4	-17.444572	35.068642
F5	-17.447700	35.071822
G1	-18.560389	36.419406
G2	-18.560933	36.419717
G3	-18.562128	36.420178
G4	-18.563294	36.421000
G5	-18.557381	36.422922
G6	-18.561344	36.423692
G7	-18.557211	36.426425
G8	-18.560797	36.427442
G9	-18.562883	36.432914
G10	-18.563033	36.437094
G11	-18.562789	36.443131
G12	-18.562700	36.444542
G13	-18.601508	36.428875
G14	-18.598344	36.429703
H1	-18.563178	36.438942
H2	-18.563250	36.440789
I1	-18.562178	36.445419
J1	-18.562058	36.447408
K1	-18.561667	36.450928
L1	-18.551806	36.426606
M1	-18.561275	36.446036
M2	-18.559314	36.450000
N1	-18.561275	36.446036
N2	-18.559514	36.449589
N3	-18.553728	36.450406
O1	-18.559780	36.449740
Q1	-18.560843	36.428524
Q3	-18.555490	36.427082
Q4	-18.556736	36.449486

4.4.3 Anchoring of the Transloader

The transloader, which will be a modified Cape-sized or Panamax-sized vessel, will be moored between 15km and 20km offshore depending on the size of the customer's ship to be loaded. The transloader will be located in the areas indicated in *Figure 4.9***.**

Figure 4.9 Transloader Location



4.5 OPERATIONAL ACTIVITIES

Barging is planned to be a 24 hour, 7-day a week, year-round operation. This all year operation will however be subject to suitable weather and river conditions. It is expected that convoys in the upper half of the river (above Dona Ana Bridge) will comprise four barges initially, with the number of barges increasing to a maximum of eight once sufficient experience has been gained on the river. Downstream of the Dona Ana Bridge, eight barge convoys will be run.

A detailed discussion the operational activities are presented below.

4.5.1 *Barge Loading*

Barges will be loaded at a loading terminal. The terminal will be supplied by conveyor. The on-river section of the terminal will consist of several floating barges guided by slides aligned with sets of dolphins driven into the river bed. These barges will be permanent parts of the terminal (not unused coal barges) and will serve as a floating dock. Coal will be delivered to the loading spout at rate of up to 3,600 tons per hour (tph). Barges will be loaded in a single pass by winching the barge under the loading spout. A barge-mounted crane would be used for trimming of the barges prior to departure if required.

Coal will be transported via conveyor from stockpiles at the Benga Mine to the loadout point on the Zambezi River [1]. The loadout point is located at an existing site that was used for barging coal from the 1920s to 1960s. The concrete structures remain largely intact and the site contains remnants of coal from previous coal stockpiles (see *Figure 4.10)*.

4.5.2 *Convoy Assembly*

Full barges will be towed by assist tugs to mooring points a short distance downstream of the loader. There they will be assembled into convoys of either four or eight barges, depending on river channel conditions at the time, and a push boat attached for the journey downstream.

The frequency of convoys will depend on various factors including coal volumes, number of barges per convoy, and load per barge, which is dependent on the prevailing depth of the navigable channel. It is anticipated that the frequency of barges travelling to Chinde will commence at several per week and grow to several per day. Lighting will be required at all loading, offloading and changeover points.

(1) As noted earlier, the conveyor will be included in the Amendment EIA for the Benga Mine.

Figure 4.10 Load Out Point at Benga

4.5.3 *Barging of Coal down the Zambezi River*

For the purpose of operations, the river will be divided into two sections of approximately equal lengths. The upper half of the river commences at the Benga barge load-out facility and ends at a mooring point immediately downstream of the Dona Ana Bridge located at the village of Mutarara. The lower half of the river begins at the Dona Ana Bridge and ends at the Zambezi River mouth at Chinde.

The division of the river into two halves for operational purposes is due to the differing characteristics above and below Dona Ana Bridge. The upper half of the river is generally shallower and the natural channel subject to tighter bends. It is also likely to experience greater sediment movement and hence channel infill. It includes a heavily braided section between the Lupata Gorge and Mutarara. The lower half of the river, while still containing shallow sections, is generally deeper and the bends are generally gentler.

Reflecting the different river characteristics, different push boats and convoy sizes will be used. Push boats in the upper half will be 3,600 horsepower (hp) units with a draft of 1.8 m, whereas those operating in the lower half of the river will be 4,500 hp with drafts of 2.2 m to 2.45 m. (Deeper drafts allow use of larger propellers which in turn enables more powerful engines to be used.) The smaller boats will be capable of handling convoys of up to six barges, whereas the larger boats can handle up to eight barges. Barge dimensions are 17.5m wide, 75m long and 4.5m high. The push boat is 39m long. An 8 barge convoy will be arranged two wide and four long. Its dimensions will be 35m wide and 300m long (339m long including the push boat). A 4 barge convoy will be arranged 2x2 and have dimensions of 35 wide and 150m long (189m including the push boat).

Depending on the outcome of a navigation safety investigation, the convoy may be "fractured" at the Dona Ana Bridge. Fracturing entails mooring the convoy before the bridge and breaking it up to allow one or two barges at a time to be pushed under the bridge. The convoy will then be reassembled at a mooring point on the other side of the bridge. Subject to the results of further investigations and consultation with relevant authorities, consideration will be given to providing fendering around the bridge supports at the navigation spans to prevent collisions between the barges and the bridge supports. This approach will also apply at the Caia Bridge. Initially, convoys in the upper half of the journey from Benga to Dona Ana Bridge will consist of four barges. At Dona Ana Bridge, two 4 barge convoys will be reassembled into one 8 barge convoy for the remainder of the journey. 'Topping up' of barges just downstream of Dona Ana Bridge via a barge-to-barge floating transfer station (FTS) may also be undertaken should it be necessary to run convoys lightly loaded in the upper half of the river due to difficulties in maintaining a deeper channel, as described earlier. The FTS would comprise a barge mounted crane fitted with a grab. Transfer rates of coal from barge to barge would be in the range of 500 to 1,000 tph.

The round trip per convoy (Benga terminal to Chinde and return) is estimated to take approximately six days. Thus if six convoys are in operation, on average, one convoy will be dispatched from Benga each day. The number of convoys passing any one point on the river would then average two per day – one going downstream and one going upstream. In the upper half of the river where smaller four barge convoys may be used, it is anticipated that two convoys would be dispatched from Tete at the same time and proceed in tandem to the Dona Ana Bridge where they would be assembled into an eight barge convoy for the further downstream journey.

The total number of convoys in the fleet is yet to be decided. It will depend, amongst other things, on the then available rail capacity and the depth of the navigable channel. Fewer convoys will be required if the channel is sufficiently deep to allow barges to be more fully loaded In certain locations where the channel is anticipated to infill quickly, locally deeper dredging would be advantageous to provide a buffer against infill.

After investigating similar barging operations around the world, it is not expected that the barges will be routinely covered. However, during heavy rain, the barges will be covered (possibly with tarpaulin or similar) should it be deemed possible that the water could affect coal quality or barge stability. Should rain or river water get into the barges, the water that remains at the bottom of the barge will not be discharged into the river. Rather this water will pumped out and delivered to water treatment facilities located at the Benga mine and at Chinde.

The barges are likely to be designed as follows:

- 75m long x 17.5m wide x 4.5m moulded depth (700t weight).
- Double hulled, light enough for river conditions, strong enough for ocean conditions.
- 2,300t of coal at 2.5m draft / 3,100t of coal at 3.0m draft / 3,430t of coal at 3.4m draft.
- Ability to be covered with manually operated tarpaulins.
- Unmanned.

The pushboats likely to be designed as follows:

- 3,600 hp where operating upstream of Dona Ana Bridge and 4,500 hp where operating downstream of Dona Ana Bridge, each measuring approximately 39 m long x 16 m wide x 3.5 m moulded depth;

- Double hull;

- Fully fuelled draft of only 1.8m (upstream of Dona Ana Bridge) and 2.2m to 2.45m (downstream of Dona Ana Bridge) and capable of two round trips without having to refuel;

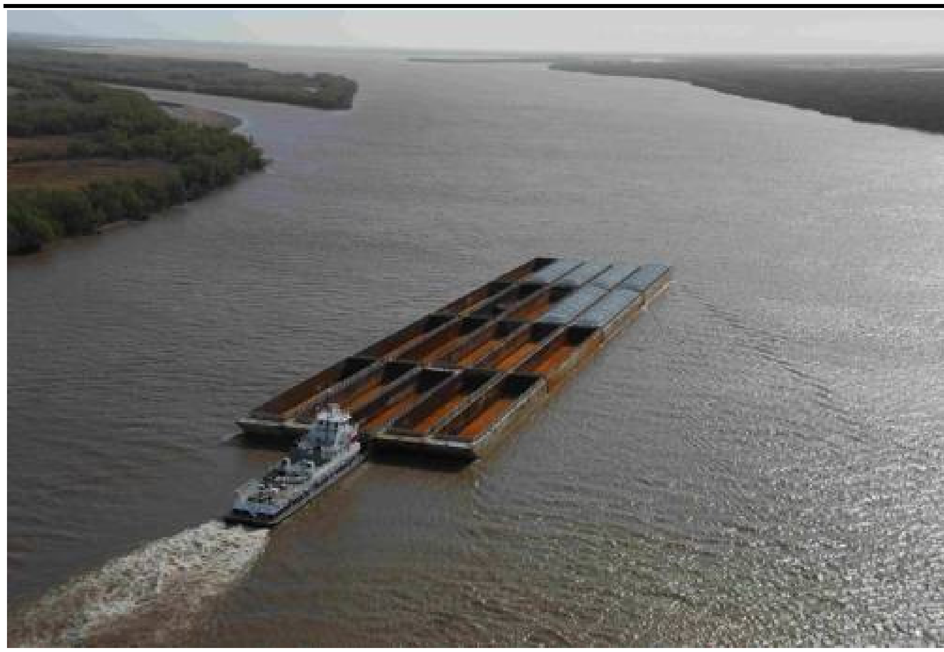
- Possible retractable pilot house for the larger push boats operating downstream of Dona Ana Bridge (the smaller push boats will fit under the bridge without needing to retract the pilot house), subject to confirmation of air draft at bridge; and

- Crew of 15 people.

Assistant tugs will be used for handling of barges at the loading point, tie up point and near Dona Ana Bridge where fractioning may be required. These are likely to be designed as follows:
- Required to be both powerful and manoeuvrable;
- Measuring 15m long x 7m wide x 1.8m draft;
- Double hulled;
- Crew of 2 people; and
- Possible retractable pilot house (pilot house can be lowered to safely pass under bridges).

Figure 4.11 below shows an example (albeit at a much larger scale) of a pushboat and coal convoy.

Figure 4.11 ***A typical barge used in coal transport***



4.5.4 Operations at Chinde

The loaded convoys would arrive at Chinde and be moored alongside piled dolphins. These dolphins would be located along the left hand bank (looking downstream) of the Zambezi River opposite Chinde township. The push boat that transported the convoy down the river would 'drop and run', i.e. release the loaded convoy and immediately pick up a convoy of unloaded barges for the return trip upstream. Upon reaching the Dona Ana Bridge, the downriver push boat would 'hand over' the empty barges to an upriver push boat.
Until such time as the larger special purpose ocean-going barges are introduced, the river barges would be towed offshore one or two at time by

the ocean shuttle tugs to the offshore transloading location. The shuttle tugs would have a bollard pull of 45t, draft of 3.0m to 3.5m and installed engine power of 3,800hp. These tugs would be permanently based at Chinde.

Following unloading at the transloading location the river barges would be towed back to Chinde by the shuttle tugs and assembled into empty barge convoys by the assistant tugs in readiness for the push boats to engage them on the return journey upstream. The assembly point would be primarily along the left hand bank opposite Chinde town; in addition a further overflow point would be located on the right hand bank of the Zambezi River a short distance upstream of Chinde.

Mooring points would also be provided in the Maria River near its confluence with the Zambezi River. This area provides greater shelter than the section of river opposite Chinde and thus provides a refuge at times of ocean storms. After the larger special purpose ocean-going barges are introduced (around 10,000 t capacity) it will be necessary to introduce a barge-to-barge transfer operation at Chinde. This would take place by means of a floating transfer station (FTS) comprising barge mounted cranes fitted with grabs. An FTS would have a transfer rate of around 1,500 tph. Alternatively, the special purpose barges may be fitted with self loading equipment with a similar loading rate.

The larger ocean-going barges would either be towed to the transloading location by the shuttle tugs (if unpowered) or, travel under their own power (if self-propelled). Self propelled barges would not require tug assistance to dock alongside the FTS.

Other facilities at Chinde would comprise a floating dry dock for emergency maintenance and repair of the downriver push boats. This facility would be located in the Maria River for additional weather protection. Shuttle tugs would travel to the Port of Beira for maintenance. River barges would be maintained at a facility at Benga. The larger ocean-going barges introduced as coal volume increase would be transported to the Port of Beira for maintenance.

4.5.5 Offshore loading of coal for export overseas

Transloading would take place 15 to 20km offshore of Chinde depending on the size of ship being loaded, eg Panamax or Cape class. *Figure 4.12* provides an example of a transloader. The transloading operation will involve use of a FTS. The FTS would be moored to the ship once it is at anchor, and typically winch itself along the ship in order to access all the ship's hatches. The barges would come alongside the FTS on the opposite side to the ship and, where required subject to weather, in the lee of the ship. For added weather protection, tugs would push the stern of the ocean-going ship to create a wind shadow for the barges. If self-powered 10,000t barges are introduced, these barges will be equipped with bow thrusters that will enable the barges to push the ocean-going ship without the need for tug assistance.

The FTS will be equipped with up to four cranes for unloading barges. These cranes will operate 25 – 35 tonne capacity grabs with throughput capacities of 1000 - 1500 tph. Grabs will transfer coal from the barges and into a hopper. If an ocean-going vessel is alongside, coal from the hopper will be fed to a conveyor system that transfers this coal directly into the ship. If no ship is alongside, the grabs will drop the coal into the hold of the FTS for storage. When a ship does arrive, the grabs will take coal from the FTS hold and drop it into the hopper feeding the conveyor system. Ship loading equipment on the FTS must have sufficient air draft to accommodate the range of design of ship(s).

In the initial stages of the barging operation when river barges are towed offshore, the FTS will include floating storage capacity in the order of 60,000t. In this case the FTS would unload the river barges into storage but, as discussed above, would also have the ability to load ships directly from the river barges. Once larger special purpose ocean-going barges are introduced, the requirement for floating storage is further reduced. In addition, these larger barges could be designed as self unloading, thereby influencing the equipment needed on the FTS.

The shuttle tugs for towing barges to the transloader are likely to be designed as follows:

- required to be both powerful and manoeuvrable to either single or tandem tow barges to the transloading station.
- Measuring 30.8m long x 11.5m wide x 5.28m overall depth.
- Draft restriction on design of around 3.0m to 3.5m.
- Double hulled.
- Crew of 5 people.

Figure 4.12 Example of a Transloading Operation

4.5.6 *Maintenance Dredging*

It is clear that the Zambezi River is a very dynamic system. This is evident from the literature, from comparison of hydrographic surveys conducted for the barging project, from observations during data collection exercises, from comparison of historical vertical aerial photography, and from limited available field measurements of suspended and bedload sediment transport.

Further data collection and numerical modelling of sediment transport processes in the Zambezi River is underway with the aim of refining the estimates of maintenance dredging requirements. The further data collection includes measurement of suspended and bedload sediment transport and further hydrographic surveys.

The annual maintenance volumes to be dredged will not be as significant as the volumes for the initial dredging operation. Based on current information, it has been estimated that annual maintenance dredging quantities could, on average, represent some 25 percent of the initial capital dredging volume, i.e. average of approximately 5 million m^3 per year. The basis for this estimate is the comparison of recent hydrographic surveys conducted at some six locations along the river between Chinde and Tete over the period 2008 to 2010, and suspended bedload sediment transport measurements undertaken in the upstream section of the river near Tete in 2006.

The volume of 25%, as noted above, is an average figure. It is expected that certain channel areas will require greater maintenance dredging effort, such as at cross over points in the river between the outside of natural river bends, and at the entrance bar. In these localised areas, maintenance dredging volumes could be considerably higher than the overall average of 25%.

The equipment that would undertake maintenance dredging within the river would include cutter suction dredgers (CSDs) and possibly the variation on the CSD, the dustpan dredger. It is proposed that initially three of the original eight CSDs engaged in the capital dredging would be retained for maintenance dredging operations. This is more than 25 percent of the capacity but reflects the uncertainty in the estimated maintenance dredging requirements and the long length of river involved combined with the need for quick response to channel infilling. It is likely the CSDs will be permanently stationed along the river near problematic sedimentation areas to reduce mobilisation time for channel maintenance.

In addition to the CSDs, it is also proposed to utilise water injection dredging (WID) equipment and a sweep bar for maintenance dredging purposes within the river, probably in a single multipurpose vessel(s). Both these dredging techniques may assist with removal of localised high spots in the channel that cannot be efficiently removed by the CSD.

At the entrance bar, the type of equipment used for maintenance dredging would be the same as that employed in the capital dredging, i.e. a trailing suction hopper dredger (TSHD) and/or a side casting trailing dredger; conditions on the bar are too exposed for a CSD to operate. It is possible the TSHD or side casting trailer dredger may also venture up the Zambezi River to undertake maintenance dredging work, as depicted in *Figure 4.3* (bottom photo).

The methods of disposal of maintenance dredging material from the river and from the entrance bar would be the same as the methods employed for the capital dredging material, i.e. back within the river system and within the nearshore coastal system respectively.

During the operational phase of the barging project, regular updates of the available depths in the channel will be obtained from soundings undertaken by each push boat as it transits downstream and upstream. This information will be relayed to other push boats and to a control centre. In addition, a number of dedicated survey launches will undertake regular surveys of the river, in particular problem areas. This will further assist in directing maintenance dredging efforts.

4.6 PROJECT OPERATING SCENARIOS

Different barging configurations have been described above. This section outlines potential operating scenarios under identified internal (within Riversdale's operation) and external (other projects on the river) factors.

4.6.1 Construction and Operation of Dams on the River

There are three proposed dams in the vicinity of the Project that may influence the Project; Mphanda Nkuwa, Boroma and Lupata.

Mphanda Nkuwa Dam

The ESIA for the proposed Mphanda Nkuwa dam is currently underway. The dam is planned to be operated as a run of river hydropower scheme whereby the average monthly discharge volumes do not change from the current status quo. Mphanda Nkuwa could be operated as a mid merit scheme or to generate base load. Mid merit means that the dam operation will generate power between the peaking periods in a 24 hour cycle. This will result in daily water level fluctuations unless the reduction in turbinated flows (ie flows through the generator turbines) during non-generating periods is offset by increases non-turbinated flows (flows through sluice gates that bypass the turbines). Should Mphanda Nkuwa be operated to generate only base load power, it may not alter the current flow regime materially. If operated as a base load station all of the time, it could tend to smooth out short term fluctuations in flows received from Cahora Bassa but should have little other effect. Thus the mid merit scheme without non-turbinated flow offsets represents the worst case scenario with respect to changes to flow. In either scenario, releases from Cahora Bassa will remain as the predominant influence on monthly and seasonal flow in the Project area.

In discussions, Mphanda Nkuwa engineers have stated that, in the worst case scenario, the direct impacts of the daily water level fluctuations will be felt immediately downstream of the dam wall and that water level changes are expected to become steadily less severe as the water moves downstream. While it can be expected that short term water level fluctuations will reduce in amplitude downstream, Mphanda Nkuwa dam has not provided RML with any estimates of the rate of change of flows or expected downstream river height fluctuations. Nor has RML been advised of the flow volume patterns being considered by Mphanda Nkuwa engineers. Therefore, RML is not able to comment on the proposed dam's specific plans. However, as part of this barging project, RML has examined actual historic river flow and height data sourced from ARA Zambezi. It shows that sudden changes in river flows emanating from Cahora Bassa dam do lead to readily observable river height changes at Tete and further down stream, and that these changes can be significant. In extreme cases, the river height changes can be substantial and occur over a short period of time. In August 2010, for example, the closing of sluice gates at Cahora Bassa dam resulted in a drop in river level at Tete of approximately 1.6m in the period between two readings that were 6 hours apart. The exact rate of the river height drop within this 6 hour period is not known as there were no intermediate readings taken. While a drop of 1.6m in 6 hours (or less) is not a common event, many instances have been noted of rapid river level drops and rises at Tete in response to flow changes at Cahora Bassa dam. ARA Zambezi historic data also shows that river height fluctuations observed at Tete can be tracked further down river and certainly to Tambara and beyond.

In view of the above, it cannot be assumed without proper studies being undertaken that the water flow and water level impact of running Mphanda Nkhuwa dam as a mid merit scheme will be confined to areas close to the dam. Further detail studies will be required by Mphanda Nkhuwa to shed light on its effect.

If further detailed studies show that any flow and river height fluctuations arising from the operation of the dam are ameliorated upstream of Tete, then the impact should be minimal. If, on the other hand, significant flow and level variations do reach Tete and below, negative impacts could arise. These impacts could include a reduction in the working draft available to the barge convoys due to short but repeated periods of low flow, potential for more rapid navigable channel infill due to short but repeated periods of high flow (river bottom sediments become more mobile as flows increase), and potential impacts on river bank erosion due to repeated wetting and drying of earthen river banks.

Lupata Dam and Boroma Dam

Although EIA studies have commenced for the proposed Lupata and Boroma dams, this hydropower scheme does not appear to be as close to fruition as Mphanda Nkuwa. Both dams are in the EPDA Phase but no baseline studies have begun in earnest. It is possible that the EIA studies are being completed so that Lupata and Boroma are in readiness should the need for additional hydropower arise.

Start dates for Lupata and Boroma are not defined and may be some time in the future. Boroma dam is located upstream of the Barging Project.. Unlike Mphanda Nkuwa and Boroma, Lupata Dam would be constructed within the barging Project area. Hence, apart from potential flow changes it also could provide a physical obstruction to barging. Using examples and case studies from around the world (notably the Ohio River in the United States, the Tocantins-Araguaia in Brazil and the Yangtze River in China), it can be seen that an effective system of locks can facilitate river navigation where dams are present on rivers.

Riversdale's proposed solution to operation in the event of the construction of Lupata Dam is to liaise with the dam concessionaire during construction to ensure that locks are developed as part of the dam design.

Locks provide navigation access through the dam complex, by which vessels are lifted or lowered from one pool to the next. The lock chamber is essentially a concrete box fixed into the riverbed with two matching gates at each end that close at an angle directed upstream against the river flow. The gates can open or close only when the water level is the same on both sides. One set opens to let the watercraft enter and then closes to allow the water level in the chamber to be raised or lowered depending on the direction of travel. The other set of gates then opens to let the boat leave. Raising or lowering from one pool level to the next is called a "lift".

The filling and emptying of the lock chamber is done by valves which control the flow of water through large, deep culverts in the lock walls. No pumping is necessary as the water flows through the culverts and into and out of the lock chamber entirely by gravity. The lock chamber never empties completely, but drops only as far as the pool level of the river downstream of the lock.

4.6.2 *Emergency and Upset Conditions*

Collisions with bridges

Convoys will need to navigate under two bridges – the Dona Ana railway bridge at Mutarara, and the new road bridge at Caia. The Caia bridge spans have a horizontal clearance of 137.5m and clear channel both above and below the bridge. This clearance is more than adequate for safe navigation and will pose no impediment to safe passage of 8 barge convoys.

The Dona Ana bridge, which was constructed in 1935, has spans which are approximately 70m apart. At the bridge, the river's current generally runs parallel along the north (Mutarara) bank of the river and at 90 degrees to the bridge spans. The main channel runs directly under the bridge and not at an angle. This will aid navigation as there should be no strong cross currents.

While the spans of the Dona Ana bridge are wide enough to enable the 8 barge convoys to pass in safety, RML will as a precaution, not run loaded 8 barge convoys under the bridge until sufficient experience has been gained and it is proven that it can be done safely. Initially, 4 barge convoys will be used in upper river. Additionally, moorings will be placed above and below the bridge to allow convoys to be fractured before passing under the bridge. Fracturing of the convoy will reduce the width from 35m to 17.5m thus providing greater clearance. Furthermore, navigation speeds will be reduced on approach to the bridges. For loaded convoys heading downstream, speeds will be reduced to about 2 knots above the current speed, down from 4 knots above current speed in the river away from bridges. This reduction in speed, as well as reducing the risk of any collision will reduce the impact energy to about 50% of its original value, therefore significantly reducing the potential damage should a collision occur. Should it be desirable to reduce the convoy speed under the bridge even further, this will be possible because the push boats will utilise Z-drive engine technology. This technology gives the push boats steerage control irrespective of the boat's speed through water. Unlike conventional rudder boats which require water to be flowing over the rudder to create steerage control, Z-drives steer by altering the direction of propellers. They have excellent steerage even when moving at the same speed as the current (or in reverse). Thus the convoys can navigate under the bridges at any speed that is deemed appropriate while remaining in full steerage control.

Riversdale is also investigating fendering systems that might be used to protect the bridge. Information on the bridge design is being sought and will be investigated. Discussions then will be held with relevant authorities.

The most likely type of collision with the bridge, should it occur, would be a glancing impact due to a convoy approaching the bridge on an angle. This could be caused by strong cross winds or currents, or pilot error. A glancing collision, unless at a very severe angle, would be unlikely to cause significant damage to either the convoy or bridge, particularly if the bridge is protected by fendering. The barges are strong being made of steel. They are also double hulled. Therefore, if a collision with a bridge or other hard object, such as a rock wall, were to occur, the steel outer shell would absorb the impact and abrasions. If the outer shell were ruptured, the intact inner shell would prevent water entering the inside of the barge. Likewise, push boats are double hulled.

A worst case accident would be a fully loaded 8 barge convoy striking a bridge pier head on. While an 8 barge convoy might weigh up to 25,000t, there are a number of mitigating factors which mean that the bridge is unlikely to receive the full impact implied by the gross weight of the convoy:

- Barges have raked bows, which would serve as an energy absorbing 'crimple zone' during a head on collision.

- The convoy is made up of a number of individual barges. If the impact were severe, ties between barges would tend to sever allowing barges to either crumple against one another, or break free (partially or wholly). Both actions would reduce the impact on the bridge.

Investigations will be carried out to ascertain fendering requirements for bridges.

Operation of the barge convoys would be the subject of a Navigation Management Plan. This plan would include, amongst other things, procedures such as fracturing and speed management at bridges to mitigate the risk of collision and damage potential.

Barge/ convoy capsizing

It is very unlikely that a barge would capsize in the Zambezi River or offshore. The barge has been designed to be stable for the carriage of coal on ocean voyages. The stability was checked based on IMO (IS) Code 4.7.3 – "Intact Stability Criteria for Pontoons (Barges)". Barges are designed to have adequate longitudinal strength for ocean voyages. The longitudinal strength criteria were developed based on "ABS Rules for Ocean Going Barges." With regard to river operations, at a length of 75m and width of 17.5m, the water in the river is simply too shallow to allow a barge to turn upside down in all but exceptional circumstances. Only in flood events, with a very strong current running, would it be conceivable to flip over a barge of this size and stability, especially while loaded with coal.

In the unlikely event that a full barge did fully turn over, the coal in that barge would fall into the river. In this process the barge would fill with water but would not sink. Due to the buoyancy from the double skinned compartments, the barge would float at a draft of approximately 3.3m and would be easily recovered.

It is extremely unlikely that an entire convoy could be over turned because the barges would separate rather than flip.

Grounding/ collisions of barges and dredgers

Grounding of barges can be expected to occur from time to time because the channel will be subject to infill and the river height can change quickly depending on releases from Cahora Bassa dam at any given time. Freeing of grounded barges will be straight forward in most circumstance. Firstly, grounding should not damage the barges as studies have shown that the river bottom is comprised of loosely compacted sand. In most instances, grounding will involve one or two barges, not the entire convoy. Typically the grounded barge would be one of the lead barges in a loaded convoy. The remainder would still be afloat. The pushboat itself will still be afloat because the barges always will be loaded to drafts greater than the pushboat (standard operating procedure).

Various operations can be undertaken to free a grounded barge. If the grounded barge cannot be freed by reversing power while the convoy is attached to the pushboat, the grounded barge would be uncoupled from the convoy and the floating barges moved to a nearby location where they can be temporarily secured, either by securing them to the shore or gently grounding them on a sandbank. The pushboat would return to the grounded barge. It would then back up to the barge and, using its z-drive motors, send jets of water under the barge to scour away the loose sand holding the barge. Once sufficient sand had been removed to free the barge, it would be pulled free and reattached to the rest of the convoy.

If the grounding were very severe such that a barge could not be freed by the push boat alone, various other steps could be taken. One option is to send a floating crane and empty barge to the site and remove sufficient coal to refloat the grounded barge.

If a pushboat became grounded, in most instances it would be able to free itself simply by directing jets of water from its motors to scour a channel and reverse out. If the pushboat damaged propellers or motors in the grounding incident and were unable to free itself, then it could call for assistance from other pushboats. It should be noted that the pushboats will have three (4500HP boats) and four (3600HP boats) propellers each independently powered, so the chances of all engines failing in a single incident are low.

The likelihood of a collision between barges and dredgers undertaking maintenance of the channel is considered negligible. The barge convoys and the dredgers would be in regular radio contact so that the respective positions of all waterborne traffic in the RML fleet would be known. In addition, all vessels would be appropriately lit at night. The convoys would need to wait for maintenance dredging plant to complete dredging should the channel infill sufficiently to be an impediment to safe passage. However where maintenance dredging was being conducted for the purpose of deepening a still navigable section, the dredging plant would temporarily relocate from the channel to allow the convoy to pass.

At all times, dredging fuel barges would be moored well away from the navigable channel.

Complete loss of fuel from dredger and fuel barges.

Diesel fuel will be transported from Beira to Chinde in marine certified double hulled flat top barges with a capacity of 20,000 barrels, or approximately 2,400 cubic metres. They will have a number (4 to 6) of separate compartments. Fuel at Benga will either be supplied from the mine's own supplies or by barge. Fuel supply arrangements for Benga are not finalised. Approval is sought under this ESIA for supply by barge.

Fuel barges would be towed from Beira to Chinde by ocean going tugs. For fuel destined for Benga, the fuel barge would be attached to a push boat at Chinde for the trip up river. Prior to the journey to Benga, some of the fuel would be transferred to a floating fuel barge at Chinde. In addition to supplying Chinde's needs, this would enable the fuel flat to reduce its draft prior to the journey up river.

In the event of an accident on the trip from Chinde to Benga loadout, various actions could be undertaken depending on the nature and severity of the accident. The fuel barges will be strong and will not rupture easily. The worst case would be a rupturing of the double hull of the fuel barge by, for example, collision with an unmapped under water rock pinnacle, or a severe collision with a rock at Lupata Gorge. Given the low speeds involved (maximum up-river speed over ground of 5 to 6 knots) and taking into account the double steel hull, it is unlikely that a collision would cause a large enough rupture to enable all the diesel to escape in a short period of time. A more likely scenario is that a rupture would result in a slow leak from one of the compartments.

All push boats will be equipped with oil spill containment kits. However, these will only be effective for containing small or single event spills. The kits will not be capable of containing an ongoing leak, especially if it occurs in a rapid current. Diesel escaping the containment curtains would, however, tends to disperse quickly given the nature of the current.
If a significant rupture did occur, various actions could be taken. One action could be to pump the diesel into either another compartment (if undamaged and is not completely full) or another barge. This action would reduce the volume of diesel that could leak into the river. In an emergency, the diesel could be transferred into an empty coal barge. If the rupture were in the bottom of the barge, another possible action would be to ground the fuel barge onto a sand bank to slow the rate of leakage while fuel is removed.

Dredging will be carried out by third party contractors, not by RML directly, but will be under the management of RML. These contractors will supply the equipment so details cannot be specified in this report. The following discussion is based on common practice in the industry. The situation might vary depending on the contractor selected and the equipment they will use.

For most of the time, dredgers will be stationary or moving at very slow speeds. For fuel tanks to be ruptured, the dredger would need to collide with a vessel or alternatively be let loose from its moorings – eg in a major flood.

Dredgers will carry fuel in separate tanks. The dredgers to be used on the Zambezi River are likely to be mostly small to medium sized cutter suction dredgers with fuel carrying capacities of 13 cubic metres each, or 52 cubic metres in total. These dredgers will be serviced by on site fuel barges which will be resupplied by the RML's larger fuel flat barge. The dredgers' fuel barges will be anchored close to the dredgers and their movement will be minimal. Fuel in the dredger barge typically will be 500 cubic meter capacity, with the fuel stored in 4 separate tanks. These fuel barges will be constructed of heavy wall plating with corners double plated.

In the event of a rupture, it is likely that only one tank would be affected. In addition to deploying spill containment curtains, action would quickly commence to pump fuel from the leaking tank to other tanks, or even to dredgers, provided the fuel being pumped was not contaminated by river water. If there was insufficient storage capacity on site (eg the fuel barges other tanks were full) then empty coal barges could be quickly brought in by RML to act as an emergency holding tank.

Safety and environmental protection practices and procedures will be developed with the dredging contractors. The contractor Environmental Management Plan (EMP) would need to be approved by RML prior to commencement of dredging.

4.6.3 Climate Change

Studies recording and further investigating climate change in Southern Africa are ongoing. At this point the general consensus is that temperatures in Southern Africa will rise by 0.2^{0}C per decade up to 2050. By 2050 precipitation is expected to decrease by about 10 percent (UNEP, http://www.grida.no/publications/other/aeo/, viewed on 12 January 2011). Sea level rise depends on ocean currents, atmospheric pressure, and natural land movements at specific locations, but the accepted average sea level rise for Africa is 25cm by 2050.

Climate change on African water systems will be affected through changes in the hydrological cycle, the balance of temperature, and rainfall. According to the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Regional Impacts of Climate Change (2001), the Zambezi basin has a low runoff efficiency and a high dryness index, indicating a fair sensitivity to climate change. In addition, the report also states that the Zambezi basin is particularly sensitive to climate warming, resulting in the runoff decreasing in the basin even when precipitation increases. This is due to the large role played by evaporation.

The Zambezi River has the worst scenario in Southern Africa with projected decrease in precipitation of about 15%, increased potential evaporative losses, 15-25%, and diminished runoff, about 30-40%. Concomitantly, increases in the frequency and intensity of flooding and drought will be expected (IPCC Third

Assessment Report, 2001). The seasonal pattern of rainfall is expected to remain unchanged.

What this means is that by 2050, the Zambezi River may experience considerable changes with associated implications for hydropower generation, agriculture, and fish production (IPCC, 2001). Preparing for and adapting to climate change in the Zambezi basin depends on better planning of water projects and strategic inter-country partnerships to support integrated basin management. The reduced runoff has the potential to the operation of the Cahora Bassa dam, which in turn could affect the proposed Project. Thus ongoing communications between Riversdale and Cahora Bassa is critical to develop adaption strategies.

4.7 PROJECT ALTERNATIVES

Alternatives refer to alternative routes, site alternatives, technology alternatives or process alternatives.

4.7.1 Route Alternatives

RML will be transporting coal via the Sena Railway and intends to be involved in transporting coal via the proposed Nacala Corridor in the future. Given the large coal resources in the area and given that other mining companies also need to transport coal, *all* three routes are likely to be utilised by RML to ensure that they are able to optimise the export potential from their current and future mining operations. Thus the three routes are complementary and not alternative options. However, it should be noted that a primary factor behind RML's desire to barge coal down the Zambezi River is that there is insufficient rail capacity available or likely to be available in the foreseeable future to meet the needs of coal producers and aspiring coal producers in the Moatize coal basin.

Looking at the river as a corridor, alternative alignments were considered within the corridor. RML selected alignment for the navigable channel by utilising as much of the thalweg (the naturally deeper channel within the river active channel) as possible, and dredging to link up the deep channels. This reduces the amount of dredging required. This results in a naturally sinuous navigable channel. The alternative of dredging a straight navigable channel would result in excessive dredging leading to high costs and extensive modification to the river system. Therefore this alternative was screened out and not assessed further.

4.7.2 Layout Alternatives

Alternative layouts that will be considered relate to the layouts of the land-based support facilities at Chinde and Benga.

The land based layouts illustrated in *Figure 4.5* to *Figure 4.8* above are the culmination of a process of refining and amending the layout to the point that potential impacts are minimised. For example, the original plan of the land-based support facilities on the north bank at Chinde. As a result of further investigation and input from the ESIA team the plan was refined, moving the facility footprints northwards and primarily off the mangroves. Similarly, based on feedback from Chinde communities and the ESIA team, Riversdale is likely to place some facilities like offices and accommodation close to Chinde town, providing a source of local employment. At the Benga loadout point the land based facilities were modified to move further away from the Fabachana property thus minimising potential noise impacts and other disturbances.

4.7.3 *Technology Alternatives*

With respect to technology alternatives, different technologies for dredging (different types of dredgers), different technologies for barge design (which is informed by channel depth and river/ marine conditions) and different technologies for transloader equipment (specifically the design of the coal grabs) will be considered.

Barging technology, comprising pushboats and unpowered 2,500t capacity barges was selected after review of various alternatives. The main determining factor was the need to navigate a shallow and twisting river while also being scalable, able to handle a sufficiently large payload and capable of making ocean voyages to a transloader.

The two main alternatives considered were self powered barges and the pushboat-style system that was ultimately selected. Other systems which involve the towing of barges behind a tug boat were ruled out because the river current is too strong for this type of operation. Self powered barges are common in many parts of the world but are less suitable for shallow river systems than pushboats. An advantage of a pushboat operation is that it is very flexible. For example, convoys can vary from 2 barges to 8, depending on conditions. Having selected a pushboat system, attention turned to designing boats and barges. These were designed by leading marine architect, Robert Allen Ltd based in Vancouver Canada. A feature of the boat design is the use of z-drive propulsion, rather than conventional fixed propeller/rudder combination. An advantage of Z-drives is that they deliver excellent steerage control even when the boat is moving slowly or, indeed, stationary, whereas conventional rudder systems require the boat to be moving for steerage.

Transloading will be undertaken by a third party contractor yet to be selected. Different transloader companies will have differing technologies and approaches. RML favours utilising a transloader with at least 60,000t of floating storage capacity because it requires a buffer stock at the Chinde end. Different transloader companies may offer alternative designs, but RML will likely require that the transloader have at least 60,000t of floating storage capacity. While specific design details will be the responsibility of the transloader contractor, these will need to meet acceptable environmental standards, and the Environmental Management Plan will need to be approved by RML before operations commence. It is anticipated, for example, that the transloader barge unloading system will be by way of grabs guards to contain any spillages.

Options to improve safety and environmental protection practices and procedures will be developed with the dredging contractors. The contractor Environmental Management Plan (EMP) would need to be approved by RML prior to commencement of dredging.

4.7.4 Process Alternatives

No process alternatives are relevant for this Project.

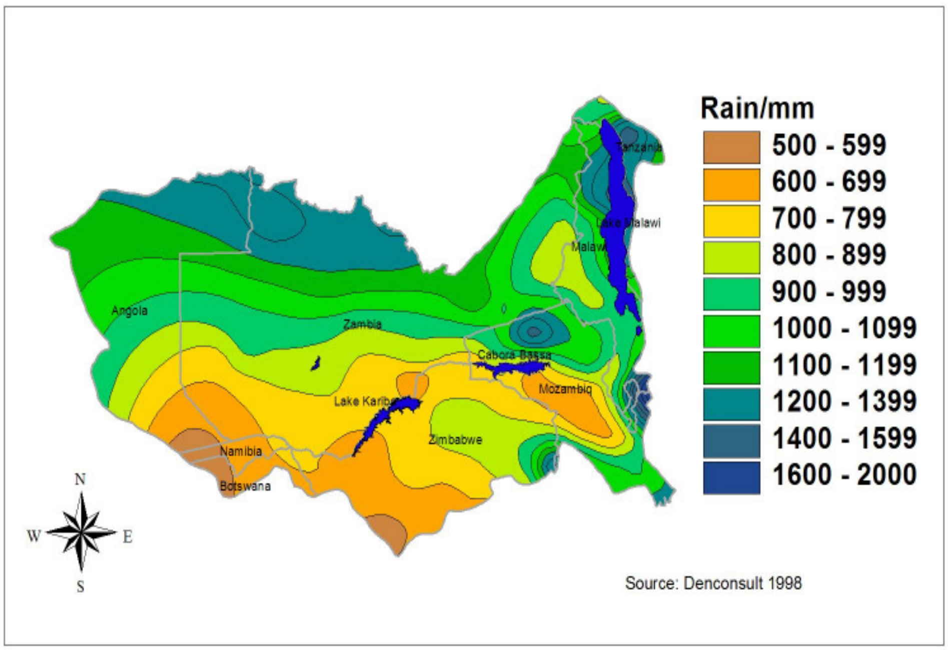
4.7.5 No Go Alternative

All assessments are made against current baseline conditions ie against the "no go". Thus should this project not go ahead, the identified positive and negative impacts will not materialise and the status quo will continue.

5.1 CLIMATE

The Zambezi basin has three distinct seasons; cool and dry (April to August), warm and dry (September to October), and warm and wet (November to March). The basin precipitation centres on a pronounced rain season, which extends from October to April. Monthly rainfall increases from November to reach a maximum in January, decreasing until it ends in April. The average rainfall for the entire basin is approximately 970mm, but varies considerably across the catchment itself. The northern parts of the basin (Malawi, Tanzania, north and north-western Zambia) have an average annual rainfall of 1,200mm, while the southern and south-western parts average around 700 mm. *Figure 5.1* illustrates these variations.

Figure 5.1 Mean Annual Rainfall for the Zambezi basin



Source: Denconsult sector study, 1998

These seasonal and spatial variations in rainfall and evaporation lead to complex runoff patterns, with the annual volumes of runoff being relatively small.

The lower Zambezi valley, where the Project will take place, is influenced by several factors, such as maritime air, anti-cyclonic activity over the Indian Ocean and the annual movement of the Inter Tropical Convergence Zone. The climate is further influenced by topography where in mountainous terrain the temperature is lower and rainfall higher.

The hot and rainy summer season lasts from November to March/April and the moderately warm and dry winter season from May to August. In the summer, the winds are predominantly north-westerly and in winter south-easterly (SWECO/SWEDPOWER, 1982).

The annual average temperature is approximately 26ºC in the entire lowland area from Lupata to the sea. Temperatures above 40ºC have been recorded between September and January and above 45ºC in October and November. The lowest temperature, 2.5ºC was recorded in Mutarara in June – July (SWECO/SWEDPOWER, 1982). The mean annual rainfall over the Zambezi Delta region is between 1000 and 1200mm, at Vila Fontes 987, at Mutarara 711 and at Tete, 643mm (SWECO/SWEDPOWER, 1982).

5.2 *WEATHER SYSTEMS*

The mean occurrence of cyclones in the Mozambique Channel is just over three per annum [(1)], primarily between January and March. Between 1993 and 2004, twenty-nine cyclones occurred along the Mozambican coast, as listed in *Table 5.1* below. The area under study is not a high occurrence area for cyclones, between 4 and 8 cyclones have been recorded in the past 75 years (*Figure 5.2*), and their paths did not reach the study area, with the coastline being more affected (*Figure 5.3*).

Table 5.1 Cyclones reaching the Mozambican Coast 1993 to 2007

Cyclone Season	Tropical Cyclone
1993/94	Daisy, Geralda, Julita and Nádia
1994/95	Fodah and Josta
1995/96	Bonita and Doloresse
1996/97	Fabriola, Gretelle, Josie and Lisette
1997/98	A19798 and Beltane
1998/99	Alda and D19899
1999/00	Astride, Eline, Glória, Hudah and 1319992000
2000/01	Dera
2001/02	Cyprien and Atang
2002/03	Delfina and Japhet
2003/04	Cela, Elita and Gafilo
2006/7	Favio

Source: Mozambican National Institute of Meteorology (INAM) 2008

(1) Tinley, 1971

Figure 5.2 Frequency of cyclones that hit the Southern African Zone in the Last 75 Years

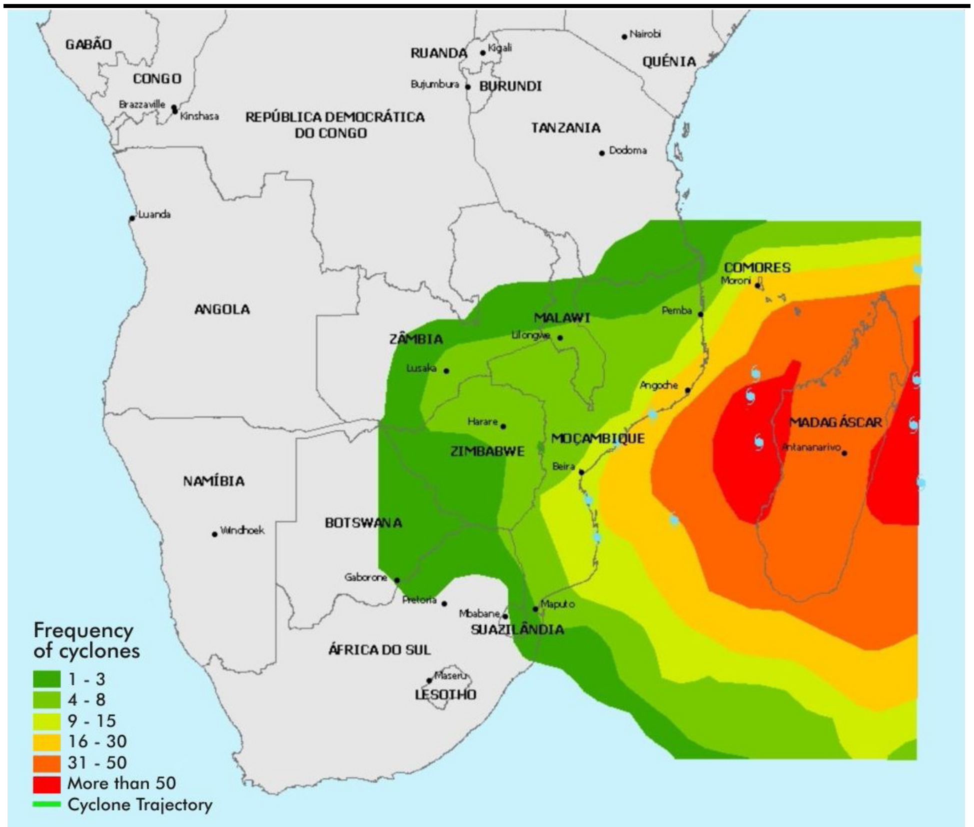
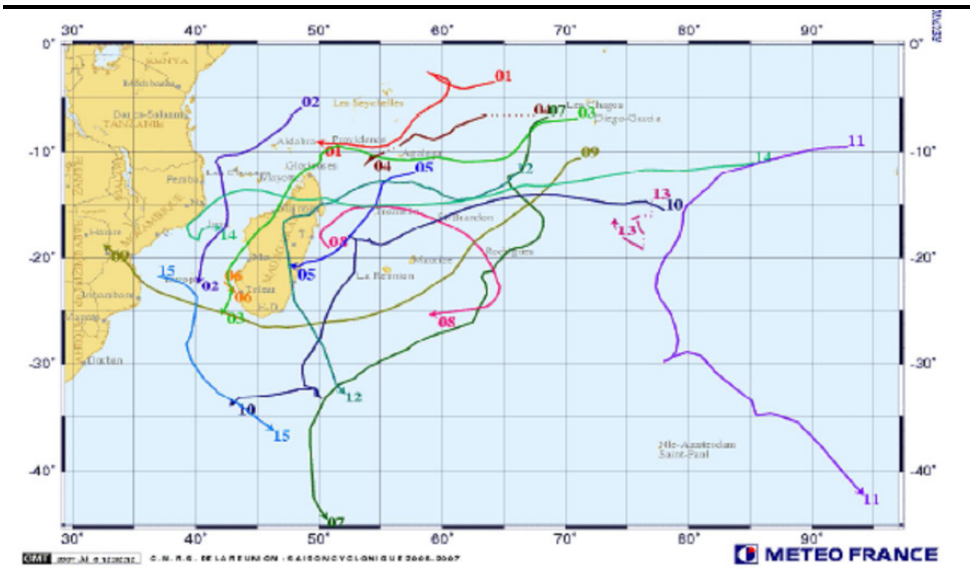


Figure 5.3 2006/2007 cyclone season – Complete Trajectories (from Meteo France)



5.3 *PHYSICAL OCEANOGRAPHY*

Information for this section has been sourced from Impacto and CSA International (2006) and various other reports and publications on the oceanography of the study area.

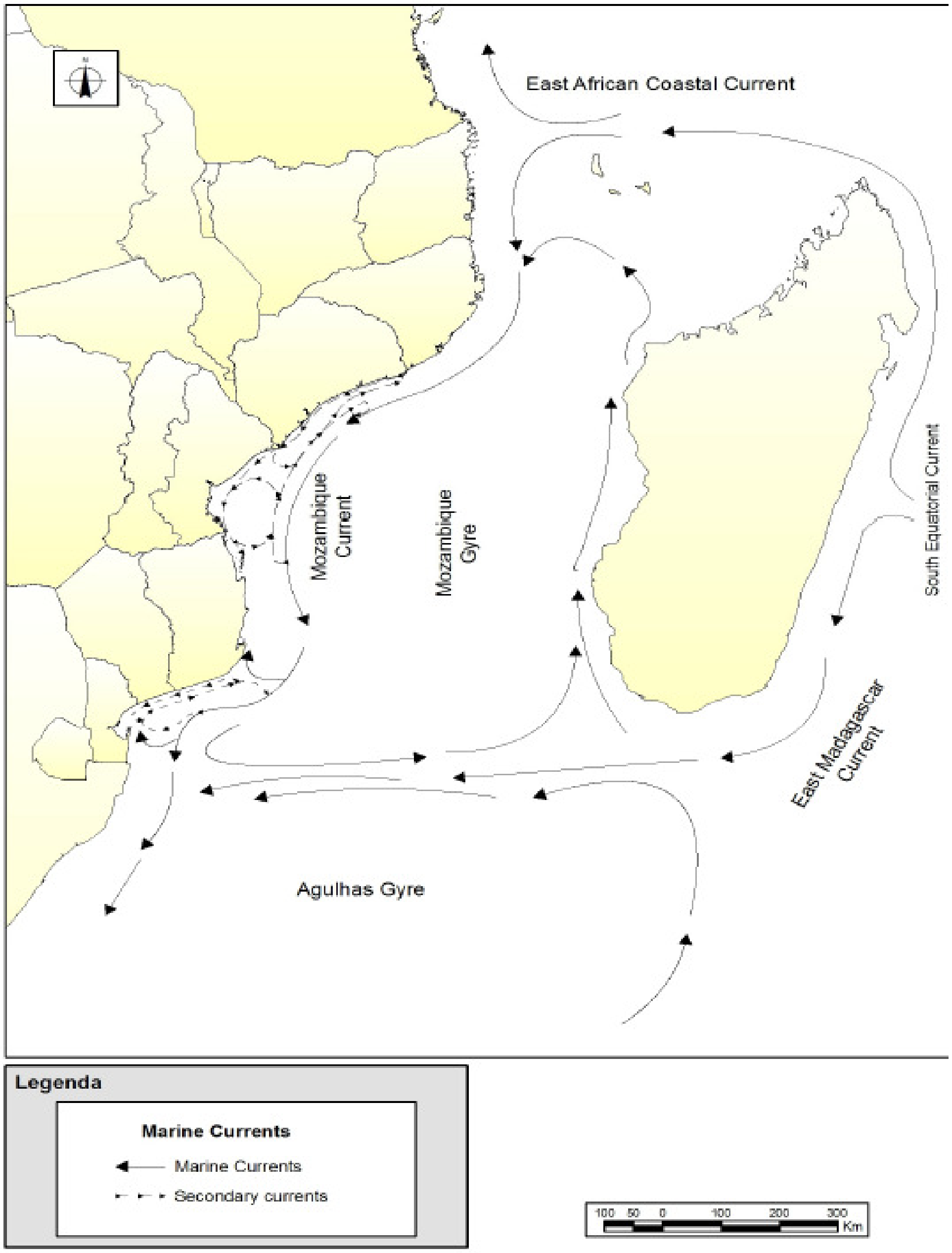
Currents

The Indian Ocean contains a large gyre of water, known as the South Equatorial Current (SEC), which circulates anticlockwise, driven by the winds (*Figure 5.4)*. This equatorial water mass flows westward across the Indian Ocean and then splits when it reaches the eastern portion of Madagascar. Here, the SEC splits into the East Madagascar Current (EMC) flowing southward, and a northern branch flowing to Cape Amber, the northern point of Madagascar, and then towards the coast of Africa, where it branches again into northward and southward flows. This northward flow becomes the East African Coastal Current, while the southward flow becomes the Mozambique Current.

Data from the World Ocean Circulation Experiment (WOCE) Hydrographic Program (WHP) indicates a southward transport above 2500 m depth of 29.1 and 5.9 SV (1) at lines 12 and 14. According to the Western Boundary Current (WBC) model (2), the southward flow through the Mozambican Channel does not appear to be a continuous flow, but as several large cyclonic and anti-cyclonic eddies of approximately 300km in diameter (3). The narrowest part of the Mozambique Channel (approximately 17 ºS) flows southward at approximately $1 m.s^{-1}$ on the western side of the channel (4). The flow within the Mozambican Channel is greatest within the 0 – 200m surface layer and decreases to $0.5 m.s^{-1}$ at 500m below surface.

(1) 1 SV is equivalent to $1x10^6$ $m^3.s^{-1}$
(2) Di Marco et al (2002)
(3) Saetre and da Silva (1982, 1989) and de Ruijter et al, (2002)
(4) Rinderinkhof et al (2003)

Figure 5.4 Circulation Patterns in the Mozambican Channel



Source: Impacto and CSA International Final EIA Report (2006)

5.4 SOILS

The main soil types in the study area are alluvial, which vary in texture from fine clay to coarse sands. The largest continuous alluvial deposits are to be found in the Rift Valley, particularly north of the Zambezi on the Inhangoma Island and along the Shire River. South of the Zambezi, the alluvial deposits continue to the coast near Beira.

Fine textured clay soils cover the depressed, broad plains, while coarser material is found adjacent to large rivers on levees and in river channels.

Vertisols develop in materials composed mainly of finer particles. Most of the soils exhibit hydromorphy.

5.5 BROAD VEGETATION TYPES IN THE ZAMBEZI BASIN FROM TETE TO CHINDE

This section is intended to provide a high-level overview of vegetation types in the Zambezi basin from Tete to Chinde. More detail on riparian and delta habitats and vegetation can be found in the relevant sections below (*Sections 5.7 and 5.8*)At a broad level, 5 vegetation types can be mapped[1] in the Project area, as shown in *Figure 5.5* below. The Mapping Units are based mainly on Wild & Barbosa (1967). These are:

- Dry tree savanna – Moist grassland – Fringing forest – Aquatic flora mosaic of big river alluviums and deltas (lowland, sublittoral).
- Dry early deciduous shrub savanna (Lowland).
- Dry early deciduous savanna Woodland (Lowland).
- Deciduous savanna Woodland.
- Littoral thicket and forest of recent dunes.

5.5.1 *Dry tree savanna-Moist grassland – Fringing forest – Aquatic flora mosaic of big river alluviums and deltas (lowland, sublittoral)*

This type of vegetation is an important coastal formation in Mozambique. The areas with this type of vegetation are mainly periodically flooded, poorly drained plains with extensive grasslands, interspersed with some slightly higher, well-drained areas. A dry savanna, with scattered trees and shrubs, occurs on the well drained areas.

This is mapped as a single unit although two main sub-units can be distinguished viz., (a) the seasonally inundated Gorongosa Tandos that links the Zambezi valley with the Pungwe System in the south via the Rift Valley, and (b) the seasonally inundated grasslands of the lower Pungwe/Buzi floodplains and estuary.

5.5.2 *Dry early deciduous shrub savanna (Lowland)*

This type occurs in a significant area of the Zambezi valley. The most common species are *Pterocarpus brenanii, Diplorhynchus condylocarpon, Combretum ghasalense, Diospyros kirkii, Terminalia sericea, Sclerocarya caffra, Acacia nigrescens, Colophospermum mopane (shrubby), Julbernardia globiflora, Combretum imberbe, Dalbergia melanoxylon, Bauhinia tomentosa, Cordyla africana*, and *Sterculia quinqueloba*.

(1) [1] There are many other vegetation types or habitats that occur within the overall broad vegetation types; these cannot be mapped at this scale but where relevant are highlighted in the text.

5.5.3 Dry early deciduous savanna Woodland (Lowland)

This type of vegetation covers large areas in the Zambezi valley, where the *Colophospermum mopane* savanna woodland is usually medium or tall (10-15m). The vegetation is almost solely *Colophospermum mopane* savanna woodland but also has some *Adansonia digitata*.

Mopane savanna woodland often grades into *Julbernardia globiflora* savanna woodland in drier areas with poorer well drained soils and into the *Adansonia, Sterculia* savanna domain. On the banks of the Zambezi River, the mopane is often replaced by *Ziziphus mauririana, Diospyrus mespiliformis* and sometimes *Berchemia discolor.*

5.5.4 Deciduous Miombo savanna Woodland

This type of vegetation is confined to the Zambézia Province, appearing in transitional soils from ferralitic to the lower lying grey soils of the granite or gneiss complex. It can be considered a mosaic of different miombos sometimes dominated by *Brachystegia spiciformis* or by B. *boehmii* or even *Julbernardia globiflora*, with influences from the *Acacia-Combretum* communities and also from the lowland and sublittoral zones.

5.5.5 Littoral thicket and forest of recent dunes

This is a vegetation type of recent dunes of juvenile soils from sands of Aeolian origin. In the central littoral of Mozambique, the commonest shrub species are *Sideroxylon inerme, Mimusops caffra, Carissa bispinosa, Salacia madagascariensis, Hugonia elliptica, Todallia asiatica, Maclura Africana, Canavalia gladiata, Xylopia holtzii, Landolphia petersiana and Hippocratea* sp.

There are nine main factors that have affected changes in vegetation in and around the Zambezi Delta over the last 100 years. The list indicates that flooding regimes and overall hydrology are not the only factors influencing change on the delta, although they are perhaps the most significant that have changed over the last 45 years:

- Increased dry season base-flows owing to power generation from upstream dams.
- Reduced flooding (both in incidence and extent) after the construction of Kariba and Cahora Bassa dams.
- Construction of bunds across distributary channels (especially on the south bank) in the 1920s to control flooding.
- Construction of sugar estates and concomitant changes in land drainage in the 1920s and onward.

- Introduction of cattle and peripheral "terrestrial" human settlements (compared to previous primarily river-fringing settlement) following on from development of the sugar estates.

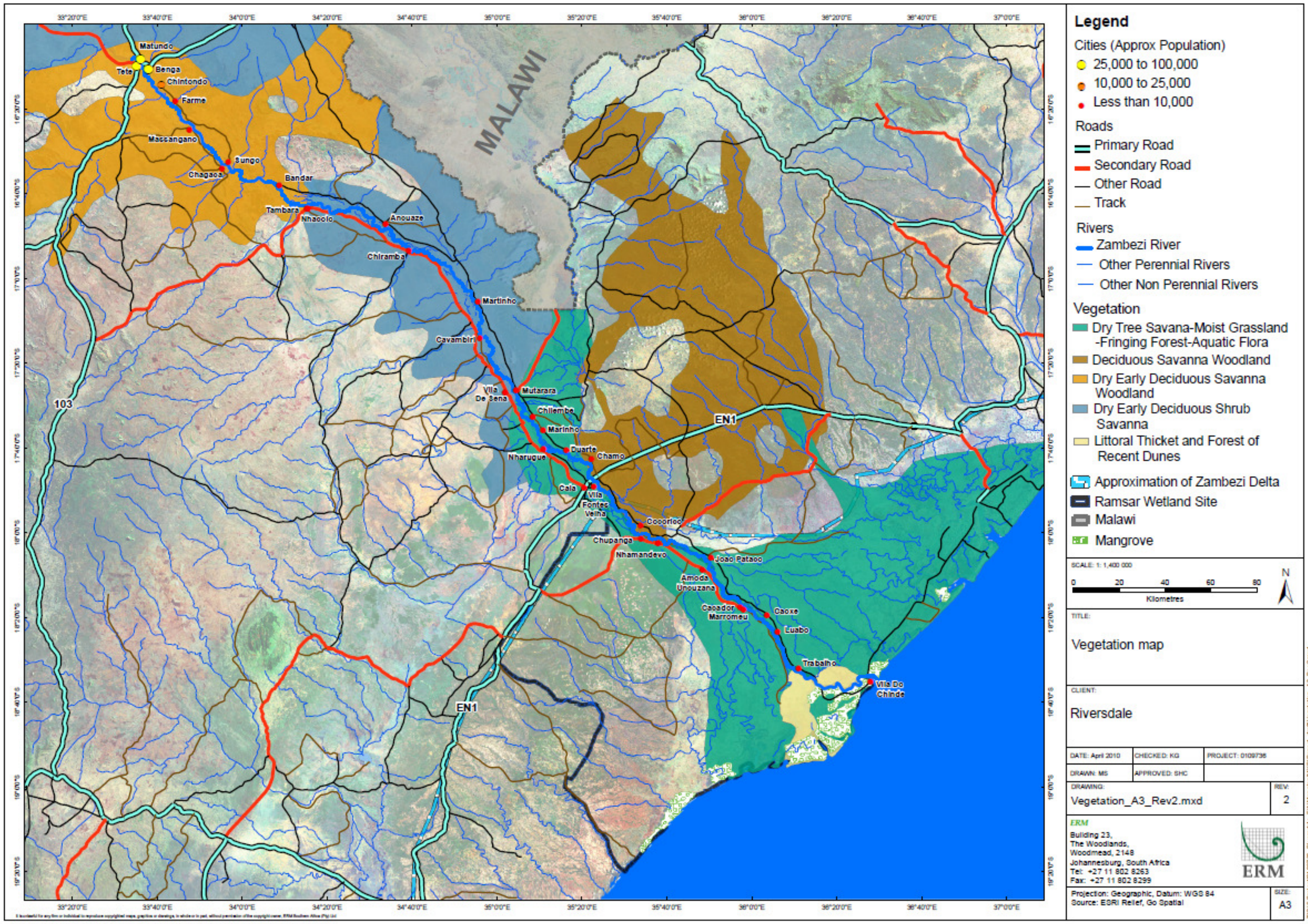
- Introduction of aquatic water weeds and their subsequent spread.

- The reduction in large herbivore grazers (elephant, buffalo, zebra, hippo) soon after the establishment of sugar plantations through meat-hunting, and again at the end of the civil war in the early 1990s. Conversely, it could be said that the great increase in large herbivore numbers during the 1970-1980s was the significant factor.

- The activities of the logging industry on the Cheringoma plateau, especially in the 1950-1960s, and perhaps again now, which included tree felling, local clearance and road construction.

- Changes in the timing and frequency of burning regime of the grasslands, with the increased frequency of fire being arguably to more important of the two.

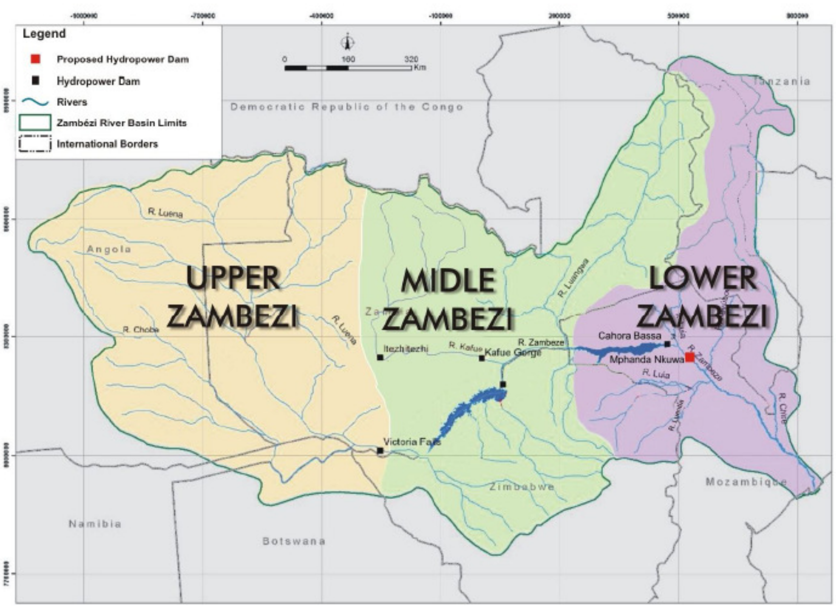
Figure 5.5 Main vegetation types along the Zambezi River



5.6 *PHYSICAL CHARACTERISTICS OF THE ZAMBEZI RIVER SYSTEM*

The Zambezi River is divided into three geographically distinct sections with differing physical characteristics. The section extending between river source and Victoria Falls is called the Upper Zambezi, the stretch from Victoria Falls to Cahora Bassa Dam is the Middle Zambezi, and the remaining section is referred to as the Lower Zambezi (see *Figure 5.6)*

Figure 5.6 Zambezi River Basin



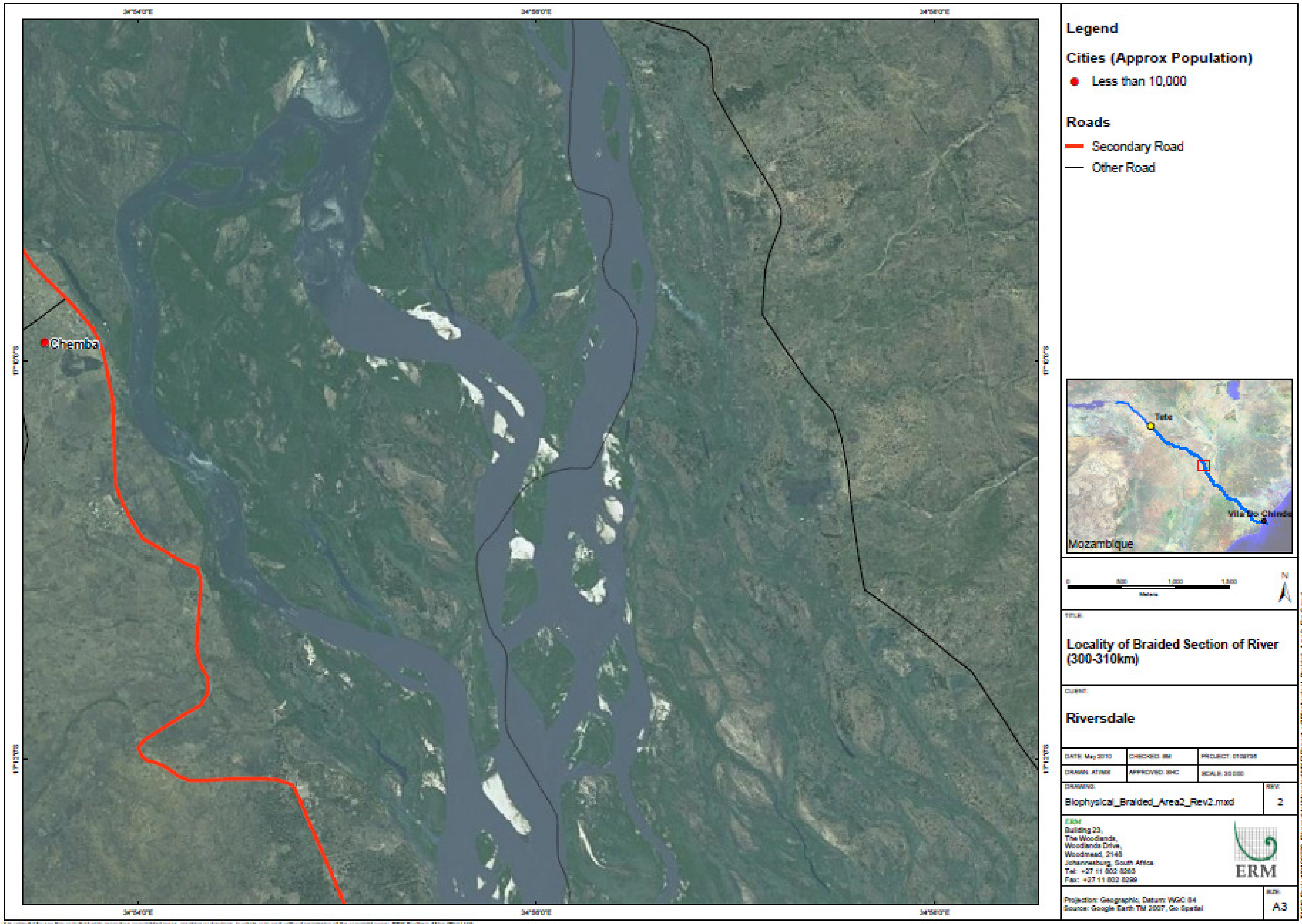
The Zambezi River is recognized as one of the largest and most important in southern Africa. Its basin is the fourth largest river basin of Africa, after the Congo/Zaire, Nile, and Niger. The area drained by the Zambezi River has been estimated at between 1,193,500 and 1,570,000 km^2 (Davies 1986). The catchment encompasses eight countries, all of which fall within the Southern African Development Community (SADC). These include Angola, Botswana, Namibia, Malawi, Mozambique, Tanzania, Zambia and Zimbabwe, The Zambezi is thus one of Southern Africa's most important natural resource systems.

The Zambezi River originates northwest of Zambia at an elevation of around 1,555m and flows over a distance of 2,650km through Angola, Botswana, Zimbabwe and finally Mozambique, where it empties into the Indian Ocean. The Zambezi basin falls within the tropical African region, lying between latitudes 10º and 20º S and longitudes 20º and 37º E (FAO, 1997).

After its confluence with the Kafue, downstream of the Kariba Dam, the Zambezi continues through a flat flood plain area before entering Mozambique and the Cahora Bassa Dam, which was created in 1974. The Zambezi then flows southeast and receives water from its last great tributary, the Shire, which drains Lake Malawi (also called Lake Nyasa) about 450 km to the north. The northern part of Lake Malawi forms the border between Tanzania and Malawi, while the southern part forms the border between Mozambique and Malawi. At the Zambezi-Shire confluence, the waters of the two rivers support extensive flood plains extending to the Indian Ocean (FAO, 1997).

For the last 350km the river is characterized by a heavily braided channel with ill-defined banks entering into the delta. The Zambezi River moves large volumes of sediment. Where water slows sediment is deposited. Deposited sediment, in turn slows water down further enabling further deposition of sediment. This creates islands or braided areas in the river channel (please see *Figure 5.7* for an example of a braided stream/island). Braided areas and islands create habitats, thus promoting biodiversity. Waterfowl are known to frequent islands and fish may use braided streams for nurseries or for shelter.

Figure 5.7 Example of a Braided Stream



The Zambezi River displays a seasonal pattern with high flows observed during the wet summer months of January to April. Historic flow cycles have been attenuated by the construction of Cahora Bassa Dam. Peak flows are usually recorded in February or March. Average annual run-off recorded upstream at Cahora Bassa Dam is estimated at 76.9 x $10^9 m^3$. It should be noted however that the annual runoff can vary from less than half the mean in some years to more than double the mean annual discharge in others. While average discharge is 2,440 m^3/s it can range from as little as 250m^3/s to flows in excess of 18,000 m^3/s. It has also been suggested that there are long term cyclical changes in discharge with the 10-year running mean increasing from early last century, peaking in 1960 and now displaying a decline (UTIP, 2001, cited in Impacto, 2003).

At a water flow of about 2,000 m^3/s the river depth ranges from 1 to 11m. Average depth is 3-4m (SWECO/SWEDPOWER, 1982).

From Benga to Lupata Gorge, the channel is shallow in parts, 1.4m to 2.5m deep. At the Lupata Gorge, the channel is usually about 600m wide, but the narrowest width is 300m. Depths are usually between 3m to 17m deep but shallow depths of less than 2.5m have been recorded. From the Dona Ana Bridge to Inhacamba Island, the river is flat, wide and relatively deep benefiting from the Shire River flow. Finally, from Inhacamba Island to Chinde, there is a naturally defined, relatively deep channel through to the river mouth.

5.6.1 Zambezi River Aquifers

Extensive primary aquifers are associated with the alluvial deposits of the Zambezi River system. These aquifers are in direct hydraulic continuity with the river. The groundwater potential of alluvial aquifers is controlled by the saturated thickness, grain size and extent of the alluvial deposit.

The alluvial aquifers were developed as a result of the deposition of sediment during flooding, in combination with changes in river flow pattern. The flood cycle typically deposits a succession of sand, gravel and silt, following a downstream trend.

The alluvial aquifers (primary aquifers) occur along the river course, with a general thickness of 7-20m, but may exceed 35m in places. Transmissivities of these aquifers are high (4,500m^2/day), indicating fast groundwater movement through the sediment (*Golder Associates, July 2009*).

Primary aquifers cover an extensive area along the Zambezi River and have the potential to supply water between 50L/s and 300L/s. Pumping from these boreholes is sustainable throughout the year (*Golder Associates, July 2009*) and yields are minimally affected by seasonal variations in the river level/flow.

Aquifer Quality

Water sampled from the alluvial aquifer near the Benga loading point has a Ca-HCO_3 characteristic and is associated with good quality and recently recharged water (*Golder Associates, July 2009*).

5.6.2 Hydrology

The natural hydrology is relevant to aquatic invertebrates because their life histories are expected to have evolved to cope with the natural variation in flows and associated sediment loads. Before the construction of large dams (ie Kariba and Cahora Bassa), the river within the Study Area had three distinct phases:

- dry period for five months (June to October), during which flows within the Study Area typically dropped to about 600 m^3/s (Rountree pers comm.)'
- "Gumura", a flood peak in February, which carried turbid, local runoff, and;
- "Murorwe", a larger flood peak in April, which carried cleaner runoff from the upper catchment (Davies 1986).

The present-day hydrology is controlled mainly by releases from Cahora Bassa Dam. The main changes from natural hydrology include significantly increased low-flows (2,000 to 3,000 m^3/s), reduced high flows (flooding), reduced seasonal variability, and reduced sediment inputs (Davies, Beilfuss, & Thoms, 2000) Beilfuss and dos Santos 2001).

5.6.3 Turbidity and Water Quality

Baseline conditions for turbidity have been obtained from Siddorn *et al. (2001*) and Basson (2006) and via ongoing investigation by Worley Parsons (2010a). The main contribution to the turbidity at Chinde is the suspended sediment from the upper reaches of the Zambezi River (Basson, 2006). Baseline values for turbidity are tabulated below.

Table 5.2 Turbidity measured for the Zambezi River

Reference	**Value [mg/l]**	**Location**
Basson (2006)	10,000	Tete
Siddorn *et al. (2001)*	450	Offshore of Chinde

Water Quality sampling was undertaken by Worley Parsons in August and in November 2010. Field parameters were measured at 38 surface water sampling points along the study area of the Zambezi River. The following parameters were measured in the field:

- Temperature;

- Oxidation Reduction Potential (ORP);
- pH;
- Electric Conductivity (EC);
- Dissolved Oxygen (DO);
- Total Dissolved Solids (TDS);
- Salinity; and
- Turbidity.

Table 5.3 below represents the results of the water quality sampling exercise. In the absence of specific guidelines for Mozambique, the World Health Organization (WHO) guidelines for drinking water have been applied. Concerning additional water uses, the results have also been screened with South African standards (DWAF 2006) for irrigation and livestock.

WHO guideline values were available for the parameters pH, EC and TDS. DWAF irrigation guideline values were available for pH and TDS and DWAF livestock guidelines for TDS.

At sampling location SSMP (Mooring Points at Chinde) EC was measured 7514µS/cm and TDS at 4,884mg/L. Measured EC and TDS at location SS_RM (Chinde River Mouth) were of 21,420µS/cm and 13,920mg/L respectively. These measurements exceed the WHO guideline values for EC and TDS (2,500µS/cm and 600 – 1,000mg/L respectively). This is understandable as the two sampling points at or near the the river mouth and subject to marine influence. In addition the DWAF guideline values for irrigation (40mg/L) and livestock (1,000mg/L) were also exceeded at these two sampling points for TDS.

Table 5.3 Results of sediment sampling test along the study reaches of the Zambezi River (Worley Parsons, 2010)

			Sampling Location (SS/ VC)	Water Quality Parameters									
				Depth	Temp	ORP	pH	EC	DO		TDS	Salinity	Turbidity
				m	°C	mV	units	µS/cm	mg/L	%	mg/L	ppt	NTU
WHO		Drinking Water					6.5 - 9.5	2500			600 - 1000		
RSA	DWAF, 1996	Irrigation					6.5 - 8.5				40		
RSA	DWAF, 1996	Livestock									1000		
			SS1	0.10	25.10	151.80	7.63	117	8.05	11.60	76	0.05	5.80
			SS2	0.10	26.10	142.50	8.13	107	8.14	103.70	69	0.05	0.06
			VC2	0.10	26.10	142.50	8.13	107	8.14	103.70	69	0.05	0.06
			VC3/SS3	0.10	26.40	146.10	8.02	113	9.02	113.00	73	0.05	0.00
			SS4	0.10	26.60	158.90	8.36	116	8.93	106.40	76	0.05	2.40
			VC6/SS6	0.40	23.53	182.60	8.15	103	7.77	97.00	69	0.05	14.07
			SS7	0.55	22.50	141.50	8.20	101	8.70	102.00	68	0.05	9.10
			VC7	0.10	27.70	91.30	8.59	81	8.31	114.60	51	0.03	0.90
			VC8/ SS8	0.40	24.33	126.73	8.36	121	8.49	103.00	80	0.06	9.23
			VC9	0.10	27.30	163.20	8.62	115	8.07	102.54	74	0.05	16.20
			VC10	0.10	27.90	150.50	8.69	117	8.29	106.30	76	0.05	12.60
			VC11	0.10	28.40	140.50	8.72	116	8.37	104.50	76	0.05	15.10
			VC12	0.10	26.20	16.96	8.42	121	7.84	98.37	79	0.06	33.60
			VC13/SS13	0.10	26.90	131.50	8.55	121	7.58	94.90	79	0.06	17.20
			VC14	0.10	27.80	112.40	8.67	123	7.96	100.70	79	0.06	34.70
			VC15	0.10	28.40	113.50	8.69	125	8.14	105.70	81	0.06	24.30
			VC16/SS16	0.10	27.20	100.70	8.54	97	7.62	97.10	78	0.06	20.20
			VC17	0.10	28.30	144.70	8.59	120	7.07	91.30	78	0.06	28.70
			VC18/SS18	0.10	28.80	176.80	8.65	118	7.28	97.10	76	0.06	19.60
			VC19	0.10	29.00	109.50	8.63	121	7.10	95.20	79	0.05	29.60
			VC20	0.10	29.00	93.00	8.57	119	7.23	97.90	78	0.06	48.00
			VC21	0.10	27.30	94.00	8.44	119	7.57	95.70	77	0.06	57.40

			VC22	0.10	27.70	98.20	8.41	119	7.54	97.60	77	0.05	61.60
			SSDA (Dona Ana Bridge)	0.1	27.90	124.90	8.41	117	7.36	95.60	74	0.05	63.30
			VC23	0.10	30.50	112.80	8.73	116	7.52	104.60	76	0.05	20.50
			VC24	0.10	28.10	169.20	8.33	124	7.72	99.10	79	0.06	88.10
			VC25	0.10	28.60	126.60	8.02	156	7.06	91.80	103	0.07	65.50
			VC26	0.10	29.10	107.10	8.19	137	7.32	93.50	89	0.06	99.80
			VC27	0.10	28.10	64.40	8.21	133	6.91	89.00	86	0.06	93.20
			VC28	0.10	28.30	70.50	8.15	134	6.79	87.40	87	0.06	91.70
			SSF (Sena Sugar Factory)	0.10	28.80	117.40	8.13		7.85				173.00
			VC29/ SS29	0.1	28.70	110.00	8.14	138	6.91	89.60	88	0.06	104.00
			WQ reading between VC29 and VC30	1.55	28.40	71.75	8.14	630		109.80	84	0.06	78.85
			VC30	1.55	28.40	131.15	8.14	135		112.80	87	0.06	81.20
			WQ reading1/3 of way between VC30 and Chinde	1.55	28.90	136.30	8.03	137		103.75	89	0.06	44.05
			WQ reading 2/3 of way between VC30 and Chinde	1.55	28.90	127.50	8.00	175		109.65	113	0.08	53.70
			SSMP (Mooring Point at Chinde)	1.55	30.00	37.25	8.06	**7514**		94.95	**4884**	3.75	190.00
			SS_RM (Chinde River Mouth)	3.00	29.60	-17.90	8.10	**21420**		100.20	**13920**	10.71	84.00

5.6.4 *Sediment Transportation*

In 1973-4, suspended loads upstream of Cahora Bassa were measured and yielded maximum suspended loads of 344mg/l on the middle Zambezi and 1016mg/l on the Luangwa River (Hall et al., 1977). Ronco et al. (2010) annualised these measurements to generate a total load estimate of 28.6 Mm3/annum. Bolton (1983) estimated the total load entering Cahora Bassa as between 20 to 200 Mm3/annum. A measurement of sediment load at Tete by Basson (unpublished) indicated a 2.65t/s sediment load at 2600m3/s discharge, with bedload at 0.18 t/s (7% of the total load). Basson suggested that the suspended loads may be as high as 10 000mg/l, which is one to two orders of magnitude higher than that observed by Hall et al. (1977) in the middle Zambezi River, but it is possible that the Hall et al. (1977) measurements did not coincide with peak loads.

In this study, the sediment rating curve generated by BEH-MFPZ (1964; presented in Ronco et al., 2010) was used to generate an annual sediment discharge for the 2001-2010 flow record. This yielded an estimate of 51 Mm3 per annum. Bedload is estimated at between 1% (BEH-MFPZ, 1964) and 7% (Basson, unpublished) of the total load for the Zambezi River, i.e., 0.5 to 3.5 Mm3 per annum.

Based on our field observations and experiences, it is apparent that much of the lower Zambezi River has a highly dynamic bed, which is not suited to the creation and easy maintenance of deep, stable channels. Even at low flows, bed sediment is highly mobile and bars migrate downstream and laterally across the bed. For instance, during the field survey in the lowflow season of 2010 (2000m^3/s), some sand bars moved more than 20m across the thalweg and prevented a shallow draft boat from using the alignment travelled five days earlier.

5.6.5 *Geology and geomorphology of the Zambezi River*

The Lower Zambezi Valley runs approximately North West to South East. Halfway between Lupata and the coast it intersects the North-South running Rift Valley, which is wider and flatter. The Shire Valley is to the north of the Lower Zambezi , with the south side defined by the Urema graben. The delta begins at Mopeia, at about 120km from the coast.

Geomorphologically, the structure of the river channel can be classified as anastomising, with multiple channels separated by vegetated or otherwise stable islands. Formation of these stable islands has probably been consolidated by a reduction in flood releases since completion of Cahora Bassa. Downstream of Lupata, the Zambezi River meanders between sand banks and islands.

The geomorphology of the lower Zambezi region is dominated by the extensively eroded African Surface, the Limpopo Surface, most prominent on the Inhaminga Plateau, and the flood plains of the Zambezi and Rift Valleys.

5.7 *AQUATIC AND RIPARIAN BIOTA*

5.7.1 *Fauna*

The Study Area falls within the Lower Zambezi Ecoregion, which is classified as "tropical and subtropical floodplain rivers and wetland complexes" (FEOW 2010). This ecoregion is characterized by a rich aquatic fauna, and a notable absence of endemic species.

Larger fauna include crocodiles and hippopotami. Crocodiles are the top predators in the Zambezi food chain and as such, play a crucial ecological role in the aquatic ecosystem in which they live. Nile crocodiles feed on fish and aquatic species, naturally controlling the populations of predatory species such as barbel catfish, so that these do not deplete the numbers of other fish further down the food chain that may be of commercial value, or provide an important source of food for other species. The crocodiles also keep river environments clean by consuming dead animals that would otherwise remain a source of pollution, which helps nutrient recycling. In this way, the Nile crocodile is a significant keystone species (having a disproportionate effect on its community relative to its abundance) (http://www.earthwatch.org/europe/expeditions/exped_research_focus/rf-zambezi0209.html; viewed on 13 December 2010).

The fish of the Zambezi River system, along with tributaries and several other historically connected rivers in the northern part of southern Africa constitute a unique biogeographic fauna. This tropical fish fauna is relatively diverse and includes around 178 species. The Lower Zambezi system is characterized by low-gradient mature river systems with floodplain reaches the fish fauna of which has commonalities with the Limpopo system (Jubb, 1961; Skeleton, 2001 cited in Impacto, 2003).

A total of ninety-four fish species have been recorded in the Lower Zambezi (Bills 1999), of which 58 are primarily freshwater species, four are catadromous eels, and the remainder is estuarine. Most of the freshwater fishes are floodplain species. Several of these also occur in the Upper Zambezi but are absent from the Middle Zambezi because of a lack of suitable floodplain habitat (e.g. *Barbus haasianus* and two anabantids, *Microctenopoma intermedium* and *Ctenopoma multispine*). A smaller number of fish were recorded by Bills (1999) in the main channel and these included rheophilic species such as *Labeo altivelis* and *L. congoro*, the two *Distichodus* species i.e. *D. schenga* and *D. mossambicus*, *Brycinus imberi*, *Schilbe intermedius* the tigerfish (*Hydrocynus vittatus*) and the vundu (*Heteronbrachus longifilis*). Estuarine species like three gobies (, the bull shark (*Carcharhinus leucas*), the oxeye tarpon (*Megalops cyprinoides*), the riverbream (*Antathopagrus berda*) and the smalltooth sawfish (*Pristis microdon*) penetrate far into freshwater to as far inland as Tete township. In the Lower Shire 63 fish species have been recorded

(Tweddle & Willoughby 1979), of which five are typical of the Lake Malawi system and have not been found in the rest of the Lower Zambezi.

Aquatic Fish Catches

The size and species composition of the catches differ among the fishing devices. The scoop-nets and mosquito-nets target a number of small specimens of *Distichodus schenga, Micralestes acutidents, Barbus spp.,Labeo altivelis, Labeo congoro, Hydrocynus vittatus, Oreochromis spp. Tilapia spp.,* that are locally known as "Usimbo". The opposite is the hook and line fishery and long line which target big specimens such as the vundu (*Hetobranchus longifilis*); the tigerfish (*Hydrocynus vittatus*) the electric catfish (*Malapterururs shirensis*) and sometimes the bull shark (*Carcarhinus leucas*) and the sawfish (*Pristis microdon*). The driftnets tend to catch fish species that dwell on the main channel such as the tigerfish, the Cornish jack (*Mormyrops anguilloides*); Nkupe (*Distichodus mossambicus*) Chessa (*Distichoudus schenga),* Manyame labeo (*Labeo altivelis*), the Purple labeo (*Labeo congoro*). Seine-nets and fish traps are much less selective catching an assorted number of species and sizes.

Almost all the fish species that occur in along the Zambezi River are caught by the fishers. From the inquiries, fishermen were able to identify about 43 fish species as occurring in their catches. Of all the enlisted species occurring in the catches, about ten are commonly caught in fresh waters; the tigerfish (*Hydrocynus vittatus*), the brown squeaker (*Synodontis zambezensis*), the Mozambique tilapia (*Oreochromis mossambicus*), the sharpthooth catfish (*Clarias gariepinus*), the chessa (*Distichodus schenga*), the manyame labeo(*Labeo altivelis*); the bulldog (*Marcusenius macrolepidotus*); the Cornish jack (*Mormyrops anguiloides*), the eastern bottlenose (*Mormyrus longirostris*) and the vundu (*Heteronbrachius longifilis*).

Aquatic Fish Endemism, Conservation Status and Seasonality

The Ruo River, a tributary of the Lower Shire, has a unique relic fauna above the 60 m high Zoa Falls. Apart from those in the Ruo there are no known Lower Zambezi endemics (Tweddle, unpublished). Despite the fact that some species are considered rare or vulnerable in the Lower Zambezi, there are three species that raise conservation concern; these are the Largetooth sawfish (*Pristis microdon*) which is enlisted as critically endangered; the Orangespotted rockcod (*Epinephalus coiodes*) and the Bull shark (*Carcharinus leucas*) that are enlisted as "Near threatened" species. The sawfish and the bull shark are amphidromous species and are capable of penetrating as far inland as the Cahora Bassa dam wall and are subjected to fishing along the way. The rockcod, on the other hand is typically a reef species and poses less concern to the Zambezi as such.

With respect to the seasonality, the bulk of the species inhabiting the area are migratory or potamodromous, seasonally visit inundated areas and swollen stream and rivers. A list of species as well as the status of their conservation, seasonality, abundance, reproductive seasonality and biology are appended to the Fish Specialist Study in *Annex C*.

Aquatic Fish Habitat Preference, Period of Activity and Food Items

The different fish species inhabiting the river use the variety of habitats differently. Members of the Charicidae and Distochodontidae families generally prefer the main river channel, and particularly open waters. Other species like *Clarias gariepinus*, *Heretobranchus longifilis*, *Synodontis* spp., most of the cichlids occupy a wide range of habits, from open waters, floodplains, and swamps, associate with substrate or vegetation. Small species such as *Barbus* spp. prefer lagoons associated with main river channel, floodplains swamps and channels, creeks and small streams. In summary, all available and suitable habitats are used by fish. In fact, apart from very few fish species that occur in the main channel, the bulk of species are found scattered among other types of habitats that the riverine environment offers.

The majority of river fish species tend to have a relatively diverse diet as part of their adaptation to the environmental seasonality and unpredictability (Payne, 1987). Such adaptation extends to reproductive cycle which is known to be timed to rains and flooding events. For this reason, the trophic interactions among living communities are quite complex. On the one hand, food intake by fishes may vary with time over the 24 – hour cycle though for most species feeding occurs at night. Cichlids for example are known to feed at the sunrise and end at the sunset.

Aquatic Fish Reproductive Seasonality

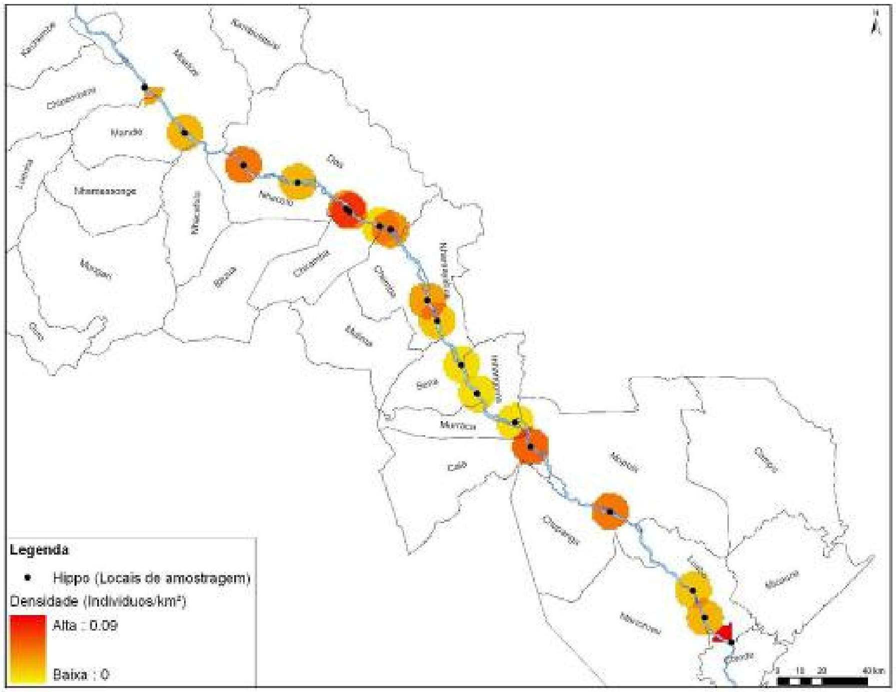
Since the hydrological regime of many rivers controls the quality and abundance of food, many river animals tend to have seasonal reproductive cycles which ensure that their young are produced under conditions within which they can survive and at the time their food is most plentiful (Payne, 1987). The majority of the fishes on the Lower Zambezi breed during summer and most of them tend to undertake breeding migrations to swollen streams and rivers as well as flooded areas in search of suitable breeding and nursery arenas.

Some species, such as *O. mossambicus* and *Tilapia sparrmanii* excavate nests on sandy banks that are used for breeding, while the *Zaireichtys rotundiceps* , a small catfish found over sand, usually buried with just eyes protruding, tends to exhibits some form of parental care (Skelton, 2001). In general, most of the species will lay their eggs in river bed or bank substrates, attached to the riverine vegetation or in the water column.

5.7.2 Macrofauna

Hippopotamus (*Hippopotamus amphibious*) occur along the entire sketch of the River between Tete and Chinde. At least 16 pods of hippopotamus were recorded during the field survey. *Figure 5.8* shows the location of hippopotamus identified during the field survey.

Figure 5.8 Location of Hippos Recorded during the Fieldtrip



Other mammals recorded in the riparian habitats include: baboon (*Papio ursinus),* vervet monkey (*Cercopithicus pygerythrus),* samango monkey *(Cercopithecus mitis labiatus) and A*aardvark *(Oryteropus afer).* Baboons were recorded for rocky and boulder shores near Lupata gorge. Vervet monkeys were recorded in several riparian forest patches along the Zambezi River. A population of Samango monkeys occurs the mangroves on the north bank of the Zambezi River opposite Chinde. Aardvark burrows occur on alluvial terraces along Zambezi River. The African clawless otter *(Aonynx capensis*) was not seen but probably occurs along this stretch of the river between Tete and Chinde.

The Nile crocodile (*Crocodylis niloticus*) was recorded at several locations on islands and along the banks of the Zambezi River.

5.7.3 Avifauna

Due to the great diversity in habitats that the region possesses, including extensive wetlands (rivers, swamps, lakes, flooding plains, etc), the area offers excellent conditions for the occurrence of a great variety of birds, including aquatic, terrestrial, and migratory species. At least 700 bird species were recorded in the Zambezi River Valley of which 15 are endemic. The list of endemic birds includes the Blackcheeked Lovebird - *Agapornis nigrigenis* and

Slaty Egret - *Egretta vinaceigula*. About 160 birds are migratory in the region of which 90 are Euro-Asian migratory and 70 are intra-African migratory (Timberlake 2000). The paleoartic migratory birds migrate to Europe and Asia, while intra-African move around between different regions of Africa.

The natural habitat along the Zambezi River are used by birds in several ways, including as a breeding ground, nesting ground, roosting ground, migratory route and for other uses. Thus, the Zambezi valley is important for the survival of many species of birds recorded there. Species of particular importance in terms of conservation include the Praticola Rock - *Glareola nuchalis*, Black-Winged Praticola - *Glareola Nordmann*, African Skimmer - *Rynchops flavirostris* and White Stork - *Ciconia ciconia*.

Above 24% of the birds of the Zambezi Valley are aquatic or somehow connected to wetlands. The highest concentration of these birds is in the Zambezi River Delta. The delta supports varied and diverse migratory and resident birds. Moreover, the delta supports a Significant Proportion of total population of Endangered and Vulnerable species. Of special interest is the Wattled Crane- *Grus carunculatus*,, a globally endangered resident of sub-saharan Africa. The vast majority of the Wattled Crane population (more than 95 percent of an estimated global population of 15,000 birds) occurs in south-central Africa, in the floodplains and dambos of the Zambezi, Pungwe, Lower Zaire, and Okavango River basins. The Wattled Crane breeds on the Zambezi Delta Floodplain. Breeding success has been affected by the changes on hydrological regime in the Zambezi Valley imposed by big dams (Bento at al 2006).

The Great White Pelican - *Pelecanus onocrotalus* and Pink-Backed Pelelican - *Pelecanus rufescens* are listed in the IUCN Red List as being vulnerable and globally endangered. A colony of pelicans composed of hundreds of individuals breeds on floodplain adjacent to the mangroves in the delta. The Mangrove supports thousands of migratory and resident birds. Among birds confined to the mangrove stands is the Mangrove Kingfisher - *Halcyon senegaloides*.

5.7.4 Riparian Habitats and Vegetation

A variety of riparian habitats occur along the Zambezi River including the following:

- Alluvial terraces with a covering of grass, herbs and, to a greater or lesser extent, trees
- Sandy islands and sandy stores with no or very sparse vegetation cover
- Sandy islands with a dense vegetation cover (mainly reeds and grasses)
- Floating Macrophytes
- Rocky shores
- Muddy shores and substrates
- *Barringtonia* swamps (“inland mangrove”)
- True mangrove

- Saline mudflats

Alluvial Terraces

Alluvial terrace is one of the dominant habitats along the banks of the Zambezi River between Tete and Chinde. Alluvial terraces have a vegetation cover of grass, herbs, shrubs and trees growing on medium textured or clayey soils above riverbanks. They provide suitable areas for termite mounds, burrow dwelling animals (e.g., aardvark) and nesting habitat for several bird species which burrow into the face of the terrace. *Ziziphus mauritiana* ("macanica") is a common tree (3 to 5m in height) occurring on the alluvial terraces. Other commonly occurring tree species include *Acacia nilotica, A. xanthphloea, Ficus glumosa, Combretum apiculatum* and *Sclerocarya birrea* ("marula").

Sandy banks on sandy shores with very sparse or without vegetation cover

Sandy banks and sandy shores with no or sparse vegetation cover occur in areas that are regularly inundated and where grasses or herbs are not able to become established to any great extent.

Floating Macrophytes

Floating macrophytes may accumulate in along protected shores and small bays where the river flow is low or absent. These are temporary habitats and may be washed downstream during floods. They provide temporary habitats for a number of bird, amphibian and fish species. Floating macrophytes include *Eichornia crassipes and Nymphaea* sp.

Of concern is the presence of aquatic weeds in the system. Large floating mats of the water hyacinth (*Eichornia crassipes*) and water lettuce (*Pistia stratioides*) frequently come down the Shire River and from the upper reaches of the Zambezi. Water hyacinth is a perennial herbaceous, free-floating plant native to the Amazon basin (Center, 1994). Each inflorescence can produce over 3,000 seeds with a single rosette capable of producing several inflorescence each year (Barrett, 1980). Seeds can remain viable in the sediment for up to 25 years however population growth is driven mainly by vegetative means. Under ideal conditions, these characteristics can result in growth rates of up to 6 percent per day (Ashton et al., 1979). These weeds have the potential to become entangled in propellers, hindering boat movement in the river.

Rocky shores and islands

Through most of its course between Tete and Chinde, the Zambezi River flows through low lying terrain comprising mainly unconsolidated sands and alluviums. Rocky shores and islands are of limited occurrence. Rocky formations occur only in the vicinity of Lupata gorge some 70km downstream of Tete. Trees and bushes may occur in depressions and slopes where sufficient soil accumulates.

Muddy shores (not associated with mangroves)

Muddy shores occur around islands and along the banks of the Zambezi River where heavy textured clay sediments accumulate. Where inundation is periodic and partial grass and cyperaceous species may become established e.g., *Echinochloa pyramidalis, E. scabra, , Leersia hexandra, Oryza longistaminus, Cyperus digitatus, C. exaltatus* and *C. distans.*

Muddy shores are important feeding grounds for a variety of bird species feeding on molluscs and small fish.

Barringtonia *swamps ("inland mangrove")*

Barringtonia evergreen swamp forest occurs on coastal waterways some distance from the coast. Evergreen "inland mangrove" thickets of *Barringtonia racemosa* and associated species occur on muddy alluvium at the margin of tidal influence along meandering channels that extend far into the saline grassland floodplain. *B. racemosa* (10-15m high) forms dense, often monotypic stands along the channel margin. The upper canopy is sometimes dominated by tall *Adina microcephala* (15-20m). Other characteristic trees include *Anthocleista grandiflora, Cassipourea gummiflua, Celtis gomphophylla, Ficus trichopoda, Funtimia latifolia, Hirtella zanguebarica, Khaya nyasica, Manilkara discolor, Mascarenhasia arborescens, Olea capensis, Pachystela brevipes, Parkia filicoidea,Pseudobersama mossambicensis, Salicornia spp., Syzygium guineense, Vitex doniana, Voacangathouarsii, and Xylopia aethiopica,* with *Phoenix reclinata* palms. Grass cover is rare or absent. Barringtonia swamp forest covers a fairly small area on the delta coast, about 3,000ha.

True mangroves and Saline flats

True mangroves and Saline flats are discussed in detail in *Section 5.8* below where the delta is discussed in more detail.

5.8 ZAMBEZI DELTA, ESTUARINE AND MARINE BIOTA

5.8.1 Delta

The Zambezi Delta is ecologically sensitive. Sensitive sites are defined as areas or zones along the river that, for biophysical or socio-economic reasons, are sensitive to change. The change refers to any deterioration in the functioning of the sensitive site or the services provided by the sensitive site.

The Zambezi Delta is a broad, flat alluvial plain along the coast of central Mozambique. The delta is triangular in shape, covering an area of approximately 1.2 million hectares that stretches 120km from its inland apex (near the confluence of the Zambezi and Shire Rivers) to the main Zambezi River mouth and 200km along the Indian Ocean coastline from the Cuacua River outlet near Quelimane south to the Zuni River outlet (Beilfuss and Brown, May 2006). The large port city of Beira is located about 200km to the south of the river mouth. The Delta is bordered to the north by the Morrumbala escarpment that serves as a divide between the Zambezi and Shire River watersheds, and to the west by the Cheringoma escarpment that separates the Zambezi and Pungwe River watersheds. The entire Lower Zambezi basin in Mozambique covers an area of approximately 225,000km^2 from Cahora Bassa Reservoir to the Zambezi Delta (more than 27 percent of the total land area of Mozambique) and supports more than 3.8 million people (25 percent of the total population of Mozambique).

The Zambezi River flows into the sea through a number of outlets important among which are the Mucelo, Boca do Zambeze, Catarina and Chinde arms There are a large number of outlets that are generally only active in seasonal and episodic flood conditions (Beilfuss and dos Santos 2001).

The Chinde River separates from the mainstream of the Zambezi River about 20km from the coastline and meanders eastward to its mouth at Chinde itself. About 7km upstream from the coast the Chinde captures runoff from the Maria River, a small channel that breaks from the mainstream Zambezi just north of the Chinde River divide and collects runoff from the northern floodplains. The Chinde River has a deep well established channel on its northern side with water depths exceeding 4m. This channel extends through the river mouth in a south easterly direction but is interrupted by a shallow sand bar ~6km offshore. Sand waves are known to occur offshore of Beira.

The entire lower Zambezi delta area is flat and the river channels near the coast have gently sloping banks so large proportions of the area may be flooded during periods of high river flows. These flood patterns are affected by tides as the delta region has the highest tidal variation in Mozambique. Spring tide amplitude is 4.1m at Chinde and 4.7m at Quelimane. During the rainy season, high tide levels back up Zambezi flows and spread floodwaters over the coastal plains. During the dry season, tidal influence is evident for 80km upstream (Beilfuss and dos Santos 2001).

The Zambezi River delta area supports a wide range of vegetation communities with 12 types being recognised (Beilfuss et al., 2001). These include Borassus palm savanna, Acacia savanna, open dry grassland, wet open grassland, evergreen forest, riverine forest, swamp grassland, papyrus swamp, ridge vegetation, mangrove forest, dune scrub, and foreshore vegetation. The important emergent vegetation communities in the lower portion of the Chinde River and Chinde mouth area are mangroves and associated communities and coastal dune communities.

5.8.2 Estuary

Estuaries rank along with tropical rainforests and coral reefs as the world's most productive ecosystems, more productive than both the rivers and the ocean that influence them from either side (Smith and Smith, 1999). In the Zambezi estuary, nutrient–rich river waters combine with warmer, light infused shallow coastal waters and the upwelling of nutrient-rich deep ocean waters to generate primary productivity. The mixing of lighter fresh water and heavier salt water trap and circulate nutrients such that they are often retained and recycled by benthic organisms to create a self-enriching system. Estuaries can generate year-round primary production from macrophytes, benthic microalgae and phytoplankton. This vast primary productivity is the cornerstone of the estuarine food chain, providing food for large populations of shellfish.

The Zambezi estuary supports a high biodiversity but also subsidises Sofala Bank productivity and fisheries through the export of organic matter. The conservation of the important habitats within the estuary (mangroves, salt marshes, tidally emergent sand/mud banks and water column), and sustainable use of their resources should help preserve the major biodiversity dependent ecosystem services of artisanal, semi-industrial and industrial fisheries and the human communities dependent on these services.

5.8.3 Mangroves and associated communities

Coastal mangroves and associated species occur on alluvial mudflats. The mudflats are strongly saline and inundated by tides at or above the topsoil level. Numerous drainage creeks dissect the mangrove flats. Mangrove forest includes eight species of true mangrove, often occurring in zones or bands according to tidal variation in water depth, salinity, and shade tolerance. *Sonneratia alba* and *Avicennia marina* have the greatest range of all the species, often occurring on the exposed seaward front. *Ceriops tagal*, *Xylocarpus granatum* and *Heritiera littoralis* are also abundant. As sediments accumulate in the *S. alba* and *A. marina* rooting systems, they are replaced by *Rhizophora mucronata* and *Ceriops tagal.* A zone of tall *R. mucronata* often develops behind the *A. marina* zone, followed by a zone of *C. tagal* thicket on thicker sediments. *Bruguiera gymnorrhiza* (sometimes in association with *Ceriops tagal* in the substratum) replaces *A. marina* in shallow waters frequently flooded by tides to a moderate depth.

Xylocarpus moluccensis co-occurs with the *C. tagal-B. gymnorrhiza-R. mucronata* association in the interior along small inlets. *Lumnitzera racemosa* is found along riverbanks associated with *B gymnorrhiza* and *X. moluccensis. Heritieria littoralis* is found at furthest inland extent of mangrove giving way to associations of *Barringtonia racemosa* in the landward zone. Associated plants, usually on sites less flooded by tides include the large shrubs *Guettarda speciosa*, *Hibiscus tiliaceous*, *Pemphis acidula*, *Suriana maritima*, and *Thespesea populnea* and the large fern *Achrostichum areum*. Salt marsh (halophytic) plants such as: *Sesuvium portulacastrum*, *Arthrocnemum perenne* and *Salicornia perrieri* occur in tidally flooded areas on the fringes of mangroves, especially in creeks. Interspersed with and inland of the mangrove belt are salt flat areas with *Phragmites*. Apart from their role in stabilising shorelines mangroves are important habitat for crabs, including mangrove crab Scylla serrata, as nursery areas for juvenile fish and shrimp, as foraging area for predatory fish, including members of the Carangidae, Lutjanidae, Sphyraenidae etc. and as breeding sites for white pelican (*Pelicanus onocrotalus*) (Bento and Beilfuss 2003).

Mangrove forest currently covers about 100,000 ha in the delta. The distribution of mangroves in the vicinity of Chinde is shown in *Figure 5.9*.

Figure 5.9 Extent of Mangroves

5.8.4 Saline Mudflats

Extensive mudflats occur on the seaward side of mangroves. These are important feeding grounds for a variety of bird species feeding on molluscs and crustaceans.

5.8.5 Coastal Dune Communities

The higher altitude sand dune areas behind the primary fore dune belt have been modified for coconut cultivation. The fore dunes support low creeping and tufted plants such as *Dactyloctenium germinatum*, *Halopyrum mucronatum*, *Ipomea pes-caprae*, *Scaevola thunbergii*, and *Sporobolus virginicus* in association with *Cyperus maritima*, *Ipomoea stolonifera*, *Launaea sarmentosa*, *Sophora tomentosa*, and *Tephrosia purpursea* (Beilfuss et al., 2001).

5.8.6 Sofala Bank

The Sofala Bank comprises the continental shelf area extending from the Save River mouth in the south west to Angoche in the north east. The edge of continental shelf is located at ~36km offshore in the north of the region (Quelimane), ~54km off Chinde and ~120km off Beira in the south. The continental shelf break is typically between the 80m and 120m isobaths and is considered to be precipitous (Brinca et al., 1981). Sediment texture on the inner continental shelf is mainly muddy sand and sandy mud adjacent to and north of Chinde but is mainly fine and medium sands south of this. The seafloor in the central and northern section is mainly smooth although there are isolated patches of coral and/or rock on the middle continental shelf at depths of 40-60m. The seafloor in water depths <50 m in the southern section has marked undulations considered to be sand waves making this region unsuitable for bottom trawling (Brinca et al., 1981).

Water properties in the region are strongly influenced by the Zambezi river outflow which has an annual discharge rate of approximately 100km^3 (Hougane, 1999). Turbidity levels are elevated and surface salinity depressed Due to density differences the effects of the fresh water outflows are mostly expressed in the surface layers with measurements off Quelimane indicating that the low salinity water is restricted to the upper 15 m to 20m of the water column. A notable feature of the surface salinity distribution is the marked salinity front that develops at the southern extremity of the Sofala Bank where oceanic water penetrates towards the coastline. Sea surface temperatures in the region range from 23 °C in winter to 28 °C in summer with limited spatial variability (Hoguane, 1999).

Current velocities in the Sofala bank area are typically low (~10cm/s, Sete et al., 2002) but are influenced by tides. Leal (2009) shows time series data for a site located in 50m water depth immediately offshore of the Zambezi River mouth demonstrating cyclical variation in direction between northward and offshore flow consistent with a tidal cycle. In this time series lowest current velocities were 15cm/s, coincident with 'residual' northward flow whilst higher velocities (~30cm/s) were associated with the offshore flow. Leal's (2009) data indicates that the currents were barotropic although his coverage did not extend fully into the upper mixed layer.

The water circulation patterns on the Sofala Bank are not yet fully understood but Hougane (2007) indicates the presence of cyclonic circulation in the vicinity of Quelimane while Lutjeharms (2006) describes evidence of a coastal upwelling cell of Angoche. Considered in unison it is likely that the elevated nutrients and productivity generated by the upwelling is retained in the Sofala Bank area by the cyclonic circulation. This process adds to the overall biological productivity of the area evidenced by its shrimp and fish populations.

No primary data was sourced on benthic in- or epi-fauna community structure on the Sofala Bank. However, given the elevated organic matter levels in sediments and the abundance of benthic detritivores and carnivores (shrimps) the benthos is expected to be rich and diverse. As in other marine environments community structure is expected to be linked to sediment properties (e.g.Newell et al., 1998).

5.8.7 Marine and Estuarine Fauna

Marine and Estuarine Fish

The Zambezi River mouth areas offer a range of fish habitats including mangrove fringes, tidally inundated salt marshes and sand and mud banks and deeper channels. This area has not been formally surveyed despite the acknowledged importance of large estuarine systems as sources of fish and their roles as nursery areas for the fish fauna of their adjacent continental shelves (Brinca et al., 1981).

According to Brinca et al. (1983) the marine fauna of the Sofala Bank comprises more than 1,000 species and include fish, molluscs, crustaceans and other living organisms. The fish include more than 340 species in four ecological groups namely:

- the coastal-estuarine group that includes fishes that occur in the mouth of the rivers;
- the transition group of fish species inhabiting the zone where coastal waters mix with oceanic waters;
- the neritic-oceanic group of fishes that inhabit waters with high levels of salinities (lower limit of the continental shelf and upper limit of the slope), and;
- the oceanic group which includes fishes dwelling in open ocean waters.

In the estuary, there are six commonly caught namely the riverbream (*Acanthopagrus berda*), freshwater piperfish (*Microphis fluviatilis*), tornfish (*Terapon jarbua*), bluespot mullet (*Valamugil seheli*) kelee shad **(***Hilsa kelee*) and the blacktip sea catfish (*Ariodes dussumieri*). The most important fish species in the coastal-estuarine group is the Clupeidae *Hilsa kelee* which make up the bulk of the commercial catches in river estuaries and the adjacent nearshore waters. The transition group fish include all of the species caught as by-catch in the shallow water shrimp (prawn) fishery. The important pelagic fish species are the Carangidae *Carangoides malabaricus*, *C. chrysophrys*, *Elopidae Megalops cordyla*, Clupeidae *Pellona ditchela*, and Engraulididae *Thryssa vitrirostris*.

DNFBB (1998) surveyed fish catches in 15 artisanal fishing camps within the Zambezi River delta from which the following can be considered as 'true estuarine fish species':

- *Mugil cephalus*
- *Thryssa vitrirostri*
- *Terapon jabua*
- *Johnius dussumieri*
- *Arius dussumieri*
- *Otolithes ruber*
- *Pomadasys kaakan*
- *Apogonoidae sp.*
- *Leiognathus equulus*
- *Hilsa kelee*
- *Liza macrolepis*
- *Ambassidae sp.*
- *Megalops cyprinoides*
- *Trichiurus lepturus*
- *Pellona ditchela*
- *Scomberoides tol*
- *Claridae*

In terms of relative abundance artisanal fishery data for the Chinde area indicate that the surface gill-nets are dominated by the Clupeidae (52 percent), Trichiuridae (18 percent) and Mugilidae (10 percent). Catches in deep (i.e. subsurface) gill nets are more heterogeneous with Carcharinidae (22 percent), Carangidae (21 percent),
Ariidae (17 percent), Scombridae (11 percent), and Haemulidae (10 percent) comprising the main elements of the catches.

The demersal component of the transition group is much more diverse; the important fishes include the Sciaenidae *Otolithes ruber*, *Johnius belengerii* and *J. dussumieri*, amongst others. The neritic-oceanic group is composed of about 100 species most of which are demersal (about 87 species) dominated mostly by two families namely, the Synodontidae (*Saurida undosquamis* and *S. tumbil*) and Trichiuridae (*Trichiurus lepturus*). The sharks (Carcharhinidae and Squalidae) are also common in this group. The most important pelagic species belong to the Carangidae (*Decapterus*, *Scomberoides* and *Sellar* spp.), Scombridae (Rastrelliger kaknagurta) and Scomberomoridae families.

The oceanic group is composed of about 69 fish species with Coryphaenidae being an important epi-pelagic predator while the Myctophidae and Gonostomidae are the major elements of the mesopelagic component whist the Chloriphthalmidae, Nomeidae (*Cubiceps natalensis*), Perichthyidae (*Neoscombrops annectens*) and the sharks (Squalidae) are the most important components of the demersal zone.

The crustaceans found in the region include shrimps (prawns), lobsters (coral reef and deep water lobster), crayfish and crabs (mangrove, shallow and deep water crabs). According to depth of occurrence there are two groups of shrimps namely the shallow water (0-70m) and the deep water shrimps (300-700m). The shallow water shrimps include two families namely the Penaeidae (*Penaeus indicus*, *Metapenaeus monocerus*, *P. monodon*, *P. japonicas* and *P. latisulcatus*) and the Sergestidae (*Acetes erithreaus*) (Brinca et al. 1983). The deep water group of shrimps includes *Haliporoides triarthrus*, *Aristaemorpha foliacea*, *Aristeus antennatus* and *Penaeopsis balssi* (Silva and Sousa, 1988).

The crab fauna includes 25 families and more than 200 species. The most important mangrove crab species is *Scylla serrata* which occur in all of the mangrove areas (Silva and Sousa, 1988). Other marine and estuarine resources found within the Sofala Bank region include a variety sea cucumbers, sea urchins, sea turtles, octopus, squids, cuttlefish, bivalves and sharks.

Marine and Estuarine Macrofauna

Large fauna that occur in the Sofala bank region include whales, common dolphin, whale sharks and turtles. Dugongs occur south of the Sofala Bank in the vicinity of the Bazaruto Island archipelago but as these animals are dependent on sea grass beds they are not expected to venture into the Zambezi River mouth region.

Five marine turtle species are listed to occur in Mozambique waters, green *Chelonia mydas*, olive ridley *Lepidochelys olivacea*, loggerhead *Carreta carreta*, hawksbill *Eretmochelys imbricate* and leatherback *Dermochelys coriacea* (Costa et al., 2007). Costa et al. (2007) state that all five of the turtle species that have been recorded in Mozambique may occur in the Sofala Bank area. Turtle nesting appears to be restricted to beaches to the north (*E. imbricata*, *L. olivacea* and *C. mydas*) and south of Beira (*C. mydas*). Turtles are caught as 'by-catch' by shrimp trawlers and Gove et al. (2001) estimated a remarkably high catch rate of 1305-3672/year in the industrial fishery and 627-1,764/year by artisanal fishers. It was not stated whether these catch rates are equivalent to fishing induced mortality rates. If so, given that approximately 1,000 turtle nests are established in Mozambique annually (e.g. Pereira et al., 2010) the estimated level of by-catch is unsustainable and represents a significant risk to turtle populations in Mozambique. There are no available records that indicate that any of these species do or may enter the Zambezi River mouth system. Similarly a number of whale and dolphin species occur in the Mozambique nearshore waters but no records of any of these penetrating into the Zambezi could be located.

Marine and Estuarine Benthos

Commonly occurring molluscs should include mangrove whelks (*Terebralia palustris*), creepers (*Cerithidea decollate*), venus shell (*Meretrix meretrix* and *Dosinia* sp), razor shell (*Solen* sp), sand mussel (*Donax* incarnates, *D. madagascariensis*) *Mactra* sp., and cephalopods *Sepia*, *Loligo*, *Omastrephes* and *Octopus*. Commonly occurring crustacea include penaeid shrimps, mainly post larvae and juveniles that utilise the estuary as a nursery area, caridean

(Pandalidae) shrimp, portunid crabs (swimming crabs and mangrove crab), callapid (box) crab, along with smaller amphipods, isopods, copepods, barnacles etc.

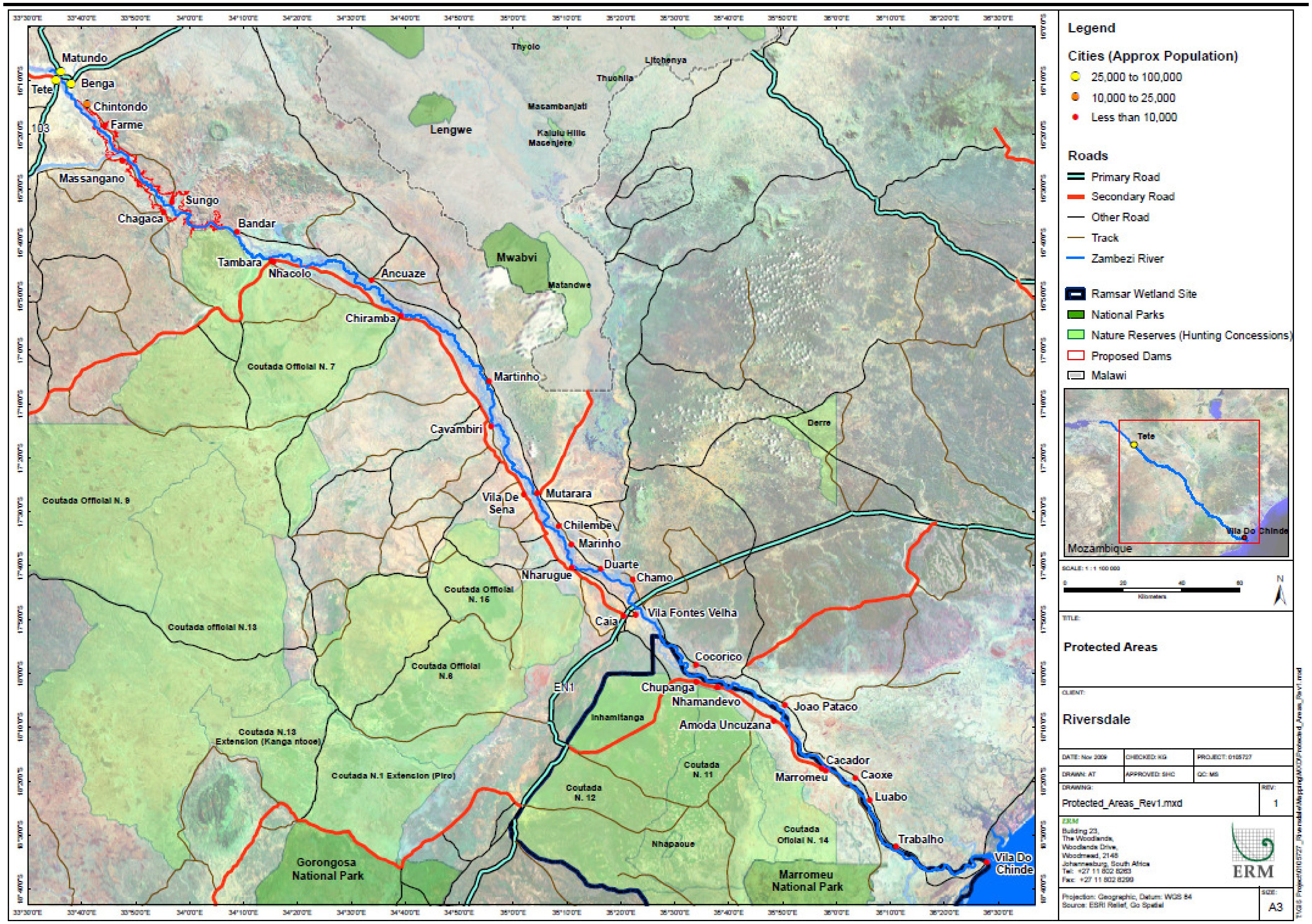
The penaeid shrimps form the most important component in terms of abundance and their role in the artisanal and industrial fisheries in the region. Five species have been recorded in the Zambezi delta. White shrimp (Penaeus (*Fenneropenaeus indicus*) is dominant followed by brown shrimp (*Metapenaeus monoceros*), tiger shrimp (*Penaeus monodon*), flower shrimp (*Penaeus japonicus*) and *Penaeus semisulcatus*. Distribution of penaeid shrimps within mangrove dominated estuaries and creeks is not uniform with *P. indicus* utilising the mangrove fringe as well as the interior of mangrove forests to a greater extent than does *M. monoceros* (Ronnback et al., 2002). These authors attribute this to the fact that M. *monoceros* juveniles can burrow into sediments to avoid predation whereas *P. indicus* cannot and is this more dependent on the habitat complexity offered by mangroves to avoid predation. However, neither of these two species nor *P. monodon* or *P. semisulcatus* appears to depend upon mangrove detritus directly as a food source. Stable carbon and nitrogen isotope investigations on these species and probable food sources in an Inhaca Island mangrove/mudflat/seagrass habitat complex by Marcia (2004) indicated a uniform preference for detritus, microscopic algae (probably benthic microalgae) and (micro) benthos. The link between the shrimp species and mangroves is thus probably more physical in terms of predation avoidance than nutritional.

5.8.8 Conservation in the Delta and Marine Environment

Mozambique acceded to the Ramsar Convention on 3 August 2004. The 688,000ha Marromeu Complex in Sofala Province remains the country's only Ramsar Site (*Figure 5.10*). The Ramsar Site comprises the protected Marromeu Buffalo Reserve, four surrounding hunting concession areas, one buffer area to the south-western side and a further zone to the north-east. It includes a variety of habitats including Zambezian coastal flooded savanna, coastal dunes, grassland, freshwater swamps, dambos associated with miombo forest, mangroves and seagrass beds (Pritchard et al., 2009).

There are two marine conservation areas in Mozambique that are fairly distant to the Zambezi delta. The Bazaruto Archipelago National (marine) Park (BANP) is located about 300km to the south of the delta and the Quirimbas National Park is about 900km to the north. The former is 1,430km^2 in extent and includes the five islands and surrounding waters of the Bazaruto Archipelago. It provides protection to the largest and only remaining viable population of dugongs in the Western Indian Ocean; five species of sea turtles; coral reefs; whales, dolphins and other marine animals; plus several endemic terrestrial gastropods and lizards. It is also an important bird area, in particular hosting significant aggregations of Palaearctic migrant water birds (www.panda.org, viewed on 2 August 2010). The Quirimbas National Park, stretching along the northeast coast of Mozambique, protects 750,639ha of coastal forest and mangroves, rich coral reefs and abundant marine life, including sea turtles, dugongs and hundreds of fish species (www.panda.org, viewed on 2 August 2010).

Figure 5.10 Protected Areas



5.9 PHYSICAL CHARACTERISTICS OF THE MARINE AND ESTUARY

5.9.1 *Offshore Bathymetry*

The predominant bathymetric feature around Chinde is the Sofala Bank. The average depth of the continental shelf is 20m, with the depth increasing to over 1,000m at the edge of the shelf.

5.9.2 *Tides*

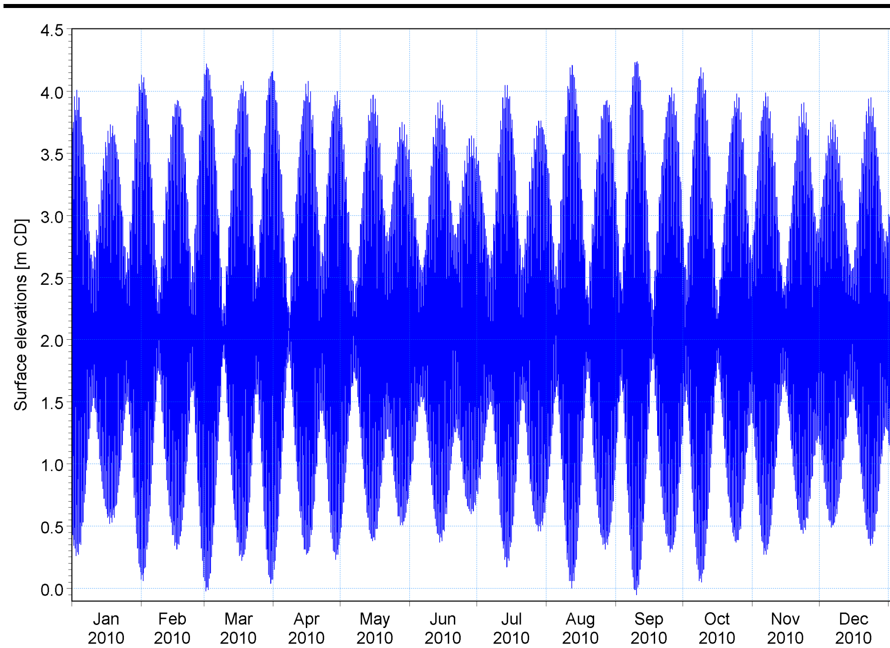
Predicted tidal surface elevations have been obtained from the C-Map Digital Charts Database. Tides are semi-diurnal. The mean surface level is 2.1m above chart datum (Chart 49629-M, 1986). Predicted tidal elevations for the year 2010 are shown in *Figure 5.11* below. Values for the predicted maximum, mean, 10th and 90th percentiles tidal levels are shown in *Table 5.4*.

Table 5.4 Percentiles of predicted tidal elevations

Percentile	Surface elevations [m CD]
Maximum	4.24
90th Percentile	3.38
Mean	2.04
10th Percentile	0.78

The tidal rise and fall is felt for about 40km within the mouths of the delta, and the effect of the ingoing tidal stream in checking the current of the river is felt for many kilometres farther up the river (Admiralty Charts, 1980).

Figure 5.11 Predicted tidal elevations at Chinde for 2010



5.9.3 *Salinity*

There is a large body of literature available detailing the measured salinity on the Sofala Bank offshore of and due to the Zambezi River plume entering the Indian Ocean (Siddorn *et al,* 2001, Leal *et al,* 2009) . As part of the Riversdale River Barging Project baseline salinity was measured to determine the upper extent of the estuarine influence (Worley Parsons, 2010a), these data is presented in *Table 5.2* above.

Average salinity measured on the Sofala Bank directly offshore from Chinde are tabulated below.

Table 5.5 Salinity measured offshore in the vicinity of the Chinde mouth

Reference	Lower Limit [psu]	Upper Limit [psu]
Sete *et al. (2002)*	34.0	35.3
Siddorn *et al. (2001)*	20.0	30.0
Leal *et al. (2009)*	34.8	35.2

5.9.4 *Tidal Speed*

The in-going and outgoing tidal streams turn about 1 hour after high and low water, respectively, at the bar. At springs, the outgoing tidal stream attains a rate of 3.5 knots (1.8m/s), and the in-going tidal stream a rate of 2.5 knots (1.3m/s); during neaps there is occasionally no perceptible in-going tidal stream and the out-going tidal stream is only from 1 to 2 knots (0.51 to 1.03m/s).

Offshore surface currents have been measured (Sete *et al., 2002*) and the typical range is between 0.1 to 0.6m/s. Two Acoustic Wave and Current Profilers have recently (November, 2010) been deployed at the offshore transloader locations (ERM, 2010a).

5.9.5 *Waves*

The table below shows the average wave climate for Chinde (Location: 37.5° E, 19° S at depth > 1,000m).

Table 5.6 Mean annual wave conditions at Chinde

Parameter	Value
Significant wave height (H_s)	1.32 m
Peak wave period (T_p)	7.15 s
Peak wave direction (θ_p)	139°

The following seasonal variations have been observed and are documented (Worley Parsons, 2010). Information regarding waves associated with tropical cyclones is not included due to spatial and temporal resolution of the available hindcast data.

Seasonal variations in significant wave height:

- Low range of wave heights throughout year, from 1.14 m in December to 1.47 m in October.
- Peak months: October, September, July
- Low months: Summer, i.e. Dec, Jan, Feb, Mar

Seasonal variations in peak wave period:

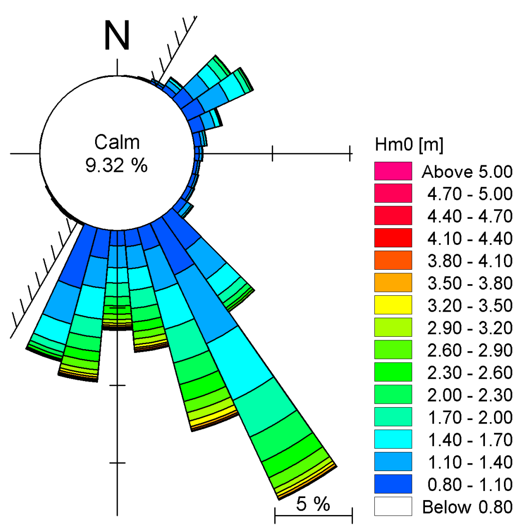
- Range from 6.49 sec in November to 7.68 sec in May
- Peak months: Autumn to Winter, i.e. May, June, July
- Low months: Summer, i.e. October to February

Seasonal variations in peak wave direction:

- Range from 123° in November to 150° in May
- More southerly wave climate in Autumn to Winter, i.e. April to July.
- Likely to be due to Southern Ocean swell generated by mid-latitude cyclones in the Roaring 40s latitudes.
- The SE trade winds affect the site from February to June, reinforcing the ocean swell.
- More easterly wave climate in Spring/Summer, i.e. August to December.
- Predominance of sea wave climate in Spring/Summer as mid-latitude cyclones shift southward and the NE trade winds generate sea waves.

For the purpose of calculating the longshore sediment transport budget for the present study, 13 years of wave hindcast data (NCEP, 2010) was obtained offshore of Chinde at 36.75° E, 19° S and a depth of 1,200m. The wave rose of this data is shown in *Figure 5.12*

Figure 5.12 Wave rose plot of available offshore data (NCEP, 2010)



The wave rose shows the dominant offshore wave direction as ~150° with a secondary component from ~50 to 60°.

5.9.6 *Wind*

Seasonal variations in wind speed:

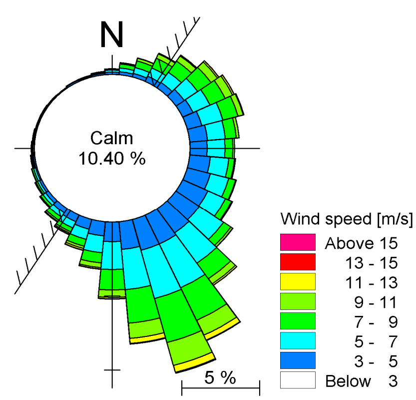
Average wind speed is 5.32 m/s and ranges from 4.74 m/s in March to 6.04 m/s in September. Wind speed is higher in Spring (September to November) and lowest in the first half of year, especially March.

Seasonal variations in wind direction:

The average wind direction is south east and ranges from east in November to south south east in May. Wind direction is more easterly in Spring (August to December), associated with stronger winds. In the first half of the year wind direction is more southerly, especially April and May, associated with lighter winds.

Offshore wind conditions from NCEP have also been analysed. This data has been extracted at the same location as the offshore wave data. The wind rose for the NCEP location used in this study and is shown in *Figure 5.13*.

Figure 5.13 Wind rose from NCEP data offshore of Chinde



It can be seen that the primary wind direction is from the south east.

5.10 COASTLINE CHARACTERISTICS

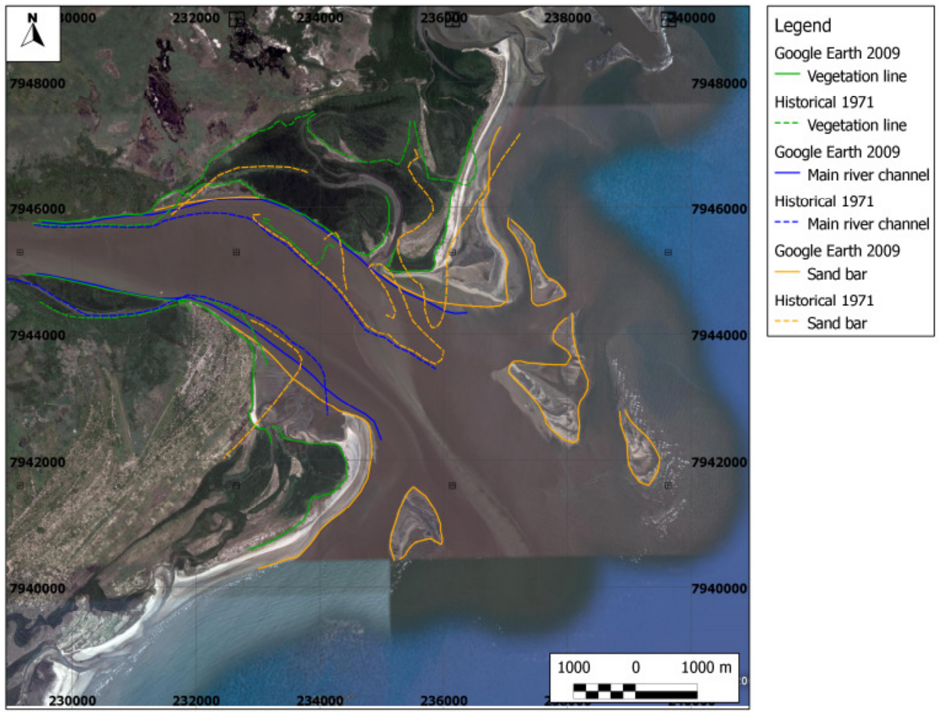
5.10.1 *River Mouth*

Numerous sandbanks, the inner parts of which dry from +2.4 to +3.0 m CD, front the entrance to Chinde mouth and extend approximately 4km seaward. The sea breaks heavily on these banks. There is a bar across the entrance, situated near the outer edge of the drying banks, but the position of the channel and depths across the bar are subject to frequent changes (Admiralty Charts, 1980).

5.10.2 *Assessment of Coastline Changes*

Local erosion/accretion trends are illustrated in *Figure 5.13.*

Figure 5.14 ***Vegetation, main channel and sand bar locations from analysis of historical aerial photographs (UTM Zone 37S)***



As can be seen in the above figure the mouth of the river has undergone substantial changes in the past ~40 years. The widening of the river channel with subsequent erosion on the northern and southern banks is clearly visible. The southern shoreline has accreted approximately 2km in 40 years. The tidal flats north of the channel have been infilled with sediment and colonised by mangroves. Further it can be seen that the areas which were predominantly sand bars previously have now been vegetated. It is clear that the river mouth is very dynamic in terms of the sediment transport.

6 THE SOCIO-ECONOMIC RECEIVING ENVIRONMENT

6.1 OVERVIEW

The Zambezi River valley includes an area of about 225,000km^2, covering the whole Tete Province and the Districts of Morrumbala, Mopeia, Chinde, Milange, Mocuba, Maganja of Costa, Namacurra, Nicuadala, Inhassunge and Quelimane (in the Zambezia Province), Gorongosa, Maringuè, Chemba, Caia, Marromeu, Cheringoma, and Muanza (Sofala Province), Bàrué, Guro, Tambara and Macossa (Manica Province). Approximately 4 million inhabitants live in this area of the Zambezi River valley, the equivalent of about a fifth of the population of Mozambique.

Being a linear Project, the barging project crosses 10 Districts and 18 Administrative Posts (see *Table 6.1* below).

Table 6.1 Districts and Administrative Posts in the Project Area

Districts	Administrative Posts
Left bank (North)	
Moatize	Benga
	Doa
Mutarara	Nhamayabue
	Inhangoma
Mopeia	Mopeia-sede
Chinde	Chinde-sede
	Luabo
Right bank (South)	
Changara	Chioco
Guro	Mandie
Tambara	Nhacolo
	Nhacafula
Chemba	Chiramba
	Caia
Caia	Murraça
	Sena
Marromeu	Marromeu
	Chupanga

The Zambezi Valley has various natural resources, distributed according to the characteristics of the different geographic sub-areas. The good agriculture-climatic characteristics of the plateau sub-area of the Valley (constituted by the districts of Angónia, Tsangano, Chifunde, Macanga and parts of Chiúta and Moatize, Zóbué), enhances potential for development, of agriculture and cattle breeding. Traditionally, agricultural products from the plateau were transported via the Sena Railway Line, starting from Cambulatsisse, before the line became inoperable in 1984.

The main activities or land uses of the Middle-Zambezi, including the Districts of Zumbo, Marávia, Mágoè, Cahora-Bassa, Chiúta, Changara, City of Tete, Moatize (Tete Province) and Guro in Manica, comprise: hydro-electric power, agriculture, cattle breeding, forests, wildlife, mineral, fishing and tourism resources. With the majority of the rural population engaged in agriculture, cattle breeding and fishing, this sub-area presents a low population density, living in small dispersed communities, with the exception of some urban centres. Fishing and fish-drying activities are particularly important in Morrumbala District and in the area near the confluence of the Zambezi and Shire rivers.

The main products of the so called Chire-Zambezi (composed by the Districts of Mutarara, in Tete, Morrumbala/Zambézia, Tambara/Manica and Chemba/Sofala) are cotton, corn, millet, beans, cassava, sweet potato, peanut, sesame and horticultural. Besides the agriculture, the population is renowned for livestock (goats, cattle, pigs) and fishing, although on a smaller scale. It is a poorly populated area.

The most populated sub-area of the Basin of Zambezi is the one of the Zambezi delta that has about 1.8 million inhabitants, which represents about a half of the population of the whole Zambezi Basin. The districts of Milanje, Mocuba, Maganja da Costa, Namacurra, Nicoadala, Quelimane, Mopeia and Chinde in the Zambézia Province, and Marromeu and Caia in Sofala belong to this sub-area. The economy of this sub-area is based on agriculture, cattle breeding, fishing, trade, mines and transports. There are potentialities in the industry and tourism sectors, still not recovered from the effects of the war. In the past, this sub-area provided a significant contribution to the national economy, through the production of crops such as: rice, copra, tea, cashew nut, cotton, sugar, corn, bean, sorghum and peanut.

6.2 THE PROJECT'S AREA OF DIRECT INFLUENCE (ADI)

The Barging Project's ADI with respect to people includes the populations living or performing their activities (farming, fishing, transporting) on the Zambezi River banks or islands. For socio-economic purposes, the ADI is defined as a band including the River, the river islands and a strip of 2km on each bank of the Zambezi margins from Benga to Chinde. This band was defined having in mind that 2km is the average maximum distance between residential hamlets and family agricultural plots. It is, therefore, considered that families residing up 2km from the river banks can have *machambas* on the banks or on the river islands.

6.3 ADMINISTRATIVE SETTING

In accordance with the Mozambican law, the political structure in Mozambique comprises both formal and traditional authorities. At the Province level, the highest level of authority is the Provincial Governor, designated by the President of the Republic. The Governor is supported by technical staff belonging to Provincial Directorates representing several sectors (Health, Education, Economic Activities, Finance, etc.)

Below the province level, the districts are headed by District Administrators, who directly report to the Provincial Governor. The structure of District Government is defined by Decree n.º 6/2006, of April 12. Each District is headed by a District Administrator, supported by District Directorates and by a Consultative Council, integrating elements from both formal and traditional leadership.

Each District Administrator supervises a number of Chiefs of Administrative Posts, who are appointed by the Ministry for State Administration (Ministério da Administração Estatal - MAE). Administrative Posts are further sub-divided into localities (*Localidades*), which are headed by the Chief of Locality (C*hefe de Localidade*).

Below the Locality level, officially, there are no formal state institutions, power being exercised by Líderes Comunitários (Community Leaders), which include both traditional leaders, selected according to traditional rules, and elected leaders. During pre-colonial times the traditional chiefs embodied the political power in their areas. Their authority and legitimacy were anchored in ancestry and succession was made according to elaborate succession rules. Soon after independence the government virtually abolished the positions of traditional leaders. However, traditional leadership has proved to be a resilient institution; the influence of traditional leaders has never really died out and they continue to play an important role in rural life. Over the past decade, therefore, local traditional leadership structures have been increasingly integrated into the formal administration system. Thus, traditional/ community leaders operating below the locality level are supposed to enforce government decisions. These Community Leaders are selected by the communities according to a number of criteria (which are rooted on traditional principles of legitimacy, i.e. based on kinship), and their formal status has been formalised through the Decree 15/2000, which provides them with authority for taking decisions on a range of community issues, including land allocation.

The authority of the traditional structures is maintained by the State essentially because of their continued legitimacy as a source of authority at community level (i.e. along kinship-based social structures such as the clan, lineage etc.) and not necessarily because of their performance. Many of these leaders take on the function, but have no resources and/or a functional agenda which would allow them to define and implement any development projects. Their function is thus limited to solving day-to-day conflicts and some specific activities of political nature.

Most important about this structure is the recognition of the legitimacy of traditional leaders within the community, so its role as advisers and "helpers" of the formal structure is fundamental. In addition, this structure plays the crucial role of perpetuating traditional ceremonies, beliefs, traditions and customs, thus maintaining social cohesion at community level.

6.4 *ECONOMIC CONTEXT*

Mozambique's economy is one of the fastest-growing in the world although this is recognised as starting from a very low base. In the past 15 years it has surged 8 percent a year on average (7.8 percent over the last 6 years), slowing slightly to 6 percent during the 2009 global meltdown, with nearly 7 percent expected this year. It is well above the World Bank's 4 percent forecast for all of southern Africa. However, despite this economic growth it lags behind in many other ways. It is still among the world's worst performers in the World Economic Forum's global competitiveness index, being ranked 129th out of 133 countries. It ranked 172nd out of 182 countries in the UN's human-development index. According to the IMF, it is still close to the bottom in terms of per capita GDP, at less than $1,000 in purchasing-power parity. Despite a widely publicized fall in the poverty rate from 69 percent in 1997 to 54 percent in 2003, the absolute number living below the poverty line actually rose to 11.7M in a population of around 20.5M.

Agriculture is the most important economic sector in terms of output and has remained between 25 percent and 27 percent of GDP between 2003 and 2009. Mining has been the fastest growing sector over the last six years (19.4 percent) followed by the trade (10.4 percent) and transport sectors (10.1 percent). Tete Province makes up about 10 percent of the 20.5M Mozambican population. A tenth of Tete province's residents live in Moatize District where the main coal basin is located. A further 1.2M people, almost 6 percent of the country's total population, live in the ten districts located on the banks of the lower Zambezi between Tete and Chinde.

The annual population growth rate for the country has been 2.4 percent over the past decade. However Tete Province, which has the third highest population of all provinces, has experienced a much higher growth rate of 3.3 percent. Close to 90 percent of the country's labour force works in the informal sector, earning a living through subsistence agriculture with remuneration often received in kind instead of cash. The large informal sector is reflected in relatively high levels of self-employment (62.1 percent) and private household activities (24.6 percent). Formal employment is mostly confined to cities and towns (36.2 percent), especially Maputo (59.9 percent), while the informal sector predominates in rural areas (95.2 percent). The percentage of informal employment increases from the relatively urbanised southern (73.4 percent) region, to the more rural central (90.0 percent) and northern regions (92.3 percent). The provinces in the lower Zambezi Valley mirror this pattern: people living along the southern banks of the river in the provinces of Manica (12.3 percent) and Sofala (20.9 percent) are more likely to be formally employed than those living on the opposite, northern side in the provinces of Tete (9.7 percent) and Zambezia (5.1 percent).

Over 85 percent of Mozambique's total labour force derives their income from agriculture. This percentage increases to 95 percent outside cities and from just over 70 percent in the South, to around 90 percent in the Centre and North. Again, as in the case of informal sector employment, agriculture's share of local employment increases as one travels north. The southern region which borders South Africa and includes Maputo is more urbanised and has a more developed, diversified economy, compared to the more remote rural hinterland in the central and northern regions where subsistence agriculture forms the mainstay of the economy.

The lower Zambezi Valley reflects a similar north-south divide. In Tete and Zambezia, the provinces on the river's northern bank, farming provides 90 percent of employment. By contrast in Manica and Sofala on the opposite southern side the sector's employment contribution drops to 80 percent. There is, in general, lower unemployment in rural areas. The reason for this is that land is relatively abundant and underutilised and people can engage in subsistence farming as a means of self-employment. Because of the high levels of self-employment in subsistence agriculture, unemployment rates are inversely correlated to the percentage of agricultural employment. Unemployment is lower in more rural and agricultural areas. As a result unemployment is lower in the agrarian and less developed economies of central (16.2 percent) and northern Mozambique (16.6 percent) compared to the more urbanised south (25.0 percent). Similarly, the northern provinces of the lower Zambezi valley, namely Tete (16.5 percent) and Zambezia (11.2 percent), have far less unemployment than the southern provinces of Manica (23.6 percent) and Sofala (21.2 percent).

Most Mozambicans live on less than $1.25 a day, the UN's measure of "extreme poverty". Since there is little in the way of a welfare state, the smallest rise in the cost of living can become a question of life and death. People in Tete Province earn an average of MZM376 per month. This exceeds the national average of MZM325 and is second only to Maputo City.

6.5 AGRICULTURE AND LIVESTOCK

The Zambezi basin's river systems provide most of the Southern African Development Community (SADC) region's hydropower generation, support some of the region's poorest subsistence communities, and represent a series of critical assets in terms of the region's tourism and recreation opportunities. The 1.39 million km² river basin is home to about 32 million people, 80 per cent of whom depend on agriculture, whilst communities living on the Zambezi's shores rely heavily on fishing. As such all economic activities within the basin depend critically on its water, mineral, and biological resources.

Agriculture is the mainstay of the economy of the Zambezi Basin, supporting millions of people as both producers and consumers. On average, agriculture contributes 34 percent of southern Africa's gross domestic product (GDP), employs 80 percent of the total labour force, accounts for about 26 percent of foreign exchange earnings, and contributes more than 50 percent of raw materials to industry (Chenje, 2000).

Agricultural production in the basin is characterized by low yield and low labour productivity. Year to year, agricultural productivity and growth rates continue to be strongly affected by climate variability and rainfall fluctuations. The influence of rainfall underscores the importance of natural resources management policy, especially those relating to food security and development of water resources.

Despite its dominant role in the economies of the basin, agriculture is threatened by lack of development and stagnation due to limited cooperation between basin countries, inadequate resource mobilization , and high rainfall variability across the basin (Granit et al. 2003). However, the basin's agricultural sector has potential for development, and could make a significant contribution to the reduction of poverty, if adequately managed and developed. A key instrument for agricultural development is the full utilization of irrigation potential for providing food security and alleviating poverty in the basin, yet less than half of the potential productive area in the basin is currently under irrigated agriculture (FAO, 1998).

6.6 FISHING

After aluminium, fish is Mozambique's second largest single export product, accounting for between 10 and 15 percent of all exports and contributing approximately 1.5 percent to Mozambique's annual gross domestic product (GDP). Licensing of fisheries within the Provinces is administered by the Provincial Department of Fisheries and the Maritime Administration. Fishing activities in Mozambique can be classified into three categories, namely, artisanal fishing, semi-industrial fishing and industrial fishing, which are described in further detail below.

From Tete Township to Lupata Gorge, some 70km downstream of Tete, the Zambezi River generally follows a clearly defined channel. The fishing activities in this portion of the River takes place in the active channel (usually river margins) and from islands. In the active channel the fishing method is the drift-net which is conducted by one or two people, normally at night; seine- netting is conducted in the sandbanks and traps are set along the river in calm waters. It is also common to see children fishing with mosquito-nets catching small specimens commonly known as "Usimbo".

Industrial fishing from larger vessels is targeted at shallow water shrimp as well as deepwater fish species located further from the coast in the north. These catches are mainly exported, rather than sold on the domestic market. Modifications to the fish or prawn nurseries may result in a decrease in populations of such species. This may have concomitant implications for the local economy. Changes to fisheries could also affect livelihoods and the economy.

6.6.1 *Fishing villages*

Four provinces (Tete, Manica, Sofala and Zambézia), share the portion of the Zambezi River affected by the project. Within these provinces there are a total of 12 districts, distributed as follows: Tete (3); Manica (2); Sofala (4) and Zambézia (3).

According to a survey conducted in 2007 by IDPPE, there are at least 119 fishing villages along the affected area. This number does not include the many temporary structures found along the river, especially in islands. It only refers to the permanent settlements. One of the areas that has an important fishery is the Danga Lagoon (16°48'21.3"; 34°38'08.2") which connects to the Zambezi during high floods via the Macatue River(16°48'37.6"; 34°34'57.4"). This lagoon, together with the Lifumba and Duarte lagoons are located in the Mutarara District. These lagoons support a fishing industry whereby fish are caught, sundried and exported to Malawi (Mafuca, 2006). The fish and Fisheries Specialist Report in *Annex C*, shows the list of settlements distributed along the Zambezi River, according to the last frame survey.

6.6.2 *Fishing methods*

The varieties of marine and estuarine aquatic resources are exploited by four fisheries, namely subsistence, artisanal, semi-industrial and industrial (Sousa and Silva, 1988). These are described below.

Subsistence Fishery

This fishery is conducted with or without a fishing boat, using rudimentary fishing gear. It is usually conducted as a secondary activity mainly for household consumption though the catch can be sold. Fishing practices within this group include direct collection and the use of fish traps.

Artisanal fisheries

By definition, the artisanal fishery is exerted only by national citizens (due to permit requirements) and it takes place within three miles from the shoreline (Lei das Pescas). Within the project area the artisanal fishery is conducted both within the Zambezi River estuary and on the adjacent marine area.

There are about 80,000 registered artisanal fishers in the overall Sofala Bank area (IDPPE, 2009). Artisanal fishing is conducted using an assortment of gear such as gill-nets, seine-nets, fish traps, long -lines and hook and lines, amongst others. A total of 886 fishing apparatus were recorded during the last census survey of which a large majority was gill-nets.

Although comprising <10 percent of the absolute numbers of fishing gear beach seine nets are used more extensively than any of the other gear, support most fishermen and provide >75 percent of landed catches. In comparison to beach seine netting, gill-nets and line and hooks are not as labour intensive. Gill-nets and hook and line methods require canoes and are relatively more selective in terms of the size of fish caught than the beach seine net. Gill-nets and hook and line methods also contribute a low proportion of the catch landed in the Zambezi delta area.

From inspecting the detailed catch and effort statistics from 'Pescart database' of the IIP it was concluded that the artisanal fishing operations occur mainly from 04h00 to 13h00 on week days. Supinho (2006) working with similar data from Sofala Province found that Sundays, days of mourning due to death of a community member and days of bad weather can reduce fishing days by as much as 19 percent on an annual basis.

The total number of fishers in the Zambezi delta region is estimated at 7,299, which is about 9 percent of the estimated 80,000 artisanal fishers in the Sofala Bank area (above). These rely on about 2,740 boats mainly in the form of dugout canoes for their daily labour. These vessels represent about 17 percent of the vessels recorded for the entire Sofala Bank in 2007 (IIP Pescart database, Maputo).

Semi-industrial and Industrial fisheries

The semi-industrial fleet comprises those vessels that generally do not use ice to preserve their catches. They therefore tend to operate close to their home ports and spend a maximum of 1-2 days at sea fishing. A fleet of about 57 semi-industrial trawler vessels operate in shallow waters from 1 nautical mile to offshore and within the Sofala Bank and are based in Angoche, Beira and Chiloane (Ministerio das Pescas, 2010). Although they don't frequently fish in the Zambezi river mouth area, this region is part of their fishing ground. The fleet targets both shrimp and by-catch composed of finfish mollusks and crustaceans and together with the artisanal sector, is one of the main suppliers of seafood to the Mozambican fish market. Another fleet of 15 semi-industrial vessels target line-fish in the Sofala bank (Ministerio das Pescas, 2010).

The industrial trawler fleet comprises those vessels fitted with catch freezing facilities. A total of 58 of the Mozambique fleet are dedicated to commercial shrimp fishing on the Sofala Bank including the Zambezi delta area. Home ports are the city of Beira (about 70 percent of the fleet), Quelimane and Maputo city (Ministerio das Pescas, 2010). The bulk of the catches made by these vessels serve the export market for shrimp and the by-catch species that they land.

6.6.3 *Catch and profits*

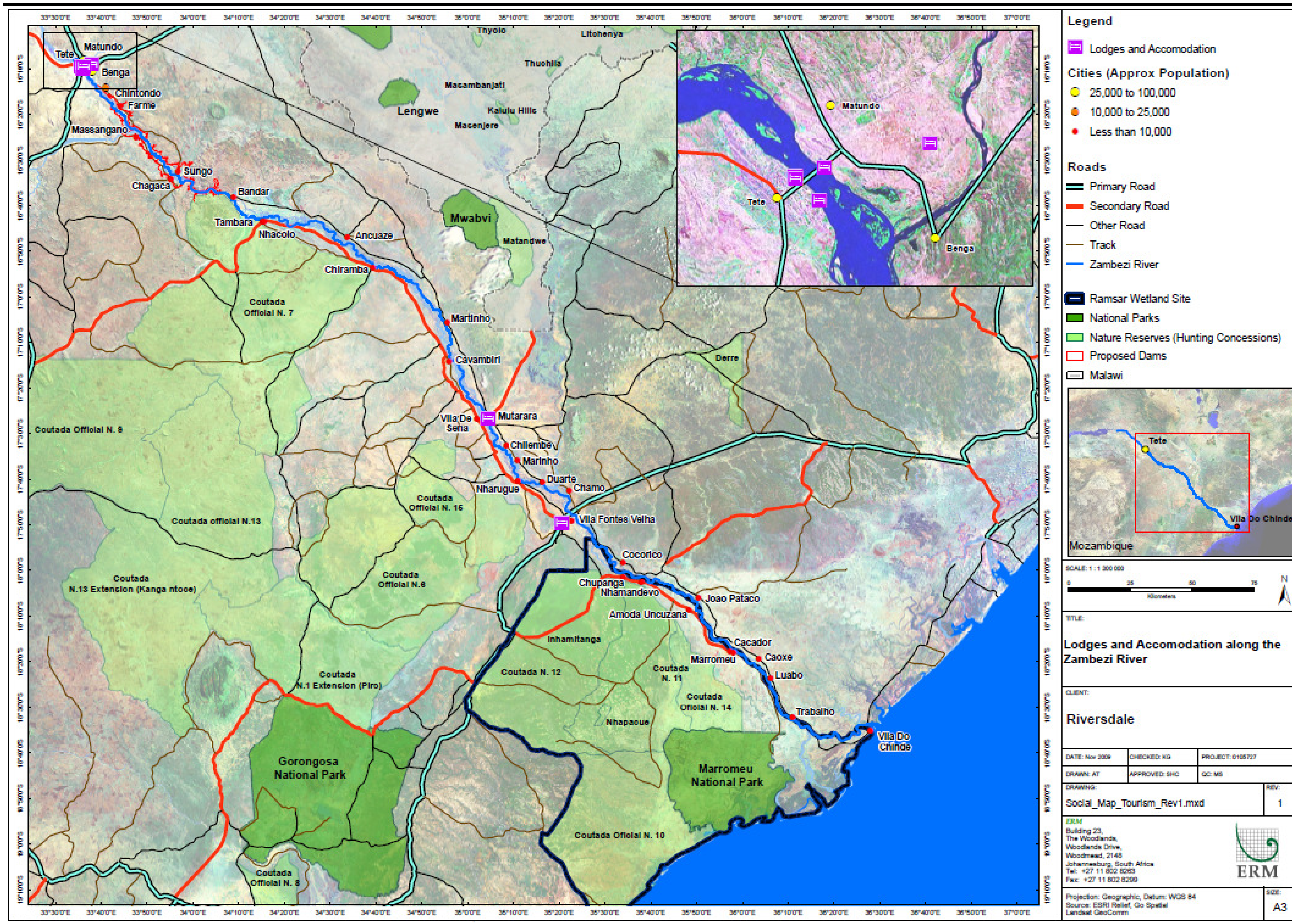
The estimated total annual catch accrued from fishing along the Project's ADI is about 16,000 tons. The most important fishing gear seems to be the gill-net because of its multiple uses. It can be set near vegetation in relatively calm water, but also can be used adrift, during the night. However, in terms of catch rates, the beach seine-nets are much more efficient catching about twice the catches of the gill-nets. The problem with seine-nets is finding suitable fishing areas, because it can only be used in sand banks or in drying out lagoons, during dry season. Based on results from the interviews, the fish are sold at average price of about 40 MZM/Kg. Assuming that at least 60 percent of the catch is sold an estimated annual revenue of about 384 million MZM was calculated.

6.7 *TOURISM POTENTIAL IN THE STUDY AREA*

The strategic plan for development of tourism sets out tourism's role in the Mozambican economy and in poverty alleviation. It highlights the tourism potential of the region, and outlines tourism trends and strategic markets in Mozambique and the broader region. Finally, it provides an implementation framework, a Vision for 2025 and the Mission for the development of Tourism in Mozambique.

Apart from two clusters of high quality beach resorts (In Inhambane and Cabo Delgado Provinces) the Mozambican tourism industry remains largely undeveloped. Wildlife (potentially the biggest resource in terms of tourism attraction) is severely depleted even inside the existing National Parks, and this situation is a severe handicap. The Mozambique Government, through the Ministry of Tourism, has developed and is implementing a National Tourism Policy and Implementation Strategy for 2004-2013 (PEDTM – Plano Estratégico para o Desenvolvimento do Turismo em Moçambique). Under this policy, the Government recognizes the necessity to prioritize areas for development of tourism - Priority Areas for Tourism Investment (PATIs). Currently, 18 priority areas for tourism investment (Áreas Prioritárias para Investimento em Turismo – APITs), have been identified and classified in three categories: short-, medium- and long-term areas. None of those PATIs is located on the Project's area of influence. In fact, the only PATI along the Zambezi is the Cahora Bassa Tourism Zone, some 150km upstream Benga. *Figure 6.1* below indicates the location of known lodges. As can be seen they are few in number and do not seem to cater for river-based tourism at present (i.e. no tourism by boat).

Figure 6.1 *Lodges and Accommodation*



The area along the Zambezi has no significant tourism activity and is currently rated as a "low tourism infrastructure area" (1). The only significant tourism activity in the Project area is centred in the hunting concessions (coutadas) on the southern bank close to Marromeu (Sofala Province). This activity, however, is not river dependent and is not likely to be disturbed by the Project. There is also a tourism complex in the Chemba District, Complexo Mozunaf Safaris in Chiramba, 40km west of Chemba, close to the Zambeze right bank. Also in the Chemba District there is a considerable wealth of wildlife, in the former hunting concession nr. 6 (coutada). This hunting concession however, is not being exploited currently.

6.8 *LOCAL RIVER TRAFFIC*

Due to the poor quality of roads along the Zambezi and the scarcity of public transport, local populations rely heavily on the river for transport. Furthermore, the very nature of the riverine communities' survival strategies (for instance, some families reside in one bank but have agricultural plots on islands or on the opposite bank; some sell their surpluses or have commercial ties with communities residing on the opposite bank, etc.) contributes to generate canoe traffic along the banks, from bank to bank and from the banks to the islands.

Local river traffic falls into two main categories:

- Dug-out canoes used for fishing and transport purposes and operating everywhere between Benga and Chinde; These canoes represent, by far, the biggest share of river navigation, being operated by a variety of people, including women and small children;

- Water taxis (larger boats powered by diesel engines), transporting passengers in the delta area (mainly between Marromeu, Luabo and Chinde);

- Local traffic occurs not only during the daylight but also during the night. This is due to the fact that a great deal of fishing activity is nocturnal. The risk of accidents involving barge convoys and local canoes, therefore, does exist, and has been stated as a concern during community meetings. Since barge convoys are expected to operate round the clock, night navigation will represent an increased risk.

(1) Plano Estratégico para o Desenvolvimento do Turismo em Moçambique, p. 55.

6.9 *NATURAL RESOURCE UTILIZATION*

6.9.1 *Mangrove forest*

Mangroves are an important source of timber for rot-resistant housing construction, for firewood by coastal communities as well as for countering erosion. Mangroves also serve as an important nursery for prawns and other crustaceans which are harvested by local communities.

6.9.2 *Riparian trees*

Hardwood trees are used for construction and fuelwood; local communities harvest riparian fruit trees.

6.9.3 *Reed and papyrus swamp*

Reeds are important for thatch and construction; papyrus is also used as a writing material.

6.9.4 *Palm savanna*

Hyphaene palm is used for making an alcoholic beverage as well as for construction material, while there has been a certain amount of interest in the local exploitation of Borassus palm for timber.

7 *BIOPHYSICAL IMPACTS*

7.1 *INTRODUCTION*

This chapter has been informed by the following specialist studies:

- Environmental Flow Study
- Study of Sediment Dynamics at the River Mouth
- Benthic Fauna Study
- Terrestrial and Riparian Ecology Study
- Bird study
- Fish and Fisheries Study
- Groundwater Study

7.2 *KEY PROJECT ACTIVITIES*

Biophysical impacts are those impacts on biota and physical functioning on systems as a result of changes brought on by the Project. With respect to biophysical impacts the key Project activities are:

- the location of land based facilities;
- the capital and maintenance dredging;
- the sites chosen for deposition of spoils (dredged material); and
- the potential for coal spillages at transfer sites along the river and the sites chosen for river infrastructure (mooring points, fenders, floating transfer stations, floating dry docks, etc).

Of these activities, the ones with the potential to have the greatest influence on the biophysical environment are the dredging and deposition of spoils. This influence would be exerted through changes in the river flow.

7.3 *SUMMARY OF THE ENVIRONMENTAL FLOW STUDY*

The EF Study allows us to understand how the flows in the river change as a result of the proposed dredging and spoil deposition. Therefore, in describing the expected physical changes to the river flow, it informs an understanding of the potential biophysical (and socio-economic) impacts as a result of the expected physical change. This summary is intended to describe the expected changes in river flow and concomitant changes to biophysical indicators in order to contextualise the impact assessment to follow.

7.3.1 *Scenarios Evaluated*

The dimensions of the dredge channel that were evaluated were:

Orientation: Centre line c. following thalweg [(1)].
Target depths: 3.5 and 5.5 m
Width: 60 to 110 m, with one 1.5 km segment between 21.87 and 23.37 km requiring a 220 m wide channel

Three scenarios were evaluated:

1. Dredge channel (as described in the EF Report, *Annex C*), with no spoil deposition.
2. Dredge channel (as described in the EF Report, *Annex C),* with spoil deposition alongside the dredged channel.
3. Dredge channel (as described in as described in the EF Report, *Annex C*), with spoil deposition in the lees of islands and mid-channel bars.

Scenario 1 (no spoil deposition) is a hypothetical scenario, which was evaluated because it provides the most conservative estimates of changes in effective discharge, as deposition of the spoil in the channel would offset these changes, particularly at higher discharges.

The expected changes as a result of the three scenarios were evaluated relative to present day, *viz*. present day conditions, i.e., no change in channel geometry as a result of dredging. Each included some consideration of maintenance dredging as follows:

- the geometry of the proposed dredge channel would be maintained for the period of assessment (10 years);
- deposition of the spoil resulting from maintenance dredging would be deposited in the same areas, and relative proportions as that for capital dredging, but would be 25% of the volume of capital dredging.

7.3.2 Study Area and Study Reaches

The study area for the EF Assessment is defined as the riverine environment (river channel and immediately adjacent floodplain) from Tete to Chinde. Within this, three study reaches were selected:

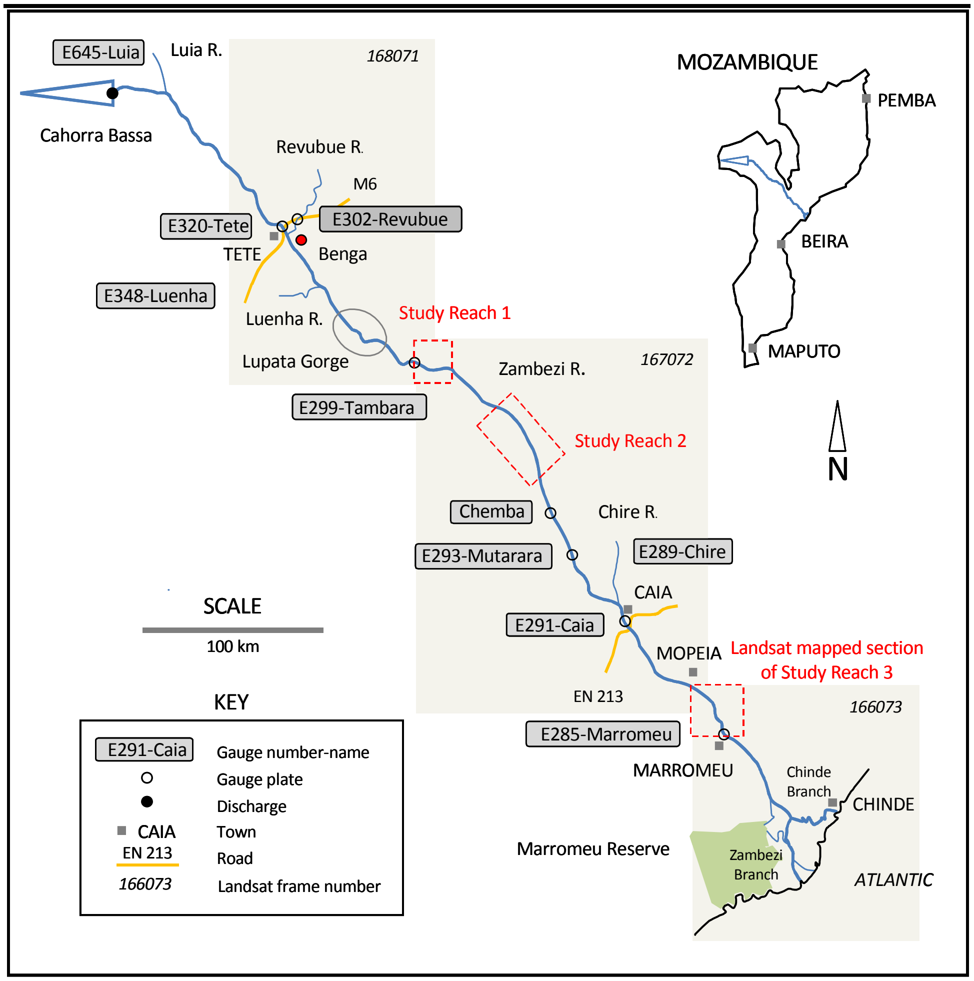
Study Reach 1: Tambara (421.5 – 395.0 km from Chinde, along the centerline of the dredge channel [(2)]) – *c*. 26-km long reach;

Study Reach 2: Chirumba (360.5 – 330.10 km from Chinde) – 30-km long reach;

Study Reach 3: Marromeu (157.30 - 108 km from Chinde, plus the Marromeu Wetlands) – 50-km long reach.

(1) The deepest channel within a river
(2) Centreline at Chinde is at c. +10 km.

Figure 7.1 Study Reaches for EF Study



7.3.3 *Ecoclassification*

The present-day (2010) condition of the habitat in all three study reaches is a C-category (1), which means that the system is moderately modified from the Reference Condition. A loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged.

7.3.4 *Predicted Changes to the River Environment*

The following table summarises expected changes in the three study reaches as a result of dredging and with the two possible spoil scenarios.

(1) As defined by the Wetland Index of Habitat Integrity developed by the South African Department of Water Affairs and Forestry.

Table 7.1 *Area of active channel affected by the dredge channel, and the two spoil disposal options for Study Reaches 1, 2 and 3*

	Units	Reach 1	Reach 2	Reach 3
Discharge mapped	m3/s	1789	1950	1898
Area of active channel (pre dredge)	ha	3050	3334	1839
IMPACT OF DREDGE PATH:				
Width of dredge channel	m	65	70	100
Area of dredge channel	ha	162.5	210	190
% of active channel area affected	%	**5.4**	**6.4**	**10.5**
Volume of material to be dredged from reach	Mm3	2.0	2.5	1.3
Expected water level change at this discharge after dredging	m	-0.06	-0.08	-0.06
Expected new area of active channel (post dredge)	ha	2999	3284	1816
% reduction of in-channel habitat area due to lower water level	%	**1.7**	**1.5**	**1.3**
Total % area affected (area reduction + dredge path)		**7.1**	**7.9**	**11.7**
IMPACT OF SPOIL DEPOSITION:				
SIDE DEPOSITION				
% of active channel area affected by spoils (excl. dredge path)	%	**17**	**17**	**17**
Average bed depth change in spoils area (incl. WL change)	m	0.45	0.52	0.47
LEE BAR DEPOSITION				
% of active channel area affected by spoils (excl. dredge path)	%	**12**	**11**	**15**
Average bed depth change in spoils area (incl. water level change)	m	0.60	0.77	0.55

This table indicates that the impact of dredging on the various "habitats" in the active river channel in the study reaches is relatively minor. "Habitats" in this context refers to the various water depths in the active river channel. In changing the bed profile, dredging alters (increases or decreases) the available area/ volume of "habitat". In terms of spoil, deposition in the lee of islands or bars is favoured as it minimises the percentage change to the active channel.

7.3.5 Study Reach 1: Effects on Individual Biophysical Indicators

The differences in the hydraulic indicators for the present day situation and for Scenario 1: Dredge – no spoil deposition for Study Reach 1 are relatively small:

- water level ≤ 8 cm;
- velocity ≤ 0.02 m/s;
- depth ≤ 8 cm;

Mean changes in the biophysical indicators for the proposed dredging and spoil deposition options relative to present day are presented below.

Table 7.2 Effect on Biophysical Indicators for Study Reach 1

	Indicator	No spoil deposition	Spoil disposed alongside dredged channel	Spoil deposited in the lees of islands and in-channel bars
Geomorphology	Area of mobile sandbars	-6%	-1%	+2%
	Area of stable (vegetated) islands	-0.2%	-0.2%	-0.2%
	Active channel width	-3%	-4%	-6%
	Length of lowflow distributaries	-3%	-12%	-5%
	Length of annually (flood) activated distributary channels	-4%	-4%	-4%
	Area of large floodplain lakes	-2%	-2%	-2%
Vegetation	Channel outer edge: riverbank	-0.3%	+4.2%	+3.2%
	Channel bars: mid-channel and lateral	-1%	-1%	-1%
	Floodplain: wetlands, swamps	-2%	-2%	-2%
	Floodplain: inundation of cultivated areas	-1.1%	-1.1%	-1.1%
	Floodplain: flood activated distributaries	-5.2%	-5.2%	-5.2%
	Floodplain: grassland	-5.2%	-5.2%	-5.2%
	Floodplain: woodland	-1%	-1%	-1%

The table indicates that changes (both increases and decreases) to biophysical indicators are relatively small.

7.3.6 *Study Reach 2: Effects on Individual Biophysical Indicators*

The differences in the hydraulic indicators for the present day situation and for Scenario 1: Dredge – no spoil deposition for Study Reach 2 are relatively small:

- water level ≤ 14 cm;
- velocity ≤ 0.09 m/s;
- depth ≤ 14 cm;

Mean changes in the biophysical indicators for the proposed dredging and spoil deposition options relative to present day are presented below.

Table 7.3 Effect on Biophysical Indicators for Study Reach 2

	Indicator	No spoil deposition	Spoil disposed alongside dredged channel	Spoil deposited in the lees of islands and in-channel bars
Geomorphology	Area of mobile sandbars	+3%	+4%	+5%
	Area of stable (vegetated) islands	-0.1%	-0.1%	-0.1%
	Active channel width	-1%	+4%	+1%
	Length of lowflow distributaries	-3%	-12%	-5%
	Length of annually (flood) activated distributary channels	-2%	-2%	-2%
	Area of large floodplain lakes	-1%	-1%	-1%
Vegetation	Channel outer edge: riverbank	-0.8%	+2.5%	+3.5%
	Channel bars: mid-channel and lateral	0%	0%	0%
	Floodplain: wetlands, swamps	-1.6%	-1.6%	-1.6%
	Floodplain: inundation of cultivated areas	-0.9%	-0.9%	-0.9%
	Floodplain: flood activated distributaries	-5.6%	-5.6%	-5.6%
	Floodplain: grassland	-5.6%	-5.6%	-5.6%
	Floodplain: woodland	0%	0%	0%

The table indicates that changes (both increases and decreases) to biophysical indicators are relatively small.

7.3.7 *Study Reach 3: Effects on Individual Biophysical Indicators*

The differences in the hydraulic indicators for the present day situation and for Scenario 1: Dredge – no spoil deposition for Study Reach 3 are relatively small:

- water level ≤ 27 cm;
- velocity ≤ 0.17 m/s;
- depth ≤ 27 cm;

Mean changes in the biophysical indicators for the proposed dredging and spoil deposition options relative to present day are presented below.

Table 7.4 Effect on Biophysical Indicators for Study Reach 3

	Indicator	No spoil deposition	Spoil disposed alongside dredged channel	Spoil deposited in the lees of islands and in-channel bars
Geomorphology	Area of mobile sandbars	-0.6%	+1.9%	+5.2%
	Area of stable (vegetated) islands	-0.2%	+0.2%	-0.2%
	Active channel width	-2%	+2%	-1%
	Length of lowflow distributaries	-3%	-10%	-5%
	Length of annually (flood) activated distributary channels	-0.7%	-0.7%	-0.7%
	Area of large floodplain lakes	0%	0%	0%
Vegetation	Channel outer edge: riverbank	0%	+5%	+6%
	Channel bars: mid-channel and lateral	0%	0%	0%
	Floodplain: wetlands, swamps	-1.3%	-1.3%	-1.3%
	Floodplain: inundation of cultivated areas	-0.2%	-0.2%	-0.2%
	Floodplain: flood activated distributaries	-0.6%	-0.6%	-0.6%
	Floodplain: grassland	-0.6%	-0.6%	-0.6%
	Floodplain: woodland	-0.1%	-0.1%	-0.1%

The table indicates that changes (both increases and decreases) to biophysical indicators are relatively small.

7.3.8 *Effects on Overall Habitat Condition*

The effects of the proposed dredging as assessed will mostly be in the active channel, i.e., localized impacts. The effect is greatest at Study Reach 1, albeit still relatively low, and although the impacts will be noticeable they are not expected to result in a drop from the present-day C-category to a D-category.

7.3.9 *Conclusions*

The outcome of this assessment hinges on the configuration of the proposed dredge channel (as at July 2010), the assumed volume associated with subsequent maintenance dredging, and the reference discharge provided for barging (approximately 1,800 m3/s). The outcome of the study predicts that the impacts of the proposed dredging on the hydraulics of, and habitats in, the lower Zambezi River are expected to be muted by the sheer size of the Lower Zambezi ecosystem relative to the proposed dredged channel and influence of spoil. The measureable changes (relative to the present day situation) predicted are mainly limited to the active channel. These include:

- small changes to the effective average discharge in the dry season;
- a loss of available deep water habitat; and
- an increase in mobile sandbars.

4.

Should the dredging and spoil deposition activities change significantly from that presented (e.g. the actual dredging operations, in particular maintenance dredging, will exceed those proposed both in area and frequency, and/ or spoils are deposited outside of the channel resulting in levees that cut the floodplain off from the river) the EF Study would need to be revised in order to determine the effect of these changes.

7.4 *IMPACT OF DREDGING AND SPOIL DEPOSITION ON THE ZAMBEZI DELTA AND RAMSAR WETLAND*

7.4.1 *Impact Assessment*

This potential impact could occur during the construction and operational phases of the Project. Dredging a navigable channel has the potential to modify water level and flood patterns, which in turn has direct implications for the Zambezi delta and Ramsar wetland. The delta and Ramsar wetland provide valuable ecologically services to an array of biological and social receptors. Some of the ecological services provided include provision of habitat, supply of food and water and enhancement of biodiversity. Some of the social services include supporting fish and prawn artisanal and semi-industrial fishing, provision of land for agriculture, provision of firewood. The maintenance of these ecological and social services relies on the seasonal flooding of the delta and wetland areas during the wet season.

The EF Study shows that during the wet season, there will be a negligible difference in water level or flood patterns. Importantly, distributaries in the delta will not have any noticeable change in water flow during the wet season as a result of the proposed Project. Accordingly, the intensity of this impact is rated as negligible with a local extent and long term duration. The magnitude of impact is thus expected to be negligible. Coupled with an unlikely probability of occurrence, the expected significance of this impact is *Negligible*.

7.4.2 *Mitigation*

Mitigation Objective

To ensure that the dredging does not result in significant changes to flood patterns and water levels in the wet season.

Mitigation Measure(s)

- Should the design of the navigable channel (in terms of dimensions, volume of sediment dredged or following the river's natural meander) change significantly, the EF Study should be undertaken and the new channel design modelled to determine potential impacts.

7.4.3 *Residual Impact*

The residual impact is expected to remain as *Negligible.*

Table 7.5 Impact of Dredging and Spoil Deposition on the Zambezi Delta and Ramsar Wetland

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long-Term	Long-Term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long-Term	Long-Term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, benthic habitats are likely to return to present day conditions over time.	

7.5 *IMPACT OF DREDGING AND SPOIL DEPOSITION ON BENTHIC HABITAT*

7.5.1 *Impact Assessment*

Dredging and deposition of spoils is certain to disturb benthic habitats during operation and construction phases. Impacts on aquatic invertebrates anticipated during the decommissioning and closure phase are expected to be negligible, so these are not discussed further. The area affected directly by the dredge path is estimated to comprise 7.1 to 11.7% of the active channel (Southern Waters 2010a). By contrast, the area affected by deposition of spoils is estimated to comprise 17% of the active channel (Southern Waters 2010a). Deposition of spoils may also alter flows in distributaries if the entrances to these channels are blocked, and this could affect a much larger area. The spatial extent of this impact is likely to be local, but could be regional in a worst-case scenario in some areas, if distributaries are affected.

Invertebrate recolonisation of dredge spoils is rapid, and typically takes 30 to 45 days (Harvey 1986, Thomas 1985). However, dredging is expected throughout the construction and operational phases, so the duration is rated as long-term.

Dredging and deposition will have detrimental impacts on invertebrates found in sediments, such as the burrowing caddisflies, gomphid dragonflies and thiarid snails. Deposition of spoils could have detrimental impacts on sensitive invertebrates found in marginal vegetation, such as prawns, shrimps and heptageniid mayflies. The intensity of this impact is rated as medium.

The magnitude of this impact is rated as medium, and the probability is definite, so the overall significance is rated as *Moderate* for both construction and operational phases.

7.5.2 Mitigation

Mitigation Objective

The objective of this mitigation measure is minimise disturbance to benthic habitat through minimising maintenance dredging.

Mitigation Measure(s)

Two mitigation measures are recommended as follows:

- Spoils should be deposited in lee of existing islands, where this is possible. This should reduce the intensity of maintenance dredging, and reduce the area affected by spoils from 17% to between 11 and 15% of the active channel (Southern Waters 2010a).

- Spoils must not be deposited in or near the entrances of distributaries.

7.5.3 Residual Impact

The proposed mitigation will reduce the spatial scale and intensity of this impact, so the overall significance of the residual impact is expected to be *Minor.*

Table 7.6 Impact of Dredging and Spoil Deposition on Benthic Habitat

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long-Term	Long-Term
Scale	Local to Regional (Worst Case)	Local
Intensity	Medium	Low

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Moderate	Minor
	Operational Phase	
Duration	Long-Term	Long-Term
Scale	Local to Regional (Worst Case)	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, benthic habitats are likely to return to present day conditions over time.	

7.6 *IMPACT OF ROUTINE COAL SPILLAGE ON FRESHWATER AQUATIC INVERTEBRATES*

7.6.1 *Impact Assessment*

Spillage of coal at the loading zone at Benga, and the transfer area at Dona Ana Bridge, will permanently alter the river bed substrates in the immediate vicinity of the loading and transfer areas during the operational and closure phases, and this is certain to reduce biodiversity in these areas. Some of this material is likely to move downstream during periods of high flow, but the extent will remain localised. Coal spillage is not anticipated during the construction phase, so this phase is not discussed further.

The sensitivity of invertebrates found in the sediments to coal spillage at Benga has been shown to be high, so the Intensity is rated as high.

The likelihood of coal spillage is definite, and the magnitude is rated as low, so the overall significance is rated as *Minor* for both operation and decommissioning and closure phases.

7.6.2 *Mitigation*

Mitigation Objective

The objectives of these mitigation measures are to reduce the likelihood and spatial extent of coal spillage.

Mitigation Measure(s)

The following mitigation measures are recommended:

- ***Procedures.*** Procedures for loading and transferring coal must be clearly defined, communicated and enforced.

- ***Demarcation.*** A sacrificial zone around the loading and transfer areas must be clearly demarcated, and spillage of coal within this zone can be tolerated.

- An Environmental Management Plan will be prepared that includes reporting of any coal spillages, regular testing of the river bottom both within the sacrificial zone and areas nearby areas of interest. Should coal be found outside the sacrificial zone, procedures will be incorporated of modified to avoid future spillages.

7.6.3 Residual Impact

The intensity and likelihood of coal spillage are likely to reduce with mitigation, so the overall significance of the residual impact is expected to be *Negligible*.

Table 7.7 Impact of Routine Coal Spillage on Freshwater Aquatic Invertebrates

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long-Term	Long-Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Low	Negligible
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.7 Impact of Accidental Fuel Spills on Aquatic Invertebrates

7.7.1 Impact Assessment

The proposed Project is likely to increase the likelihood of accidental spills of diesel during the construction and operational phases. Accidental spillage during the decommissioning and closure phase are expected to be negligible, so these are not discussed further.

The impact of accidental spills on aquatic invertebrates is likely to be highly localised. The impacts are likely to be of short-duration due to current speed and rapid evaporation of fuel. The intensity is rated as medium because of the presence of taxa that are sensitive to water quality deterioration, such as prawns, shrimps and heptageniid mayflies.

The magnitude is rated as low and the probability likely, so the overall significance is therefore rated as *Minor* for the construction and operational phases.

7.7.2 *Mitigation*

Mitigation Objective

The objective of these mitigation measures is to reduce the likelihood of accidental spills.

Mitigation Measure(s)

The following mitigation measures are recommended:

- Develop and implement procedures for spill prevention and emergency spill clean up (e.g. using absorbent material, soil remediation where necessary) measures.
- Ensure all personnel are trained appropriately
- Implement standard operating procedures consistent with good international practice.

7.7.3 *Residual Impact*

The implantation of the above mitigation measures would result in the significance of the residual impact reducing *Negligible.*

Table 7.8 Impact of Accidental Spills on Aquatic Invertebrates

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Low	Negligible
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Operational Phase	
Duration	Temporary	Temporary
Scale	Local	Local

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Intensity	Medium	Medium
Magnitude	Low	Negligible
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	Long-Term
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.8 *Impact of Bank Collapse on Aquatic Invertebrates*

7.8.1 *Impact Assessment*

Wave action from barges and other powered craft used during construction and operation phases may increase the rate of bank collapse in areas where the banks are already exposed, depending on the speed of the convoy and "distance" off in these bank areas. Exacerbated bank collapse at closure is expected to be negligible, so these are not discussed further for this phase. Bank collapse is a natural feature of delta systems, and it is probable that river banks in the lower Zambezi River were significantly more dynamic and unstable under natural conditions. Increased bank collapse caused by the proposed barging could therefore be regarded as a change towards more natural conditions. However, areas where banks have collapsed have little to no marginal vegetation, so available cover and substrate for invertebrate colonisation is low. Biodiversity and associated ecological goods and services are therefore very low in these areas. Furthermore, sediments adjacent to collapsing banks become smothered, and were shown in this study to support a very low diversity of benthic invertebrates. Stable banks therefore improve ecological goods and services, so any increase in bank collapse over and above the present-day rate is regarded as a negative impact.

The wake magnitude depends on the speed of the convoy through the water and the depth of the navigable channel. The impact of the wake depends on these factors as well as proximity of the bank to the navigable channel. The further away the bank, the less the impact. According to the wake study (Robert Allan, 2010) for loaded barges with the convoys moving at 5.0 knots downstream through the water (about 8 knots over ground speed) the surface waves generated at the bow and stern of the convoy are insignificant (changes in elevation of 0.1m to 0.3m) and quickly dissipate within a short distance from the convoy. The impact of wakes is more pronounced for lightly loaded barges moving upstream. At 9 knots through the water upstream (about 6 knots over ground speed), the convoy will generate changes elevation from 0.2m to 0.5m. These turn into a wave system when the wake propagates from the navigable channel into shallower water. The study shows that when the speed is reduced to 7 knots through the water (about 4 knots over ground speed), while changes in elevation do remain (close to the convoy), it dissipates fairly rapidly and the surface wave system in the shallow water disappears. The scale of the anticipated increase in bank collapse is likely to be localised. The duration of this impact is rated as long term.

Intensity of this impact is rated as low due the naturally low biodiversity in these areas and due to natural ongoing bank collapse. The magnitude is rated as *Low*, and the probability is definite, so the overall significance of this impact, before mitigation, is rated as *Minor* for construction and operational phases.

7.8.2 Mitigation

Mitigation Objective

The main objective of this mitigation is to ensure that river bank instability is not aggravated by barging and associated activities.

Mitigation Measure(s)

The following mitigation measure is recommended:

- Implement and enforce speed limits. Loaded barges moving downstream should not exceed 9 knots speed through water. Light barges moving upstream should not exceed 7 knots speed through water.

- Set the length of the navigable channel. The length of the navigable channel should remain fairly constant to ensure that the present-day sinuosity of the river is maintained.

7.8.3 Residual Impact

Should speed limits be implemented the residual impact is expected to be *Negligible.*

Table 7.9 Impact of Bank Collapse on Aquatic Invertebrates

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Permanent	Permanent
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Low	Low
Likelihood	Definite	Unlikely
Significance	Minor	Negligible
	Operational Phase	
Duration	Permanent	Permanent
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Low	Low
Likelihood	Definite	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.9 *IMPACT OF DREDGING ON TURBIDITY AND FISH*

7.9.1 *Impact Assessment*

This impact could occur during the construction and operational phases. Capital dredging will be carried out by eight barges operating in parallel 24 hours per day 7 days a week over an 18 month period Maintenance dredging is planned to occur through the life of the Project an is estimated to removed 25 percent of the capital dredge volume annually. Dredging activities could result in a change in water quality due to an increase in suspended sediment load and turbidity which is known to result in a decrease in dissolved oxygen and an increase in water temperature. An increase in turbidity due to dredging activities may affect fish by clogging fish gills, removing protective mucus or scales, reducing visibility (which affects prey/predator relationship) and/ or reducing light penetration (which may affect primary production with cascading effects on the trophic levels and fish injury). Fish species that prefer clear water are expected to be the most affected under the scenario of increased suspended sediment. These include the Common Mountain catfish (*Amphilius uranoscopus*); Redeye labeo (*Labeo cylindricus*) and the Northern barred minow (*Opsaridium zambezense*). There are no significant contaminants in the river bed that could be mobilized through dredging.

The assessment conducted along the dredging path revealed that in most of the river stretch is composed of medium and coarse sand. Fine materials tend to suspend easily in the water column, whist medium and coarse material do not. Assessment conducted along the dredging path revealed that in most of the river stretch is composed of medium and coarse sand. Therefore, it is expected that change in water quality would be localised to dredging areas, with a low magnitude over a long term. The overall magnitude is expected to be low with a likely probability of occurrence. Thus the expected significance of the impact is anticipated to be *Minor* during construction and operation. This impact will not be felt during the decommissioning and closure phase.

7.9.2 Mitigation

Mitigation Objective

To minimize impacts on fish due to dredging associated activities.

Mitigation measure(s)

- Limit the dredge area and depth to that strictly necessary to maintain the navigable channel.

7.9.3 Residual Impact

The residual impact is expected to remain as *Minor*.

Table 7.10 Impact of Dredging on Turbidity and Fish

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.10 IMPACT OF ACCIDENTAL FUEL SPILLS ON FISH

7.10.1 Impact Assessment

A 3,600HP push boat (1.8m draft) will carry 85 cubic metres (85,000 litres) of diesel fuel. These will be in 8 tanks ranging from 9.8 cubic meters (9,800 litres) to 20 cubic meters (20,000 litres). A larger 4,500HP boat, which will have a draft of 2.15m, will carry 135 cubic metres (135,000 litres) of diesel fuel. The push boats are double hulled and the tanks, which sit on the inner side of the ballast tanks, are themselves double walled – i.e., there are at least 4 steel walls between the fuel and the water.

A fuel barge will used to transport fuel to the land depots (Chinde and possibly Benga) to supply fuel for barging operations. The proposed fuel barge will be a marine certified double hulled flat top barge with a capacity approximately 3,180m^3 of diesel fuel (3,180,000 litres). During dredging operations fuel barges will be used to service the dredgers. These fuel barges will be constructed with heavy wall plating with the corners double plated. Movement of these fuel barges from location to location is minimal as they are anchored at a location near the dredge site where fuel can be transferred to the dredger via an auxiliary tug in smaller amounts. Dredger fuel barges will have a capacity of 500m^3 (500,000 litres). Fuel is stored within 4 separate tanks up to 125m^3 (125,000 litres) per tank. It is likely that dredgers will operate in groups of 2 or 3 per location with one fuel barge servicing each group.

Localized fuel spills could occur during bunkering or transfer of fuel. It is highly unlikely there could be a simultaneous rupture of more than one of the fuel tanks of a push boat at any one time. In any event the amount of fuel will be relatively small compared to volume and flow of the river (e.g. 20,000 litres from the largest fuel tank of a 3600HP push boat) and should rapidly spread along the surface of the river and eventually break up and evaporate. Fuel would pollute the water and may result in fish kills.

In the event of a catastrophic non-routine event such an explosion on the fuel barge a relatively large amount of fuel could be released into the water and impacts on fish. The likelihood of this occurring is considered to be low.

This impact is likely to be felt primarily during the construction and operational phases. For both phases the extent and duration of the worst case scenario would be limited. The duration of the impact is also likely to be short term as diesel evaporates fairly rapidly. Should the impact occur a medium intensity impact can be expected depending on where such an accident occurs. A medium to high magnitude coupled with an unlikely probability results in a *Moderate* significance impact for both phases.

7.10.2 Mitigation

Mitigation Objective

To minimize impacts on fish species due to diesel spills.

Mitigation measures

- Implement good operating procedures.
- Develop and implement procedures for spill prevention and emergency spill clean up.
- Crews should be trained for emergency response and oil spill clean ups.
- Ensure that pipes and hoses are properly connected, closed and in good condition when bunkering.
- Ensure that transfer hoses are of sufficient length and strength to manoeuvre vessels according to the river flow conditions.
- Incorporate automatic shut off valves.
- Ensure the refuelling area is well lit during night operations.
- Develop a management plan that may include provision to desist from refuelling operations during inclement weather.

7.10.3 Residual Impact

Post implementation of the above mitigation measures, the potential impact is likely to be *Minor* depending on where the spill occurs and the speed of remediation measures.

Table 7.11 Impact of Accidental Fuel Spills on Fish

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Medium to high	Low to medium
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
	Operational Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Medium to high	Low to medium
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a

	Without mitigation	Residual Impact (With mitigation)
Significance	After the life of the project the potential for accidental spills on fish species will be eliminated.	

7.11 *IMPACT OF ACCIDENTAL COAL SPILLS ON FISH*

7.11.1 *Impact Assessment*

During operations when fully loaded, each barge can hold 3,500t and as it is expected that each convoy will composed of 4 to 8 barges, the total weight per convoy is between 14,000t and 28,000t. In un-routinely and unlikely event of coal spillage, it is almost impossible to have all the barges on the convoy overturned. Coal is unlikely to significantly alter water quality as it will be washed prior to barging and is expected to be inert in water. Thus a large coal will present more of a physical impact on the river bed than a water quality impact. The physical impact may have implications for benthic fauna which are a source of food for fish. Again, the localised nature of such an impact means that within the context of the study area, the intensity of the impact would be low.

This impact would not occur during the construction and decommissioning and closure phase. The extent and duration of the worst case scenario would be limited and unlikely to occur. The duration of the impact is also likely to be short term with a low magnitude. A low magnitude coupled with an unlikely probability results in a *Negligible* significance impact.

7.11.2 *Mitigation*

Mitigation Objective

To minimize impacts on fish species by minimising coal spills.

Mitigation measure(s)

- Implement good operating procedures.

- Develop and implement procedures for coal spill prevention and clean-up should there be a significant spill outside designated "sacrificial" areas around coal loading areas.

7.11.3 *Residual Impact*

Post implementation of the above mitigation measures, the potential impact is likely to remain *Negligible*

Table 7.12 Impact of Accidental Coal Spills on Fish

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Low	Medium
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the project the potential for accidental coal spills on fish species will be eliminated.	

7.12 IMPACT OF CHANGES IN THE HYDROLOGY AND FLOODING PATTERN ON FISH

This impact could be felt as a result of dredging during the construction and operational phases. Change on the hydrology may affect ecological functions within the river system and its distributaries, like wetlands and seasonal flooded lakes (Nigthingale & Simenstad, 2001, LFR Lenive, Fricke, 2004). This may affect seasonal breeding and migrations of many freshwater fish species. In case of the Zambezi River, some of the important fisheries take place in seasonal flooded lakes such as Duarte, Danga and Lifumba, as well as the Nkhosi wetland

The result on the EF study (Southernwaters, 2010) shows that the will be no significant changes on the water level (about 1cm) and for this reason the present flooding pattern is not expected to be significantly affected. This is an important conclusion because most of the riverine fish species are known for their *potamodromesi* (seasonal lateral migration into swollen rivers and streams to breed) behavior which is the key for their continuity and to floodplain lakes and floodplain fisheries. In fact, most of the important fisheries areas along the lower Zambezi are located on floodplains and distributaries. It is thus, important to ensure that no significant change happen such that may affect this river characteristic as this will have negative impacts on fish populations and, consequently on the fisheries. In summary, under the scenario described above, this impact is unlikely to occur.

The EF study indicates that this impact would have a negligible intensity and magnitude with an unlikely probability of occurrence. Therefore a *Negligible* significance impact is expected.

7.12.1 Mitigation

Mitigation Objective

To ensure that the dimensions of the navigable channel don't change significantly from that proposed by Riversdale.

Mitigation measure(s)

- Should the dimensions (length, width or depth) of the navigable channel change significantly from that proposed by RML, the EF study should be amended accordingly to determine effects for hydrology and flood patterns. If required, mitigation measures should be developed an implemented at this stage.
- Spoil should not be deposited so as to block tributaries or distributaries.

7.12.2 Residual Impact

The residual impact is expected to remain as *Negligible*

Table 7.13 Impact of Changes in Hydrology and Flooding Pattern on Fish

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance		

7.13 IMPACT OF DREDGING ON INJURIES TO FISH

7.13.1 *Impact Assessment*

Entrainment occurs when organisms are trapped during the uptake of sediments and water by dredging machinery. In the Zambezi River the fish species that is most likely to be entrained are the spotted sand catlet (*Zaireichtys rotundiceps*). However, bottom dwellers and feeders such as the eels (*Anguilla* spp.), the catfishes (*Clarias* spp.), the plump barb (*Barbus afrohamiltoni*), the yellow barb (*Barbus manicensis*), the three spotted barb (*Barbus trimaculatus*), the squeakers (*Synodontis* spp.), the bulldog (*Marcusenius macrolepitodus*), the Eastern bottlenose (*Mormyrus longirostris*); the silver sillago (*Sillago sihama*), the blackhand sole (Solea bleekeri), may also be affected by entrainment.

The expected duration of the impact would be long term and local in extent. Given that most species would scatter to safer areas once dredging commences, the intensity would be low with a low magnitude. Coupled with an unlikely probability of occurrence a *Negligible* significance is expected. This impact will not be felt during the decommissioning and closure phase.

7.13.2 *Mitigation*

Mitigation Objective

To minimize dredging.

Mitigation measure(s)

- Limit the dredge area and depth to that strictly necessary to maintain the navigable channel.

7.13.3 *Residual Impact*

The residual impact is expected to remain as *Negligible*

Table 7.14 Impact of Dredging on Injuries to Fish

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low

	Without mitigation	Residual Impact (With mitigation)
Likelihood	Likely	Likely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.14 *IMPACT ON DEPTH CLASSES DUE TO DREDGING*

7.14.1 *Impact Assessment*

During the construction and operational phases, dredging will result in changes to different depth classes (eg increase in depth at the navigable channel and decrease in depth where spoils are deposited).

Depth preference varies among fish species and in relation to size of species. The extent of this impact on the fish and its associated fisheries is difficult to estimate because the actual populations of these species within the river system are unknown. The severity of the impacts will also differ, depending on the reaction of the species to the impacts. Nevertheless, the fact that this part of the river is highly dynamic indicates that disturbances on the fish habitats do happen with some regularity and fish are able to cope with the changes. Therefore, although some species may be severely affected with disturbance or change to their preferred habitats, most of the species will eventually adapt to the changes just as they did when other changes to their habitats occurred (eg at Kariba and Cahora Bassa where the majority of fish populations that existed before impoundments are still there many years after major changes have occurred).

For both shallow water and deep water fish species the duration of the impact is expected to be short term because fish species will be able to adapt to changes in time. The impact will occur on a local scale for both shallow water and deep water fish species because the effect will be along most of the active channel. The intensity of the impact is expected to be low for both shallow deep water fish, and thus will result in a low magnitude. Coupled with likely probability of occurrence a *Minor* significance.

7.14.2 *Mitigation*

Mitigation Objective

To minimize the potential impacts on depth classes due to dredging.

Mitigation measure(s)

- Where possible, plan dredging activities out of the breeding season which occurs during the rainy season and possibly three months after the end of the rainy season, to allow for the juveniles to grow.
- Limit the dredging activities to that required to maintain the navigable channel.

7.14.3 *Residual Impact*

The residual impact is expected to remain as *Minor*.

Table 7.15 Impact on Depth Classes due to Dredging

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short term	Short term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.15 IMPACT OF BENGA LAND BASED FACILITIES ON TERRESTRIAL ECOLOGY AND HABITAT

7.15.1 *Impact Assessment*

A plot of land (*Figure 4.5*) adjacent to the coal loading terminal will be acquired for the construction of warehouses, storage areas, offices, locker rooms, bathrooms, fuel tanks, oily bilge tank and coal water setting tank. The area will be enclosed with a security fence. This impact is likely to occur during construction (associated with site clearance and construction), operation (accidental spills, waste generation) and decommissioning and closure (physical disturbances associated with decommissioning structures).

The site at Benga is highly disturbed by previous human activity (cutting of trees, overgrazing by goats and soil contaminated by coal fines). Nevertheless the infrastructure will occupy land and may result in the loss some tree cover.

Based upon a perspective of conservation of biodiversity and red data plant species or special habitats, no part of the proposed Benga site is regarded as a no-go area. Thus a low intensity impact is expected, with a permanent duration. In all phases of the project life the magnitude is expected to be low, with the significance expected to be *Minor*.

7.15.2 Mitigation

Mitigation Objective

To reduce potential impacts on habitats and tree cover, especially at the riparian zone at Benga.

Mitigation Measure(s)

- All personnel involved in project activities must be informed of the need to preserve wherever possible natural tree cover especially baobabs and fringing riparian trees along the Zambezi River.

- For every tree removed with Diameter Breast Height (DBH) > 5cm the contractor should plant at least 2 replacement trees. This will enhance tree cover and shade during the operational phase and will contribute to erosion control.

- Construction areas along the bank must be monitored to ensure minimal disturbance of the river bank and riparian vegetation. Movement of personnel and machinery and vehicles along the Zambezi River bank should be restricted to demarcated work areas. As the riparian zone is already showing signs of erosion the rehabilitation of this riparian zone by the planting of shrubs and trees occurring naturally within this zone should be considered. This will stabilize the river bank and protect the land based facilities closer to the river.

- The tanks should be located on dry land 50m away from the Zembezi River or any other watercourse.

- After the works have ended and the temporary infrastructure has been removed, degraded areas must be rehabilitated in order to restore the natural situation.

- Develop and implement procedures for spill prevention and emergency spill clean up (e.g. using absorbent material, soil remediation where necessary) measures.

- Preventive and periodic maintenance of machines and vehicles in order to avoid breakdowns and the subsequent spillage of oil and fuel.

- Maintenance of equipment or vehicles to be carried out in specially designated areas an impermeable surface with adequate drainage and collection of any spills.

- Should soil be contaminated with diesel or oil, it must be subjected to appropriate bioremediation methods.

- Storage areas for fuel and other chemicals must be located at least 50m from the bank of the Zambezi River. Storage areas for fuel and chemicals must have appropriate signs in English and Portuguese and be built on cement, in impermeable containment basins that retain and permit the collection of possible spills.

- Employees working with chemical products must receive appropriate instructions and personal protection equipment (such as gloves, masks, uniforms).

- In order to avoid possible spills, the following precautions are recommended when storing and handling fuel and lubricants:
    - Fuel tanks with a capacity of more than 1000 litres must be placed on flat or slightly sloping land, surrounded by a retention basin with a capacity that is equal to 110 percent of the total tank volume. The walls and foundation of this basin must be made of impermeable material or have an appropriate lining in order to ensure that any spill can be contained. A system for collecting spilled chemicals must be installed (e.g. a drain leading to an impermeable collecting tank);
    - The storage of fuel and the maintenance or re-supply of vehicles or equipment must take place not less than 50 meters from the Zambezi River.
    - Used oil must be stored in sealed drums, and must not be mixed with other substances such as petrol, solvents and anti-freeze. Used oil may be returned to the supplier for subsequent recycling.

- The area where the work is under way must be kept clean and waste must not be burnt, buried or discarded indiscriminately.

- Scrap metal must be removed from the area and disposed of appropriately.

- Waste containers with monkey-proof lids must be provided and emptied regularly. Waste must be disposed of appropriately at a waste site.

- Biodegradable material can be used for making compost to assist the re-vegetation of any disturbed areas or deposited in waste pits and then covered in soil.

7.15.3 *Residual Impact*

With the mitigation measures in place, the significance of the impact is likely to become *Negligible*.

Table 7.16 Impact of Benga Land Based Facilities on Terrestrial Ecology and Habitat

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Temporary	Temporary
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Negligible
	Operational Phase	
Duration	Temporary	Temporary
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	Temporary	Temporary
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Negligible

7.16 *IMPACT OF CHINDE LAND BASED FACILITIES ON MANGROVES*

7.16.1 *Impact Assessment*

A number of structures will be built on land adjacent to mangroves on the north bank of the Zambezi River opposite Chinde. Construction activities could result in disturbance or loss of some trees in the mangrove forest. This impact will be felt most during construction, when site clearing and erection of the structures will occur. During the operational phase potential impacts will be associated with accidental spills, waste generation or unauthorised movement of people and/ equipment into the mangrove forest. Decommissioning and closure is expected to result in impacts similar to those during the construction phase but this would be short lived as the disturbed areas recover naturally post-closure.

From the Project layout it can be seen that the structures will be located largely out of the mangrove forest. It is possible however, that an indirect impact of construction in the area will lead to an in-migration of local people looking for work. This is likely to increase the disturbance to the mangrove forest through cutting of trees for fuel or housing material.

Access routes will probably be by raised timber pathways (to allow tidal exchanges) but it is expected that there will be some disturbance of mangroves in the access. The area that will be affected is not specified in the supplied project description but for each site it is conservatively calculated to be equivalent to a 10m wide strip extending the length of the Chinde River north bank berthing area which is estimated to be 3.5km long (i.e. 3.5ha loss for construction of access routes). Mangrove forests are extensive in the Zambezi delta area and covered ~100,000ha in 2000 (Beilfuss *et al.*, 2001) and thus the conservatively estimated loss of forest at the regional scale is <0.01 percent.

Barge and tug mooring facilities will be installed in three locations (*Figure 4.8*) at Chinde with each of these supporting mangrove stands. The long-shore extent of the berths are upwards of 3.5km of river frontage with mostly mangrove forests on the shorelines behind berths except for the upstream berth on the right bank of the Chinde River (*Figure 4.8*). Although dolphin berths will be used a precautionary approach is applied here and it is assumed that the full length of the shoreline behind the berths will be disturbed to varying degrees and that this will extend ~20 m up-shore. This may result in 7ha of mangroves being modified in total along the river bank.

Mangroves are not extensively developed at Chinde compared to the delta areas to the south. There are approximately 180ha of mangroves on the northern bank of the Chinde River mouth behind the proposed berth areas. In the worst case scenario the proportion of this that may be damaged (by access routes and mooring facilities) is approximately six percent. This is a negligible fraction of the mangrove stands at the Chinde River mouth. Accordingly the magnitude of the impact during construction and operation is likely to be low. A *Minor* significance impact is expected during construction and operation. During decommissioning and closure further disturbance to the mangroves may occur but the mangroves are expected to recover over time after decommissioning and closure. A *Minor positive* impact is expected as the mangroves recovers.

7.16.2 Mitigation

Mitigation Objective

To minimize the impacts on land and adjacent mangroves during construction of land-based facilities at Chinde.

Mitigation Measure(s)

- Clearly demarcate a no-go area beyond which personnel and equipment are not allowed to go.

- The removal of mangrove trees by workers or for construction purposes must be prohibited.

- No excavation within the mangrove for laying down the pumpout pipeline should be permitted. The pumpout pipeline must be laid over an elevated walkway along the length of its route. Alternatively the fuel barge tie zone should be located within the Maria River and the pumpout pipeline aligned behind the mangrove.

- Develop and implement spill prevention and emergency spill clean up (e.g. using absorbent material, soil remediation where necessary) measures.

- Preventive and periodic maintenance of machines and vehicles in order to avoid breakdowns and the subsequent spillage of oil and fuel.

- Maintenance of equipment or vehicles to be carried out in specially designated areas an impermeable surface with adequate drainage and collection of any spills.

- Should soil be contaminated with diesel or oil, it must be subjected to appropriate bioremediation methods.

- Storage areas for fuel and other chemicals must be located at least 50m from the bank of the Zambezi River. Storage areas for chemicals must have appropriate signs in English and Portuguese and be built on cement, in impermeable containment basins that retain and permit the collection of possible spills.

- Employees working with chemical products must receive appropriate instructions and personal protection equipment (such as gloves, masks, uniforms).

- In order to avoid possible spills, the following precautions are recommended when storing and handling fuel and lubricants:
    - Fuel tanks with a capacity of more than 1000 litres must be placed on flat or slightly sloping land, surrounded by a retention basin with a capacity that is equal to 110 percent of the total tank volume. The walls and foundation of this basin must be made of impermeable material or have an appropriate lining in order to ensure that any spill can be contained. A system for collecting spilled chemicals must be installed (e.g. a drain leading to an impermeable collecting tank);
    - The storage of fuel and the maintenance or re-supply of vehicles or equipment must take place not less than 50 meters from the Zambezi River and the mangroves.
    - Used oil must be stored in sealed drums, and must not be mixed with other substances such as petrol, solvents and anti-freeze. Used oil may be returned to the supplier for subsequent recycling.

- The area where the work is under way must be kept clean and waste must not be burnt, buried or discarded indiscriminately.

- Scrap metal must be removed from the area and disposed of appropriately.

- Waste containers with monkey-proof lids must be provided and emptied regularly. Waste must be disposed of appropriately at a waste site.

- Biodegradable material can be used for making compost to assist the re-vegetation of any disturbed areas or deposited in waste pits and then covered in soil.

7.16.3 *Residual Impact*

The proposed mitigation measures will reduce the intensity of the impact. Nonetheless the residual impact is still expected to be *Minor*.

Table 7.17 Impact of Chinde Land Based Facilities on Mangroves

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Long Term	Long Term
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long Term	Long Term
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	Long Term	Long Term
Scale	Site Specific	Site Specific
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor

7.17 *DISTURBANCE TO RIPARIAN HABITATS DUE TO DREDGING AND SPOIL DEPOSITION*

7.17.1 *Impact Assessment*

Dredging will be carried out by eight barges operating in parallel 24 hours per day 7 days a week over an 18 month period Maintenance dredging is planned to occur through the life of the Project and is estimated to remove25 percent of the capital dredge volume annually. Dredging activities could result in disturbance to vegetated islands and sandy islands (for example by laying the discharge pipeline across islands and workers trampling on the islands).

In light of the results of the EF Study the estimated change in water levels is unlikely to result in major changes to riparian habitats. The expected duration of the impact would be long term and local in extent. The intensity would be low resulting in a low magnitude impact. Coupled with a likely probability of occurrence a *Minor* significance impact is expected. This impact will not be felt during the decommissioning and closure phase.

7.17.2 Mitigation

Mitigation Objective

To minimize impacts on riparian habitats due to dredging associated activities.

Mitigation measure(s)

- Discharge pipelines should not be laid across islands.
- Sandy and vegetation islands should be considered no-go zone for any activities due to their importance as bird restore, resting and feeding areas

7.17.3 Residual Impact

The residual impact is expected to remain as *Minor*.

Table 7.18 Disturbance to Riparian Habitats due to Dredging and Spoil Deposition

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short term	Short term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long term	Long term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.18 IMPACT OF ACCIDENTAL FUEL SPILLS ON RIPARIAN HABITATS

7.18.1 Impact Assessment

A 3,600HP push boat (1.8m draft) will carry 85 cubic metres (85,000 litres) of diesel fuel. These will be in 8 tanks ranging from 9.8 cubic meters (9,800 litres) to 20 cubic meters (20,000 litres). A larger 4,500HP boat, which will have a draft of 2.15m, will carry 135 cubic metres (135,000 litres) of diesel fuel. The push boats are double hulled and the tanks, which sit on the inner side of the ballast tanks, are themselves double walled – i.e., there are at least 4 steel walls between the fuel and the water.

A fuel barge will used to transport fuel to the land depots (Chinde and possibly Benga) to supply fuel for barging operations. The proposed fuel barge will be a marine certified double hulled flat top barge with a capacity approximately 3,180m^3 of diesel fuel (3,180,000 litres). During dredging operations fuel barges will be used to service the dredgers. These fuel barges will be constructed with heavy wall plating with the corners double plated. Movement of these fuel barges from location to location is minimal as they are anchored at a location near the dredge site where fuel can be transferred to the dredger via an auxiliary tug in smaller amounts. Dredger fuel barges will have a capacity of 500m^3 (500,000 litres). Fuel is stored within 4 separate tanks up to 125m^3 (125,000 litres) per tank. It is likely that dredgers will operate in groups of 2 or 3 per location with one fuel barge servicing each group.

Localized oils spills could occur during bunkering or transfer of fuel. It is highly unlikely there could be a simultaneous rupture of more than one of the fuel tanks of a push boat at any one time. In any event the amount of oil will be relatively small compared to volume and flow of the river (e.g. 20,000 litres from the largest fuel tank of a 3600HP push boat) and should rapidly spread along the surface of the river and eventually break up and dissipate.

In the event of a catastrophic non-routine event such an explosion on the fuel barge a relatively large amount of fuel could be released into the water and some of the spill may reach land and contaminate riparian habitats. The likelihood of this occurring is considered to be low.

This impact is likely to be felt primarily during the construction and operational phases. For both phases the extent and duration of the worst case scenario would be limited. The duration of the impact is also likely to be short term as diesel evaporates fairly rapidly. Should the impact occur a medium intensity impact can be expected depending on where such an accident occurs. A medium to high magnitude coupled with an unlikely probability results in a *Moderate* significance impact for both phases.

7.18.2 Mitigation

Mitigation Objective

To minimize impacts on riparian habitats due to diesel spills.

Mitigation measure(s)

- Implement good operating procedures.
- Develop and implement procedures for spill prevention and emergency spill clean up (e.g. using absorbent material, soil remediation where necessary) measures.
- Crews should be trained for emergency response and oil spill clean ups.
- Ensure that pipes and hoses are properly connected, closed and in good condition when bunkering.
- Make available absorbent pads near the area where spills may occur on board vessels.
- For major oil spills on water ensure that floating booms are available to contain spills (however this will only be effective in sheltered areas).
- Ensure that transfer hoses are of sufficient length and strength to manoeuvre vessels according to the river flow conditions.
- Incorporate automatic shut off valves.
- Ensure the refuelling area is well lit during night operations.
- Develop a management plan that may include provision to desist from refuelling operations during inclement weather.

7.18.3 *Residual Impact*

Post implementation of the above mitigation measures, the potential impact is likely to be *Minor* depending on where the spill occurs and the speed of remediation measures.

Table 7.19 Impact of Accidental Fuel Spills on Riparian Habitats

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Medium
Magnitude	Medium to high	Low to medium
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
	Operational Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Medium

	Without mitigation	Residual Impact (With mitigation)
Magnitude	Medium to high	Low to medium
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the project the potential for accidental spills on riparian habitats will be eliminated.	

7.19 *INCREASE IN RATE OF EROSION OF RIPARIAN HABITATS DUE WAKES FROM BARGES AND PUSH BOATS*

7.19.1 *Impact Assessment*

Alluvial terraces are particularly prone to erosion from the action of waves. The current erosion patterns have been attributed to the decreased sediment load in the Zambezi River due to the impoundments at Kariba and Cahora Bassa. Along many stretches of the Zambezi River alluvial terraces are already subject to erosion as highlighted at Marromeu where the railway that originally ran along the bank of the River is now collapsing into the river. The wake from convoys and boat traffic moving up and down the river could result in an increase in the rate of erosion at alluvial terraces, mangrove terraces and sand banks and sandy margins.

One area of potential concern is around the mouth at Chinde, where the banks of mangrove and salt marsh areas are composed of very fine material (Southern Waters Ecological Research and Consulting, 2010). The sediments here may be more susceptible to erosion since the fine clays and silts are dispersive and can go into solution more easily than those in the upstream reaches of the river particularly where the marginal vegetation has been removed. Bird species that commonly feed on the mudflats adjacent to the mangroves are the open billed stork, the little tern, the little egret and the white breasted cormorant. The mangroves are important habitats for a number of bird species including the mangrove kingfisher.

The collapse of river banks due to wakes and waves may affect several bird species. For example the pied kingfisher will lose two key elements for survival, namely branches for perching (because the bushes will disappear with the collapse of the margins) and loss of stable walls for nesting. The collapse and destruction of nests can coincide with the period of laying or hatching resulting in the death of nesting pairs or chicks or the destruction of eggs. This may affect the population of this bird and others with similar habit in terms of feeding such as Giant kingfisher, mangrove kingfisher and malachite kingfisher. Several other bird species nest in the alluvial terraces that line the banks of the Zambezi River including three species of bee eaters, two species of swallows and the sand martin.

The wake magnitude depends on the speed of the convoy and the depth of the navigable channel. The impact of the wake depends on these factors as well as proximity of the bank to the navigable channel. The further away the bank, the less the impact. According to the wake study (Robert Allan, 2010) for loaded barges with the convoys moving downstream at 5.0 knots through the water the surface waves generated at the bow and stern of the convoy are insignificant (changes in elevation of 0.1m to 0.3m) and quickly dissipate within a short distance from the convoy. The impact of wakes is more pronounced for lightly loaded barges moving upstream. At 9 knots through the water upstream, the convoy will generate changes of elevation from 0.2m to 0.5m. These turn into a wave system when the wake propagates from the navigable channel into shallower water. The study shows that when the speed is reduced to 7 knots through the water, while changes in elevation do remain (close to the convoy), it dissipates fairly rapidly and the surface wave system in the shallow water disappears.

Without mitigation, the intensity would be low to medium depending on the speed of the barge convoys. This will result in a medium magnitude impact. Coupled with a likely probability of occurrence a *Moderate* significance impact is expected. This impact will not be felt during the construction and decommissioning and closure phases.

7.19.2 Mitigation

Mitigation Objective

To minimize potential erosion of riparian habitats arising from wakes and waves produced during barging operations.

Mitigation Measure(s)

- Implement and enforce speed limits.
- Loaded barges moving downstream should not exceed 9 knots through the water.
- Light barges moving upstream should not exceed 7 knots through the water and should not exceed 5 knots in the vicinity of the mangroves at Chinde.

7.19.3 Residual Impact

The residual impact is likely to remain as *Minor* for both phases.
of Riparian Habitats due Wakes from Barges and Push boats

Table 7.20 Increase in Rate of Erosion due to Wakes of Riparian Habitats due Wakes from Barges and Push boats

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Low to medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project the barging operation will cease and there will no longer be wakes due to barges and push boats	

7.20 CHANGES TO HIPPOPOTAMUS BEHAVIOUR AND AN INCREASE IN HUMAN ANIMAL CONFLICT

7.20.1 Impact Assessment

Hippos remain in the river during the day and emerge at night to graze on river banks. Their feeding behaviour is nocturnal and they are able to hide in narrow channels and impenetrable reedbeds during the day where they are relatively safe from human predation and stay cool in the heat of the day. They can remain under water for periods longer than five minutes and surface to breathe with only their nostrils appearing above the water. Hippo group size is an extremely variable; groups of between four and 15 animals were observed during the survey.

Although hippo are predominantly grazers of wild grasses and sedges, given the opportunity they will consume maize, sugar cane, pumpkins, beans, melons and other vegetables. Their damages to crops planted close to river margins can be devastating and this is source of animal - human conflict along the Zambezi River.

Dredging will affect the submerged habitats within the active channel where hippos remain submerged during the day which may force them to move closer to river banks. The position of the dredge path and the areas where spoil is expected to be deposited will influence the impact on changes to hippo behaviour. According to the EF Study (Southern Waters,

2010) spoil deposition in the lees of islands and mid-channel bars results in less percentage change to overall change to availability of different depth classes within their study reaches. Although dredging will widen and deepen the main channel (thalweg) this area will not be available to hippos while barges are using the navigable channel (three with possibly a conservative estimate of seven convoys passing a point every 24 hours). Nonetheless, significant areas of habitats of all depth classes are still available in the active channel and hippos, being highly mobile, should be able move to other submerged habitats – this was noted during the fieldwork when hippos moved out of the way of the boat well in advance of the boat's passage. This means that the likelihood of increasing human/ hippo interactions is unlikely. Thus even should magnitude be medium, the significance of this impact is likely to be *Minor* for both construction and operation phases. This impact will not occur in the decommissioning and closure phase.

7.20.2 Mitigation

Mitigation Objective

To minimise the impacts on submerged habitats for hippos and hence to minimise altering hippo behaviour.

Mitigation Measure(s)

- Deposit dredged material in the lee of islands and sandbars where practicable as this will reduce changes to the various depth classes in the river.
- The imposition of speed restrictions on barge convoys (to reduce wake and riparian erosion) will reduce any disturbances to hippo.
- Implement and enforce speed limits. Loaded barges moving downstream should not exceed 5 knots through the water. Light barges moving upstream should not exceed 7 knots through the water.
- Implement and enforce speed limits. Loaded barges moving downstream should not exceed 5 knots. Light barges moving upstream should not exceed 7 knots.

7.20.3 Residual Impact

The magnitude of the impact may drop slightly with the implementation of the mitigation measures. Accordingly the significance of the expected impact is likely to be *Negligible* to *Minor* for the contraction and operation phases.

Table 7.21 Changes to Hippopotamus Behaviour and an Increase in Human Animal Conflict

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Negligible to Minor
	Operational Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Negligible to Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project there will not be a need to dredge which will eliminate potential human animal conflict.	

7.21 *IMPACT OF HUMAN AND VEHICLE TRAFFIC ON SALT MARSH HABITAT*

7.21.1 *Impact Assessment*

Salt marshes are developed on the edges of creeks draining the mangrove areas and on the tidally wetted areas fringing the saline mudflats. The EF Study indicates that the total area of salt marsh that could be affected by changes in water levels is approximately 2%. Given no serious disruptions of the soil horizons, is expected during construction or operation, any minor disturbed areas due to construction of the berthing infrastructure and land based support facilities, would recover moderately quickly if salt marsh sods are left undisturbed or replaced from adjacent healthy stands if disturbed.

Given the medium intensity, on site extent and short term duration of the potential impact, the magnitude is expected to be low. The probability of some disturbance occurring is likely, resulting in the impact being rated as *Minor* during both the construction and operational phases of the Project. No impact is expected during Decommissioning and Closure.

7.21.2 *Mitigation Measures:*

Mitigation Objective

To minimise disturbance to salt marsh habitats.

Mitigation Measure(s)

- Ensure that care and attention is applied to reduce damage and assist recovery of damaged areas through sod replacement is recommended.

- Demarcates salt marsh areas as no-go areas.

7.21.3 Residual Impact

Given the rapid recovery time, the residual impact is considered to be *Negligible*.

Table 7.22 Impact of Human and Vehicle Traffic on Salt Marshes

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short Term	Short Term
Scale	Site Specific	Site Specific
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Operational Phase	
Duration	Short Term	Short Term
Scale	Site Specific	Site Specific
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	At the end of the Project the recovery of disturbed plants and areas should be moderately quick if salt marsh sods are left undisturbed or replaced from adjacent healthy stands if disturbed.	

7.22 Impact of Noise on River and Estuarine Fauna

7.22.1 Impact Assessment

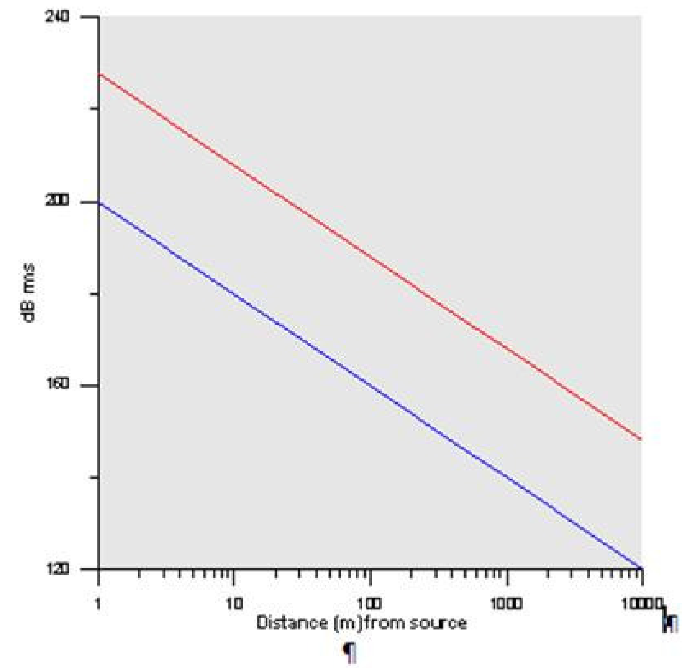
The piling method that will be employed to create the dolphin berthing facilities has not been specified at this stage of the project design but can be either percussion or vibratory/oscillatory pile driving.

Both percussion and vibratory/oscillatory pile driving will generate noise underwater. At the Benga load out point and in the Chinde River estuary the main organisms at risk from the pile driving noise (pressure wave) will be fish as invertebrates do not have air bladders neither do they appear to use sound in communication and so are considered to be impervious to underwater sound at these levels. Fish mortality appears to require very high sound intensity levels. Hastings (1990, in Turnpenny and Nedwell, 1994) found that lethal thresholds for fish began at 229 dB re 1 µPascal rms[1] and transient stunning was reported at 192-198 dB received, but that captive fish usually recovered after 30 minutes. Turnpenny and Nedwell (1994) noted that such transient stunning could be lethal in the wild due to an increase in predation but this, of course, requires that the predator is not similarly affected. Conversely, Santulli *et al.* (1999) reported no mortalities or overt pathological injury to caged European sea bass when exposed to received sound intensity levels above 200 dB re 1 µPascal rms.

Sound transmission loss in shallow waters is highly variable. Using standard sound attenuation curves (*Figure 7.2*). This indicates that fish within 600m may suffer permanent hearing impairment from percussion piling. For oscillatory/vibratory piling this reduces to 300m. This means the impact will have a local extent and short term duration (construction phase only). Intensity would be medium but overall magnitude is likely to be low. A *Minor* significance impact is expected. This impact is restricted to the construction phase.

(1) [1] Broadband sound intensity data (dB re 1 µPa @ 1 m) are generally reported as peak to peak (p-p), zero to peak (0-p), root mean squared (rms) and/or sound exposure level (SEL). Safety radii are currently specified in rms units (US NMFS 2000). The following approximate conversions apply for the same sound measured at the same location:
(2) 160 dB re 1 µPa @ 1 m_{rms} = $170\text{-}172_{0\text{-}p}$, $176\text{-}178_{p\text{-}p}$ and 145-150 dB re 1 $Pa^2.s_{SEL}$ (from LGL 2010).

Figure 7.2 ***Sound attenuation with distance estimated from Madsen et al. (2006). The red line represents attenuation from percussion and the blue line that from oscillatory/vibration pile driving methods***



7.22.2 *Mitigation Measures*

Mitigation Objective

To minimise noise disturbance during the construction phase.

Mitigation Measure(s)

The recommended mitigation is to use oscillatory/vibratory piling techniques as opposed to percussion piling. In this scenario the impact would be more spatially constrained and therefore be of very low magnitude and short term duration. Should geotechnical conditions dictate use of percussion techniques, the following measures should be adopted. (eg daylight between 8am and 5pm with respite periods.)

7.22.3 *Residual Impact*

The impact will be short lived so the residual impact is considered to be *Negligible*.

Table 7.23 Impact of Noise on River and Estuarine Fauna

	Without mitigation	Residual Impact (With mitigation)
		Construction Phase
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
		Operational Phase
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
		Decommissioning and Closure Phase
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.23 IMPACT OF DREDGING OF THE OFFSHORE SAND BAR ON SEA BED BENTHIC ORGANISMS

7.23.1 Impact Assessment

The offshore sand bar is to be dredged to safe navigation depths probably by a side casting trailer or trailer suction hopper dredger. The dredging will involve the removal of approximately 350,000m^3 of sediment from the bar, and its disposal into the near-shore, probably north east of the Chinde River. Capital dredging is expected to take two months to complete. In this process all of the benthic organisms in the dredge area sediments will be removed. The benthos in the dredge spoil dump area will be inundated by the dumped sediment. Maintenance dredging is expected be at a rate of at least 90,000m^3 annually and could be considerably higher. It is expected that maintenance dredging will need to be undertaken at irregular intervals throughout the year. The benthos in the dredge area will be prevented from recovering to a climax community due to the frequent disturbances and inundation at the spoil dump site should generate similar effects in the benthos. However, absolute mortality levels are unknown; these may be considerable in the dredging but minimal in spoil dumping (e.g. Maurer *et al.*, 1980, 1981, 1982).

Because of the relatively small area of disturbance, the magnitude of this impact is expected to be negligible. While the likelihood of the impact occurring is definite, coupled with a negligible magnitude, the overall significance is expected to be *Negligible* for both construction and operational phases.

7.23.2 *Mitigation Measures*

None possible.

7.23.3 *Residual Impact*

This will remain as *Negligible*.

Table 7.24 Impact of Dredging of the Offshore Sandbar on Sea Bed Benthic Organisms

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Long Term	Long Term
Scale	Regional	Regional
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long Term	Long Term
Scale	Regional	Regional
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, there will be no dredging on the sand bar and benthic habitats are likely to return to present day conditions over time.	

7.24 *IMPACT OF DREDGING OF THE OFFSHORE SANDBAR ON SEAWATER QUALITY*

7.24.1 *Impact Assessment*

During the construction and operational phases of the Project, dredging is expected to result in increased sea water turbidity levels due to suspension of sediments at the dredge head on the sea floor, and at the sea surface through lean water overboard (LWOB). Further, any anthropogenic contaminants in the target dredge sediments may be remobilised. Both turbidity and re-suspended contaminants may compromise sea water quality.

The available sediment property data for the off shore sand bar indicates that it is comprised of medium sand with a low mud content (PRDW 2010). Therefore generation of turbidity above what may be experienced in normal flood flows (e.g. *Figure 4.4)* is unlikely. The potential of coarse sediments to retain contaminants is low, and given the mainly rural nature of the Zambezi River catchment, there are no immediately obvious sources of such contaminants. Therefore the overall magnitude of this impact is Negligible. Together with a definite likelihood, the significance is expected to be *Negligible* during construction and operation.

7.24.2 *Mitigation Measures*

None necessary.

7.24.3 *Residual Impact*

This will remain as *Negligible*.

Table 7.25 Impact of Dredging of the Offshore Sandbar on the Seawater Quality

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Operational Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, there will be no dredging on the sand bar	

7.25 IMPACT OF ANCHORING OF TRANSLOADERS AND OGVS ON THE SOFALA BANK SEA BED

7.25.1 *Impact Assessment*

During the operational phase of the Project the offshore ship-loader will be maintained on position by anchoring. The anchors and anchor chains will represent an artificial hard substrate in an area that is typically soft muddy-sand or sandy-mud sediment habitat. This artificial substrate will eliminate the sub-sediment benthos community on which it is placed. Further, movement of chains with the motion of the vessel at the surface will chronically disturb the surface of the sea bed. Both artificial substrate and scraping movements will affect the benthos community in the anchoring area. This impact will not occur during the construction phase and decommissioning and closure phase.

Over the life of the project this impact would have a site-specific extent with a low intensity, resulting in a low magnitude. This means that the expected significance of this impact is *Minor*.

An exclusion zone of 500m would apply beyond all anchored vessels.

7.25.2 *Mitigation Measures*

Mitigation Objective

To minimise the area disturbed by the anchoring system.

Mitigation Measure(s)

Ensure that the transloader and ocean going vessel are always anchored within the same defined area for the two classes of ocean going vessels (Panamax and Cape class).

7.25.3 *Residual Impact*

The mitigation measure is expected reduce the impact to *Negligible*.

Table 7.26 Impact of Anchoring of Transloaders and OGVs on the Sofala Bank Sea Bed

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long Term	Long Term
Scale	On site	On site
Intensity	Low	Negligible
Magnitude	Low	Low
Likelihood	Definite	Likely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.26 *IMPACT OF COAL DUST ON VEGETATION AND WATER QUALITY IN THE ESTUARY*

7.26.1 *Impact Assessment*

It is considered probable that coal dust will be generated by coal handling at the Chinde facilities during transfers between river and ocean going barges. This will only occur during the operational phase.

Coal dust deposition areas are uncertain as the dust behaviour has not been modelled. It is expected that the amounts that may be generated will be small and that the generation point will be 2-3 m above the water surface, areas affected should be relatively minor.

Coal dust can affect estuary water quality through altering pH (linked to the sulphur content of the coal) and increasing turbidity. Further, coal dust can modify sediment properties on intertidal sand flats that probably support benthic microalgae affecting productivity. Coal dust can coat mangrove tree leaves reducing light levels that reach chloroplasts and thereby affecting photosynthesis and ultimately tree growth (Naidoo and Chirkoot, 2004). There is no evidence that coal dust is toxic to mangroves or that acute effects may be generated by exposure to coal dust (Ahrens and Morrisey, 2005). There are species specific differences in effects on photosynthesis in that the smooth leaves typical of *Rhizophora* and *Bruguiera* do not generally retain coal dust whereas the hairy leaves of *Avicennia* do. Hence Naidoo and Chirkoot (2004) observed more severe stunting in the latter species close to coal stockpiles in Richards Bay, South Africa compared to the other two species.

There is no evidence of direct effects of coal dust on salt marsh plants although a similar effect to that of mangroves may occur if coal dust settlement generates a continuous layer on the leaves of salt marsh plants (Ahrens and Morrisey 2005). Artisanal fishers dry portions of their catches on exposed sand areas near Chinde town and coal dust may compromise fish quality or the perception of fish quality.

The Chinde River estuary is generally turbid and therefore increased turbidity due to coal dust deposition is unlikely to cause ecological effects. Reductions in water pH levels are apparently unlikely due to low sulphur concentrations (~1% by weight, Riversdale data) according to data listed in Ahrens and Morrisey (2005). This is reinforced by the high buffering capacity of seawater (e.g. Parsons *et al.,* 1977). Therefore no effects are expected at the amounts of coal dust that may reach the water surface.

Coal dust may deposit on exposed intertidal sand flats during low tide periods. The coal dust will be light (density <1 g/cm^3, http://www.powderandbulk.com, viewed on 13 December 2010) and therefore easily re-suspended by turbulent flow of the rising tide and transported off the sand flat. Therefore exposure, if any, of benthic microalgae is predicted to be very short term (<2-3 hours) with negligible implications for photosynthesis and benthic microalgae production.

Chronic levels of deposition in mangroves may well generate negative effects through alteration of mangrove species distributions via the reduction in *A. marina* and the associated implications for use of mangroves by especially white shrimp *Penaeus indicus* juveniles (Ronnback *et al.*, 2002). This may affect recruitment to the semi-industrial and industrial fishery. The degree that this occurs is related to the area of mangrove habitat that is threatened. Given that any potential impact on mangroves will occur within a mangrove area of about 11,000ha, the likely magnitude of the impact would be low. This results in an impact of *Minor* significance.

7.26.2 *Mitigation Measures*

Mitigation Objective

To minimise the generation of coal dust.

Mitigation Measure(s)

Reduce the potential of wide dispersal of coal dust by minimising the elevation from which coal is discharged into hoppers during transfers

7.26.3 *Residual Impact*

The mitigation measure is expected remain *Minor*.

Table 7.27 Impact of Coal Dust on Vegetation and Water Quality in the Estuary

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long Term	Long Term
Scale	Site Specific	Site Specific
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.27 *IMPACT OF OPERATIONAL COAL SPILLAGE ON THE ESTUARY ENVIRONMENT*

7.27.1 *Impact Assessment*

During the operational phase it is possible that some coal may be spilled overboard during transfers between river and ocean-going barges at the Chinde facilities. This material will modify the mainly muddy-sand/sandy-mud texture of the seabed in the estuary and will probably collect, temporarily or permanently, in low current depositional areas. Such collection areas will be transformed from sedimentary to comparatively hard substrate seafloors with corresponding alterations in benthos, e.g. development of filter feeding community (oysters, barnacles) on coal rubble (Ahrens and Morrisey 2005), and possibly trophic interactions.

PRDW (2010) estimate the critical flow velocities to keep coal particles suspended and flushed out of the estuary. They show that for the larger lumps of coal (50mm diameter) flood events with current velocities in excess of 3m/s would be required to suspend and transport such coal out of the estuary. In contrast finer coal sizes will be transported out of the system by normal tidal currents even at neap tide. PRDW (2010) note that their suspension and transport estimates may be conservative as they are based on the Hjulström curve for river sediments (density ~2.6g/cm^3) while coal density is typically 1.5g/cm^3 (http://wiki.answers.com, viewed on 13 December 2010). However, the nature of the sediments in which the coal deposits, e.g. sandy mud, may increase required resuspension velocities. As the successful transhipment of coal is the primary aim of the entire project we consider it probable that operational losses of coal will be kept to the absolute minimum. However, given the duration of the project appreciable amounts of coal may end up in the estuary water body. Given the hydrodynamic sea and estuarine processes, the intensity of impact is expected to be low. This, together with the site-specific and temporary nature if the impact results in a low magnitude. The expected significance is *Minor*.

7.27.2 *Mitigation Measures*

Mitigation Objective

To minimise coal spillage.

Mitigation Measure(s)

- Good housekeeping and implementation of procedures to minimise coal spillages.
- A sacrificial zone around the coal transfer areas must be clearly demarcated, and spillage of coal within this zone can be tolerated.
-

- Develop a Coal Transfer Management Plan that includes monitoring of coal transfers and reporting of any coal spillages, regular testing of the river bottom both within the sacrificial zone and areas nearby areas of interest. Should coal be found outside the sacrificial zone, procedures will be incorporated of modified to avoid future spillages.

- Clean up coal where a spill is appreciable outside the designated sacrificial area and within low current speeds.

7.27.3 *Residual Impact*

The mitigation measure is expected remain *Minor*.

Table 7.28 Impact of Operational Coal Spillage on the Estuary Environment

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Temporary	Temporary
Scale	Site Specific	Site Specific
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.28 *IMPACT OF COAL DUST AND OPERATIONAL COAL SPILLAGE ON THE MARINE ENVIRONMENT*

7.28.1 *Impact Assessment*

During the operational phase it is possible that coal may be lost overboard of barges during transfers at the offshore ship-loader. This material will modify the mainly muddy-sand/sandy-mud texture of the seabed at this location, and at other sites if transported by seabed currents such as may be generated in storm conditions. The consequences will be alterations in benthos, e.g. development of sessile filter feeding community (mussels) and micro-predators (anemones) on coal rubble (Ahrens and Morrisey 2005), and possibly trophic interactions.

Coal dust generated during transfers can settle on the sea surface and add to seawater turbidity and modify pH balance. The offshore ship-loader position is towards the outer edge of the influence of the turbid water from the Zambezi River outflow (Siddorn *et al.,* 2001) so clear outer continental shelf water may be frequently present. Elevated turbidity may limit light penetration and thus reduce phytoplankton growth. pH may be reduced by the sulphur content in the coal. The target coal ore body has low sulphur content, however, and the buffering capacity of seawater will easily accommodate any added acidity by the coal.

Both of the coal dust effects are strongly dependent on the amounts of dust generated and, given the specified coal transfer methods of grabs and conveyers plus chutes, this should be minimal. As the successful transhipment of coal is the primary aim of the entire project we consider it probable that operational losses of coal will be kept to the absolute minimum. However, given the duration of the project appreciable amounts of coal may end up being lost overboard.

Though expected to be a long term to permanent impact, the low intensity and local extent result in a negligible magnitude. Relative to the offshore area, the impact is considered to be *Negligible*. This impact will only be realised during the operational phase.

7.28.2 Mitigation Measures

Mitigation Objective

To minimise the generation of coal dust and coal spillage.

Mitigation Measure(s)

- Reduce the potential of wide dispersal of coal dust by minimising the elevation from which coal is discharged into hoppers during transfers.
- Utilise an efficient transfer system using trained personnel to minimise coal spillages.
- Install catch plates or similar to capture spillages.

7.28.3 Residual Impact

The mitigation measure is expected remain *Negligible*.

Table 7.29 Impact of Coal Dust and Operational Coal Spillage on the Marine Environment

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Temporary	Temporary
Scale	Site Specific	Site Specific
Intensity	Low	Negligible
Magnitude	Negligible	Negligible
Likelihood	Likely	Likely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.29 *IMPACT OF OPERATIONAL DISCHARGES FROM OGVS ON THE MARINE AND ESTUARINE ENVIRONMENT*

7.29.1 *Impact Assessment*

During the operational phase the offshore ship-loader, service vessels, ships loading and unloading coal and those operating and being serviced in the Chinde River mouth area will inevitably produce various types of wastes. Any solid or liquid discharges landward of three nautical miles from the shore or entrance to the Chinde River mouth (i.e. from the baseline maritime zone) must be transported to port reception facilities. The effects of solid, liquid and gaseous discharges on the marine environment and relevant MARPOL requirements are as follows:

Sewage: Untreated sewage is a nutrient source for marine micro-organisms. It leads to a rise in bacterial levels in the water and an increased demand for oxygen. Bacteria metabolise sewage resulting in its rapid breakdown. Treated sewage should not increase the bacterial load of the sea but would increase biological oxygen demand. The volumes of sewage that will be generated on the industrial vessels will be low. MARPOL Annex IV (Prevention of pollution by sewage from ships) requires that sewage discharged from vessels be treated or comminuted (pulverised) and disinfected before discharge, and this must be at a distance of more than 3 nautical miles from the baseline maritime zone.

Deck drainage: Washings off the decks of the vessels could contain small amounts of oils, solvents and cleaners, which are potentially toxic to marine organisms. The volumes lost overboard would be small. There are no MARPOL standards for deck drainage.

Bilge water and machinery space drainage (including oily wastes from generators, fuel tanks and pumps) contain traces of oil. Low concentrations of petroleum hydrocarbons in water are readily absorbed or ingested by most marine organisms, with significant concentrations being taken up in a few hours. MARPOL Annex 1 (Prevention of pollution by oil) stipulates that the oil content of discharges originating from machinery space drainage of vessels must not exceed 15 ppm without dilution. No vessels may discharge oily wastes above these concentrations at sea and oily water must be processed in a suitable separation and treatment system before discharge. Non-complying oily wastes must be properly disposed of on shore.

Emissions to the atmosphere: Diesel is used aboard the vessels as fuel for generators and motors; exhaust gases comprise SO_2, CO, CO_2, NOx and particulates. Ozone depleting substances can be released either accidentally, during maintenance operations or during emergencies. These emissions are classified as pollutants and also contribute to the cumulative impact that 'greenhouse gases' have on global warming. MARPOL Annex VI (Prevention of air pollution from ships) sets limits on SO_2 and NOx emissions and prohibits the emissions of ozone depleting substances.

Galley waste and garbage: Galley (food) wastes are biodegradable and add to the organic and bacterial load in the sea. The volumes of galley wastes generated at sea will be low. Other wastes such as packaging, plastics, metal and glass can be hazardous, particularly to marine fauna if discharged overboard, or may constitute a visual pollutant on the shore or in river channels. Plastics in particular can persist for decades and can maim and kill marine mammals, turtles and birds which become entangled or ingest it. The impacts of the quantities of persistent or toxic rubbish that could be discarded by the vessels could be highly significant. MARPOL Annex V (Prevention of pollution by garbage from ships) requires biodegradable food waste and general garbage to be macerated to less than 25 mm in size and disposed of into the sea at a distance of greater than three nautical miles from the baseline maritime zone. Other wastes such as plastic, metals and other non-combustibles must be segregated and transferred to shore for recycling or disposal at appropriate land facilities. MARPOL Annex V and the London Convention prohibit the disposal of all plastics anywhere at sea.

If MARPOL requirements are met there will be no significant effect from operational discharges. Impacts will cease when operations end (note that if any synthetics/plastics have been discarded to sea marine life will be impacted for centuries). It is assumed that Riversdale will insist that all vessels at its facilities are compliant with MARPOL. This will result in a *Minor* significance impact. Non-compliance with regulations regarding routine operational emissions, discharges and waste disposal at sea will result in impacts of increased significance.

7.29.2 *Mitigation Measures*

Mitigation Objective

To minimise pollution and contamination from OGVs.

Mitigation Measure(s)

- Compliance with laws regulating routine operational discharges, emissions and waste disposal at sea.
- Adequate maintenance of ship engines, motors and generators to minimise soot content in exhaust gases.
- Minimisation of waste production and adoption of a 'cradle to grave' responsibility for wastes, and
- Compliance with approved Waste Management Plans.

7.29.3 *Residual Impact*

Implementation of the mitigation measures would reduce the impacts but not the significance rating. The significance is thus likely to remain *Minor*.

Table 7.30 Impact of Operational Discharges from OGVs on the Marine and Estuarine Environment

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.30 *IMPACT OF ACCIDENTAL FUEL SPILLS DURING FUEL TRANSFERS*

7.30.1 *Impact Assessment*

A tug refuelling facility is to be operated at Chinde during the operational phase. Marine diesel is to be stored on a barge and transferred to pushboats and tugs initially and possibly self-propelled sea-going barges in the future. Fuel spillage during transfers can generate lethal and sub-lethal effects on mangroves and salt marsh plants with implications for biological populations and processes dependent on these habitats. Recovery periods for affected areas can be long-term. This results in a medium intensity and medium magnitude. The unlikely probability results in a significance of *Minor*. The potential for the accidental discharge of hydrocarbons could occur during construction, operation or decommissioning and closure. The *Minor* significance is expected for all phases.

7.30.2 *Mitigation Measures*

Mitigation Objective

To minimise hydrocarbon spillages.

Mitigation Measure(s)

- Develop and implement procedures for spill prevention and emergency spill clean up (e.g. using absorbent material, soil remediation where necessary) measures.
- Use double skin reinforced hose for fuel transfers.
- Ensure that automatic shut-off valves are used to limit losses to the volume in the pipeline should this rupture.
- Use a designated dock for refuelling with fully maintained fuel storage and pumping systems.
- Limit fuel transfers to daylight as leaking fuel is difficult to detect at night.

7.30.3 *Residual Impact*

These measures should reduce both the likelihood and spread of any spilled fuel reducing the significance to *Low*.

Table 7.31 Impact of Accidental Fuel Spills during Fuel Transfers

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Low
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.31 IMPACT OF BALLAST WATER DISCHARGES ON THE MARINE ENVIRONMENT

7.31.1 Impact Assessment

This is an operational phase impact. By definition bulk carriers arriving in the offshore trans-shipment facility will be mostly empty of cargo and, for safe navigation, will be carrying ballast (loaded with water). This ballast water will be discharged during coal loading.

Ballast water discharges bring the risk of releasing organisms entrained in source ports into the receiving port environment. For example Carlton and Geller (1993) recorded >350 taxa in 'Japanese' ballast water samples taken from vessels in Oregon, USA. Most of these were holo- and mero-planktonic forms but all of the major marine taxa were represented. This case shows that it is possible to transport entire plankton species assemblages across oceans. Further, Hutchings (1992) has provided evidence that, when ballast water is drawn from heavily populated areas with inadequate waste water treatment systems, viral pathogens and contaminants can also be translocated through ballast water exchanges. In this regard IMO cites cases of cholera (*Vibrio cholerae*) apparently attributable to ballast water discharges (http://www.imo.org/Conventions). Once released into suitable environments (usually ports), alien species can become invasive through the establishment of populations and can disrupt ecological processes. Carlton and Geller (1993) record 45 'invasions' attributable to ballast water discharges in various coastal states around the world. The invasives include planktonic dinoflaggelates and copepoda, nektonic Scyphozoa, Ctenophora, Mysidacea and fish, and benthos such as Annelid oligochaeta and polychaeta, Crustacean brachyura and Molluscan bivalves.

In view of the recorded negative effects of alien species transfers, the International Maritime Organisation (IMO) considers their introductions to new environments via ship's ballast water, or other vectors, as one of the four greatest current threats to the world ocean (Awad *et al.*, 2004). The probability of alien species transfers in ballast water to the coastal areas or near-shore waters in Mozambique depends on the source of the ballast water (environmental matching with the destination port) and whether ballast water treatment has been applied (Carter, 2007). The probable trading areas for coal loaded off the Zambezi River include India and China. Both of these countries have 'tropical' ports indicating that there should be a high degree of environmental matching with central Mozambique in terms of seawater temperatures at least. Consequently organisms entrained in ballast water taken up in these areas will probably survive off Mozambique. Ballast water risk investigations in representative ports in India and China (Clarke *et al.*, 2004a & b, Anil *et al.*, 2004) show that both have organisms that are either known or suspected to be potentially invasive and harmful. Consequently it is expected that ballast water from these ports may contain harmful organisms that may be able to establish in Mozambique.

The scale of the threat of invasive species introductions via ballast water releases is also related to the degree of ballast water treatment. IMO (2004) considers that open ocean (water depths >200 m) ballast water exchanges, sufficient to achieve 95% volume replacement, will reduce the probabilities of release of non-indigenous organisms to acceptable levels. It is assumed that Riversdale will insist that bulk carriers loading coal at its facilities are compliant with the IMO ballast water exchange regulations. If invasive alien species are transferred to the Mozambican coast and continental shelf area effects on biodiversity and marine ecology may be severe as effects can reverberate even into fish quality (dinoflaggelate toxins). Should OGVs be compliant with IMO ballast water exchange regulations, the likelihood of the impact occurring is considered to be unlikely. Coupled with an overall medium magnitude, the significance of this impact is expected to be *Minor*.

7.31.2 Mitigation Measures

Mitigation Objective

To prevent alien invasive organisms from entering Mozambican coastal waters.

Mitigation Measure(s)

Apply the IMO (2004) recommended ballast water treatment procedures to bulk carriers loading off the Zambezi River and ensure that they are early adopters of new standards and treatment procedures accepted by IMO.

More definitive data on the major trading ports will improve the understanding of the risk and determine whether more stringent procedures, such as, e.g., heat or biocide treatment of ballast water or other measures may be required.

7.31.3 *Residual Impact*

These measures should reduce the likelihood of the impact occurring but not the significance. The significance is expected to remain as *Minor*.

Table 7.32 Impact of Ballast Water Discharges on the Marine Environment

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Permanent	Permanent
Scale	National	National
Intensity	Medium	Medium
Magnitude	Medium	Medium
Likelihood	Unlikely	Unlikely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.32 *IMPACT OF GROUNDINGS AND/OR COLLISIONS OF BARGES AND/ OR TUGS IN THE RIVER*

7.32.1 *Impact Assessment*

Where there is shipping activity there may be accidents. These may lead to wreckage on shore-lines and fuel spills etc. The former may disfigure the river and estuary environment but have negligible ecological consequences. Fuel spills, however, are a different matter in that they can spread widely and rapidly and can generate sub-lethal and lethal effects in mangroves and salt marshes.

NOAA (2002) chronicles a number of case histories of oiling of mangroves. Important findings include:

- Longevity of effects - The full extent of damage to mangroves only becomes apparent months or years after the oiling incident. Recovery from effects can take many years (10 – 20).

- The extent of oiling within mangrove stands or forests can be extensive with many trees being coated by heavy deposits of oil.

- Effects of oiling range from heavy defoliation and the death of trees in areas of heavy oiling to minimal leaf loss if lightly oiled.

- Recovery of mangrove trees correlates with the degree of oiling. In cases of heavy covering by oil recovery can extend beyond 4 years whereas light oiling may even lightly stimulate tree growth rates.

- A major, long term consequence of tree mortality can be the reduction of shoreline protection from the trees and thus erosion and morphological changes. Added to this can be effects on juvenile shrimp survival as the refuge function of mangroves at the fringe of the stands diminishes.

Effects on salt marsh plants can be as severe as much of the zone may become coated in a heavy layering of oil with high plant mortalities (e.g. Zhu *et al.,* 2004). The lethal response may be rapid with clear senescence of salt marsh plants within 10 days from initial exposure. Recovery periods from such oilings, including diesel fuel, can extend for 12-17 months or longer (Clarke and Ward 1994) and even then may result in modified community structure (Lin *et al.*, 2002). Normal biological succession may take some years to re-establish pre-oiling distributions (e.g. NOAA 2002).

Due to the potential impacts high intensity, long term and local extent, a high magnitude is expected. The likelihood is considered to be unlikely, which results in a *Moderate* significance impact during the operational phase. During the construction and decommissioning and closure phases, the volume of oil/fuel that could be spilled would be less than during operations, resulting in a lower magnitude and a *Minor* significance.

7.32.2 Mitigation Measures

Mitigation Objective

To prevent any accidents or collisions from occurring.

Mitigation Measure(s)

- Ensure experienced, certificated tug masters are employed.

- Implement traffic safety procedures and ensure that all operators are adequately trained.

- Ensure that spill prevention and spill remediation equipment is readily available and that personnel are adequately trained in their use.

7.32.3 Residual Impact

The significance is expected to reduce to *Minor* in all phases.

Table 7.33 Impact of Groundings and/or Collisions of Barges and/ or Tugs in the River

	Without mitigation	Residual Impact (With mitigation)
Construction Phase		
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Minor
Operational Phase		
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	High	Low
Magnitude	High	Low
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
Decommissioning and Closure Phase		
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Low	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Minor

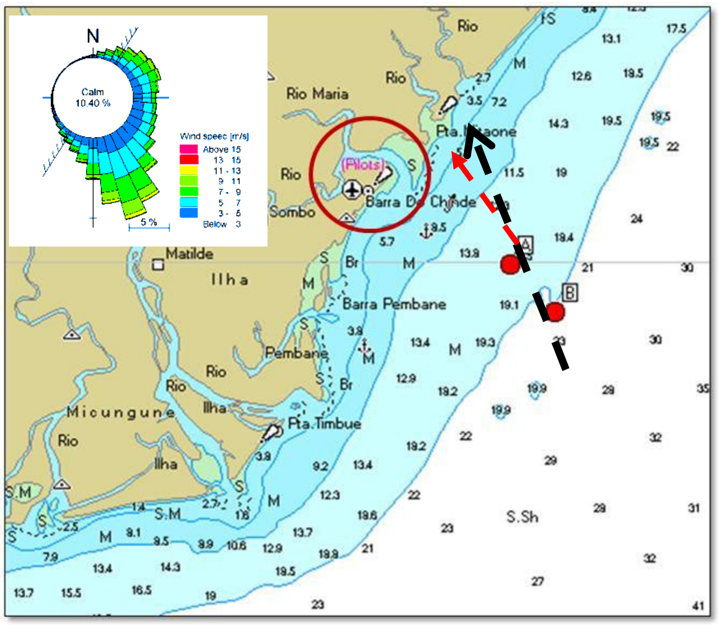
7.33 IMPACT OF COLLISIONS OF BARGES AND/ OR TUGS IN THE MARINE ENVIRONMENT

7.33.1 Impact Assessment

This is an operational phase potential impact. Shipping accident may lead to wreckage on shore-lines and oil/oil fuel spills etc. The former may disfigure the coastal environment but have negligible ecological consequences. Oil spills, however, can spread widely and rapidly and can generate sub-lethal and lethal effects in biological communities.

It is considered to be highly improbable that there would be fuel oil lost from bulk carriers whilst loading coal at the offshore ship-loader site as this would require grounding or sinking of the bulk carrier. Tugs, and eventually self-powered barges, are more vulnerable to damage and thus diesel fuel can be lost from these through collisions. Any spilt diesel would be transported by mainly wind driven currents at the sea surface. Velocity of such currents are generally 2% of the wind speed and direction slightly to the left of the wind due to Coriolis effects (e.g. http://oceanmotion.org visited on 12/12/2010). *Figure 7.3* shows a schematic of the probable oil spill trajectory in the prevailing wind field. It is apparent that, in this scenario, spilt diesel would head towards the coast and possibly reach the shoreline between Chinde and Quelimane. However, it must be borne in mind that oil spills are events in time and will respond to metocean conditions at the time of the spill which are not necessarily the median or average wind speed or direction.

Figure 7.3 ***Schematic showing probable oil spill trajectory. The inserted wind rose is from PRDW (2010). A & B show the probable ship-loader positions, the black arrow the dominant wind direction and the red curved arrow the associated wind driven surface current direction.***



Diesel is volatile and any spilt on the sea surface will be subjected to evaporation, mixing into the water column and weathering. The volume lost through these processes is mainly time dependent, given a uniform thin layer, and thus the period that the diesel takes to reach the coast will govern the amount that beaches.

The probably dominant trajectory indicates a travel distance of ~17km from ship-loader position A to the coast. 10m/s winds are close to the upper limit in the wind record (wind rose in *Figure 7.3*) which should generate a surface flow down the trajectory path of 20cm/s. The time for any oil lost at ship-loader site A to reach the shore under these conditions is therefore ~24 hours. Oil spill modelling conducted at comparable latitudes off Angola (ASA 2008) predicts that, after this period, 50 percent of the diesel would have evaporated and 14 percent would have been mixed down into the water column leaving 36 percent of the volume spilt available for beaching.

The upper limit of diesel spill volumes from a tug has been estimated as ~60m^3 (email from A. Menton, Riversdale, 15/12/2010). Therefore the amount that may reach the shore from the above calculations is ~22m^3 (19 tonnes). Most of the shoreline that may be affected is sandy. Sandy beaches are characteristically high energy and medium-coarse grained and are not known or expected to support unique biological communities. In the case of diesel, as it is a light oil, it is expected that it would rapidly percolate through the sands without making any strong layering (DTI 2007). Under these circumstances weathering will continue aided by the abrasion action of the sand grains. Therefore the consequences of a diesel spill – while expected to last weeks – are not likely to have long term deleterious effects on marine and coastal fauna. Accordingly, the medium magnitude and unlikely probability result in a *Minor* significance impact.

7.33.2 *Mitigation Measures*

Mitigation Objective

To prevent any damage to tugs and spills in the marine environment.

Mitigation Measure(s)

- Ensure experienced, certificated tug masters are employed.
- Implement traffic safety procedures and ensure that all operators are adequately trained.
- Ensure that spill prevention and spill remediation equipment is readily available and that personnel are adequately trained in their use.
- Ensure tugs have protected fuel tanks.

7.33.3 *Residual Impact*

The significance is expected to remain as *Minor*.

Table 7.34 Impact of Collisions of Barges and/ or Tugs in the Marine Environment

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Temporary	Temporary
Scale	Regional	Regional
Intensity	Medium	Low
Magnitude	Medium	Medium
Likelihood	Unlikely	Unlikely

	Without mitigation	Residual Impact (With mitigation)
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a

7.34 IMPACT OF SALINITY INTRUSION ON THE ESTUARY DUE TO DREDGING OF THE OFFSHORE SANDBAR

7.34.1 Impact Assessment

During the construction and operational phases of the Project the offshore sandbar at Chinde will be dredged. The sandbar is a dynamic sediment transport feature affected by the sediment load from the river and the littoral drift along the coastline. In stratified waters, river mouth sand bars inhibit full mixing of high salinity sea water with fresh water from the river. This reduces the level of salinity in the estuary of the river mouth and limits the intrusion of sea water up the river during flood tides.

During the construction phase, an entrance channel will be dredged through the bar to a depth of approximately 4 m below Chart Datum and 100 m width (G. Britton 2010, pers. comm., 15 November) in order to allow access to coal barge and service vessels to the offshore transloader facility. In order to maintain the navigable width and depth of the channel at least approximately 25% of the construction phase dredging will be required per year as maintenance dredging.

Due to the recorded instances of saline intrusion up the Zambezi River and the small percentage increase of the critical flow area for the proposed navigation channel dredged area relative to the existing area, it is considered unlikely that the increase in salinity will be significant. A low magnitude of impact coupled with a likely probability results in a *Minor* significance.

7.34.2 Mitigation Measures

None required.

7.34.3 Residual Impact

The significance is expected to remain as *Minor*.

Table 7.35 *Impact of Salinity Intrusion on the Estuary due to Dredging of the Offshore Sandbar*

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, there will be no dredging	

7.35 *IMPACT OF DREDGING THE OFFSHORE SANDBAR ON LITTORAL DRIFT SEDIMENT DYNAMICS AND BEACH EROSION*

7.35.1 *Impact Assessment*

During the construction and operational phases the increased depth of the channel may negatively impact the littoral drift along the coast. Baseline studies have indicated that the predominant direction of sediment transport along the affected coastline is from south to north. Littoral transport of sediment provides coastal areas with available sediment to maintain a state of dynamic equilibrium. The dredging of a channel can potentially trap sediment which could then be removed from the system by dredging and thus starve the downdrift beaches of sediment, leading to erosion of these beaches. The effects on erosion will only be noticeable relative to the underlying long term accretion of the river mouth and adjacent beaches. For example, if the existing sediment transport processes are causing an accretion of the coastline of 50m per year for the northern beach, a reduction of this accretion to 25m per year should be considered a relative erosion of 25m per year, due to the lack of sediment availability across the navigation channel.

The proposed dredge volumes are a significant percentage of the littoral transport. Dredging of the navigation channel would thus have a significant impact on the longshore drift towards the northern beaches, should the dredged sediment be removed from the littoral system, e.g. by disposing the sediment far offshore. This assessment assumes the worst case scenario i.e. the spoil is deposited away from the nearshore littoral system and is thus "lost" to the system. The intensity is considered to be medium over a long term and local area. The resultant medium magnitude, coupled with a likely probability, result in a *Moderate* significance impact.

7.35.2 *Mitigation*

Mitigation Objective

To prevent erosion of the beaches at Chinde.

Mitigation Measure(s)

Deposit dredge spoil to the north of the channel and within the littoral zone, i.e. at a depth shallower than -5m CD.

7.35.3 *Residual Impact*

With the implementation of the above mitigation, the significance is expected to reduce to *Minor*, as the sediment will remain within the system and will continue to "feed" the north beach.

Table 7.36 Impact of Dredging the Offshore Sandbar on Littoral Drift Sediment Dynamics and Beach Erosion

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, there will be no dredging	

7.36 *IMPACT OF LAND-BASED FACILITIES ON BIRD HABITATS*

7.36.1 *Impact Assessment*

The infrastructure will be constructed at Benga, Dona Ana Bridge and on the north bank of the Zambezi River near Chinde. Office, bathrooms, fuel tanks, coal water setting tanks and locker rooms will be constructed at Benga. The deployment of this infrastructure will require the acquisition of a small area of land. The area for the installation of infrastructure at Benga is highly disturbed although the remnant habitats and trees are visited by some bird species.

A number of structures will be built predominantly outside of the largely intact mangroves on the north bank of the Zambezi River opposite Chinde. The proposed alignment of the pumpout pipeline from the fuel barge tie zone to pump oil bilge and coal wash to the waste treatment plant passes directly through the eastern boundary of the mangrove area (*Figure 4.7*). Construction activities therefore could result in disturbance or partial loss of the mangrove forest. This may in turn affect bird species in the area. As the structures at Chinde are not located directly within the mangrove (except for the proposed alignment of the pipeline) only a small area of bird nesting and feeding habitats may be affected. The construction activities will result in the generation of waste, which, unless disposed of appropriately, has the potential to contaminate bird habitats, especially in the mangroves. Waste will however be contained, treated and disposed of in accordance with good practice. All construction employees will be trained regarding good "housekeeping".

Some riparian habitats may be disturbed at Benga, Dona Ana and Chinde due to the construction of mooring points, pipelines and floating transfer stations.

This impact would occur during the construction phase and continue in the operational phase. The area of disturbance would be site specific with a low intensity. The overall magnitude is expected to be low (given the small area of disturbance) with a likely probability of occurrence. Therefore the significance of the impact is expected to be *Minor*.

7.36.2 *Mitigation*

Mitigation Objective

To minimize the loss of and/or disturbance to bird habitats and land for infrastructures

Mitigation measure(s)

- A bird specialist or experience birder must visit the project impact sites in the delta region downstream of Dona Ana to confirm that the impact zones do not include any significant roosting or nesting sites. This confirmatory visit should be undertaken during the breeding season during April-May and should be early enough so that any significant findings can be used to modify the project footprint in mitigation of anticipated significant impacts.

- All construction workers must preserve wherever possible natural tree cover fringing riparian trees along the Zambezi River and mangroves.

- All work is to be limited to a designated work area.

- After the works have ended and the temporary infrastructure has been removed, degraded areas must be rehabilitated in order to restore the natural situation. The growth of native vegetation to attract birds should be encouraged rather than the planting of exotic species.

- Construction materials and waste must not be disposed of on site.

- Limit the creation and dimensions of access roads in the mangrove area to that which is strictly necessary.

7.36.3 Residual Impact

The residual impact is expected to remain as *Minor*.

Table 7.37 Impact of Land-based Facilities on Bird Habitat

	Without mitigation	Residual Impact (With mitigation)
Construction Phase		
Duration	Short-term	Short-term
Scale	On site	On site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
Operational Phase		
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
Decommissioning and Closure Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.37 *IMPACT OF NOISE ON BIRDS*

7.37.1 *Impact Assessment*

Noise will be generated primarily during the construction phase when mooring points will be pile driven into the river bed at Benga, Dona Ana and Chinde. At Chinde these will be on the north bank (looking downstream) of the Zambezi River from the point of confluence with the Maria River, within the Maria River as well as on the south banks.

Pile driving is the noisiest activity during the construction phase. Studies of the impacts of pile driving on water birds have shown that birds within 300m tended to flush and depart the area when pile driving commenced. Several returned to sit on the water within six minutes after pile driving (http://www.wsdot.wa.gov/Environment/Air/PileDrivingReports.htm).

Short term the noise from pile driving may affect reproductive behaviour. Birds may temporarily abandon their egg-laying areas. These disturbances may affect bird species such as mangrove kingfisher, pelicans, little egret, whose occurrence is closely associated with mangroves. However, the short timeframe over which pile driving will occur limits the intensity of this impact.

The duration of the impact would be short term and site specific in extent. The intensity would be low with a low magnitude impact. Coupled with a likely probability of occurrence a *Minor* significance impact is expected. This impact will not be felt during the operation and decommissioning and closure phase.

7.37.2 *Mitigation*

Mitigation Objective

To minimize impacts of noise on bird breeding, feeding and resting behaviour during construction operations.

Mitigation measure(s)

- Wherever possible the installation of mooring points by pile driving should be made outside the breeding seasons (i.e. during the winter period between April and September).

- Pile driving of mooring points should be carried only during daylight hours as this will reduce the stress on birds because they can see and avoid places where the mooring points are being installed.

- Restrict other construction activities to daylight hours.

- Carry out routine maintenance of equipment and vehicles to ensure that they are in good working order.

7.37.3 *Residual Impact*

The residual impact will be *Minor.*

Table 7.38 Impact of Noise on Birds

	Without mitigation	Residual Impact (With mitigation)
Construction Phase		
Duration	Short term	Short term
Scale	On-site	On-site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Minor
Operational Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
Decommissioning and Closure Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.38 *IMPACT OF DISTURBANCES TO ISLAND BIRD HABITATS DUE TO DREDGING*

7.38.1 *Impact Assessment*

This impact would occur during the construction phase and operational phase. Capital dredging will be required to deepen and widen the channel especially in the stretch of the river between Benga and the Dona Ana Bridge at Mutarara. Dredging will be carried out by eight barges operations in parallel 24 hours per day 7 days a week over an 18 month period Dredging activities could result in disturbance to vegetated islands and sandy islands (for example by laying the discharge pipeline across islands). On vegetated islands several species of birds were observed including many weavers, reed warblers, bee-eaters, cattle egrets and reed cormorants and yellow billed storks. Some of these species roost on the islands overnight.

This impact would occur during the construction phase and continue through the operations phase. The impact is expected to thus be long term in nature and site-specific in extent. The intensity would be low given the small areas of disturbance. The magnitude is expected to be low with a likely probability of occurrence, resulting in a *Minor* significance impact.

This impact will not be felt during the operation and decommissioning and closure phase.

7.38.2 *Mitigation*

Mitigation Objective

To minimize impacts on vegetated and non-vegetated islands and riparian habitats arising from operations associated with dredging.

Mitigating Measure(s)

- Laying of discharge pipelines across islands should be prohibited
- Sandy and vegetated islands should be considered no-go areas for any activities due to their importance as bird nesting, resting and feeding areas.
- Workers must be prohibited from setting up temporary camps or shelters on the islands, lighting fires on the islands for cooking and, in general landing on the islands.

7.38.3 *Residual Impact*

The residual impact is expected to be *Negligible*

Table 7.39 Impact of Disturbances on Island Bird Habitats due to Dredging

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short term	Short term
Scale	On site	On site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Operational Phase	
Duration	Short term	Short term
Scale	On site	On site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	This impact will not be felt during decommissioning and closure	

7.39 *IMPACT OF ACCIDENTAL FUEL SPILLS ON BIRDS AND BIRD HABITATS*

7.39.1 *Impact Assessment*

Fuel will be used during dredging and barging operations. A 3,600HP push boat (1.8m draft) will carry 85 cubic metres (85,000 litres) of diesel fuel. These will be in 8 tanks ranging from 9.8 cubic meters (9,800 litres) to 20 cubic meters (20,000 litres). A larger 4,500HP boat, which will have a draft of 2.15m, will carry 135 cubic metres (135,000 litres) of diesel fuel. The push boats are double hulled and the tanks, which sit on the inner side of the ballast tanks, are themselves double walled – i.e. there are at least 4 steel walls between the fuel and the water.

A fuel barge will used to transport fuel to the land depots (Chinde and possibly Benga) to supply fuel for barging operations. The proposed fuel barge will be a marine certified double hulled flat top barge with a capacity approximately 3,180m^3 of diesel fuel (3,180,000 litres). During dredging operations fuel barges will be used to service the dredgers. These fuel barges will be constructed with heavy wall plating with the corners double plated. Movement of these fuel barges from location to location is minimal as they are anchored at a location near the dredge site where fuel can be transferred to the dredger via an auxiliary tug in smaller amounts. Dredger fuel barges will have a capacity of 500m^3 (500,000 litres). Fuel is stored within 4 separate tanks up to 125m^3 (125,000 litres) per tank. It is likely that dredgers will operate in groups of 2 or 3 per location with one fuel barge servicing each group.

Localized diesel spills could occur during bunkering or transfer of fuel during dredging and barging operations. It is highly unlikely that there would be a simultaneous rupture of more than one fuel tank of a fuel barge or push boat at any one time. The worst case scenario is catastrophic non-routine event such an explosion on a fuel barge in which case a relatively large amount of fuel could be released into the water. This would directly affect water quality, water birds and riparian or island bird habitats.

The intensity would be medium and the extent would be local. A medium to high magnitude is expected with an unlikely probability of occurrence. Coupled with an unlikely probability of occurrence *Moderate* significance is expected. This impact will not be felt during the decommissioning and closure phase.

7.39.2 *Mitigation*

Mitigation Objective

To minimize diesel spills during dredging and barging operations.

Mitigating measure(s)

- Implement good operating procedures.

- Develop and implement procedures for spill prevention and emergency spill clean up.
- Crews should be trained for emergency response and oil spill clean ups.
- Ensure that pipes and hoses are properly connected, closed and in good condition when bunkering.
- Ensure that transfer hoses are of sufficient length and strength to manoeuvre vessels according to the river flow conditions.
- Incorporate automatic shut off valves.
- Ensure the refuelling area is well lit during night operations.
- Develop a management plan that may include provision to desist from refuelling operations during inclement weather.

7.39.3 *Residual Impact*

The residual impact will be *Minor*

Table 7.40 Impact of Accidental Fuel Spills on Birds and Bird Habitats

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Severity	Medium	Low
Magnitude	Medium to High	Low
Likelihood	Unlikely*	Unlikely
Significance	Moderate*	Minor
	Operational Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Severity	Medium	Low
Magnitude	Medium to High	Low
Likelihood	Unlikely*	Unlikely
Significance	Moderate*	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the project the potential for accidental spills on birds will be eliminated.	

7.40 IMPACT OF BIRD HUNTING BY WORKERS DURING THE CONSTRUCTION AND OPERATIONAL PHASES

7.40.1 *Impact Assessment*

During the construction and operational phases workers will be employed along the length of the Project area. Unskilled workers will mainly be recruited locally. A number of semi-skilled and skilled workers will contracted from outside the Project area. An increase in the number of workers from outside the Project area may result in an increase in hunting of birds for consumption and sale. Of special concern are the operations at Chinde where intact mangroves and mudflats are important nesting and feeding areas for large number of bird species.

In light of strict management expected to be implemented this impact would have a low intensity and site-specific extent. A low magnitude coupled with a likely probability of occurrence results in a *Minor* significance. This impact will not be felt during the decommissioning and closure phase.

7.40.2 *Mitigation*

Mitigation Objective

To eliminate hunting by RML employees.

Mitigation measure(s)

- All workers must be informed of that hunting of any fauna species (including birds) is prohibited. Employment contracts should include clauses that prohibit workers from hunting wildlife and infringements to this prohibition will result in the application of penalties.

7.40.3 *Residual Impact*

The residual impact will be *Negligible*

Table 7.41 Impact of Bird Hunting by Workers during the Construction and Operational Phases

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short-term	Short-term
Scale	On site	On site
Severity	Low	Medium
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Negligible
	Operational Phase	
Duration	Long Term	Long term

	Without mitigation	Residual Impact (With mitigation)
Scale	On site	On site
Severity	Low	Low
Magnitude	Low	Low
Likelihood	Likely	Likely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance		

7.41 *Impact of Spoil Deposition on High Flow Distributaries and Bird Feeding and Breeding*

7.41.1 *Impact Assessment*

During high flows, distributary channels provide water for floodplains and lakes along the Zambezi River especially downstream of Lupata gorge. These associated floodplains and lakes are important feeding and breeding grounds for a variety of waterfowl. Any disruption to the flow of water along the distributary channels will affect these wetland habitats.

During the construction and operational phase dredging, spoil deposition has the potential to block the channels that permit flood pulses. The intensity would be medium resulting in a medium magnitude impact. RML have committed to careful spoil deposition in the lee of islands and sandbars, focussing on keeping distributaries and tributaries clear. This renders the probability of occurrence to be unlikely. Therefore a *Minor* significance impact is expected. This impact will not be felt during the decommissioning and closure phase.

7.41.2 *Mitigation*

Mitigation Objective

To minimise blockage of high flow distributaries.

Mitigation measure(s)

- No deposition of spoil materials is permitted at the entrance to any distributary channel (these channels should be mapped using GPS coordinates).
- Ensure that dredging contractors are made aware of the importance of keeping the distributaries clear.
- Spoil deposition should be made in the in the lee of islands as opposed to spoil deposition along the dredged channels.

7.41.3 *Residual Impact*

The residual impact will be *Negligible*.

Table 7.42. *Impact of Spoil Deposition on High Flow Distributaries and Bird Feeding and Breeding*

	Without mitigation	Residual Impact (With mitigation)
Construction Phase		
Duration	Short term to long term	Short Term to long term
Scale	Local	Local
Severity	Medium	Low
Magnitude	Medium	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Negligible
Operational Phase (maintenance)		
Duration	Short term to long term	Short Term to long term
Severity	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Unlikely	Unlikely
Significance	Minor	Negligible
Decommissioning and Closure Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the project the channels might recover and flow normalized.	

7.42 IMPACT OF DREDGING ON BIRD FOOD SOURCES

7.42.1 *Impact Assessment*

Dredging and spoil deposition will occur during the construction and operational phases. Dredging and spoil deposition within the active channel may affect habitat for benthic fauna. The benthic fauna assessment indicates that without mitigation (where spoils are deposited in a linear fashion instead of in the lees of islands and sand bars) impacts on benthic fauna could be moderate. Benthic organisms and fish are the main food sources for bird species such as herons, egrets and open billed storks that feed in shallow water habitats.

Without mitigation, the intensity of the impact would be low to medium with a local extent. During the construction phase the magnitude would be low to medium with a likely probability of occurrence. During the operational phase the longer term nature of the impact would result in a medium magnitude with a likely probability of occurrence. Thus the impact on birds would be *Minor to Moderate* during construction and

Moderate during operations. This impact will not be felt during the decommissioning and closure phase.

7.42.2 Mitigation

Mitigation Objective

To minimize impacts on shallow water habitats important for bird species due to dredging associated activities.

Mitigation measure(s)

- Spoils should be deposited in lee of existing islands, where this is possible. This should reduce the intensity of maintenance dredging, and reduce the area affected by spoils from 17% to between 11 and 15% of the active channel (Southern Waters 2010a).

7.42.3 Residual Impact

The residual impact will be *Minor*

Table 7.43. Impact of Dredging on Bird Food Sources

	Without mitigation	Residual Impact (With mitigation)
Construction Phase		
Duration	Short term	Short Term
Scale	Local	Local
Severity	Low to medium	Low
Magnitude	Low to medium	Low
Likelihood	Likely	Likely
Significance	Minor to Moderate	Minor
Operational Phase		
Duration	Long term	Long Term
Scale	Local	Local
Severity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
Decommissioning and Closure Phase		
Duration	n/a	n/a
Scale	n/a	n/a
Severity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the project the channels might recover and flow normalized.	

7.43 CONSIDERATION OF GROUNDWATER IMPACTS ON GORONGOSA NATIONAL PARK

7.43.1 Impact Assessment

During the stakeholder engagement, a concern was raised with regard to possible impacts of the proposed coal barging activities on the Zambezi River system water resources and other downstream receptors, e.g. Gorongosa National Park.

Although various aquifers and river channel geometries are encountered along the Zambezi River, the likelihood for impacts on the groundwater quality of the Zambezi system, including Lake Urema is considered unlikely. It is also expected that barging of the river channel will not change the yield of the bounding alluvial aquifers. It is possible that dredging could increase the volume of baseflow to the river, which will result in higher natural recharge of aquifers.

It is likely that any link between the Zambezi River and Lake Urema (Gorongosa National Park) relates to surface water flow and flooding. Any possible groundwater link between these two systems have not been investigated before (no literature found), but due to the complexity of hard rock fractured aquifers, the fact that groundwater flow direction is inferred by topography and the low transmissivity of aquifers in the Gorongosa National Park it is unlikely that aquifer recharge associated with the Zambezi River system is significant.

Water quality impacts in the Zambezi River may relate to accidental spillages of coal and/ or fuel. In general groundwater movement and the migration of contamination plumes follow the path of least resistance. Due to the high velocities of the Zambezi River and the high transmissivity values of the alluvial aquifers associated with the Zambezi River, pollutants are more likely to diffuse in the Zambezi River and move along these alluvial aquifers. Due to the difference in transmissivity between primary alluvial aquifers and hard rock fractured aquifers and the pressure head created by the fast flowing Zambezi River it is unlikely that pollutants will migrate significant distances inland and through the hard rock formations.

In light of the act the proposed Project will not entail any activities that could result in groundwater contamination and that the any groundwater linkage between the Zambezi system and Gorongosa National Park is unlikely, this any potential impact is considered to have a negligible intensity and negligible magnitude. The probability of occurrence is unlikely. Thus the significance of this impact is expected to be *Negligible*.

7.43.2 Mitigation Measures

None necessary.

7.43.3 *Residual Impact*

This impact will remain as *Negligible*.

Table 7.44 Groundwater Impact on Gorongosa National Park

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Operational Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project, there will be no potential impact.	

8 SOCIAL AND ECONOMIC IMPACTS

8.1 INTRODUCTION

This chapter has been informed by the following specialist studies:

- Economic Study
- Socio-economic Study
- Noise Study
- Fish Study
- Environmental Flow Study
- Wake Study (undertaken by Riversdale)

8.2 KEY PROJECT ACTIVITIES

Social and economic impacts are those impacts on the local, regional and national economy as well as on people and livelihoods as a result of changes brought about by the Project. With respect to social and economic impacts the key Project activities are the location of land based facilities, the capital and maintenance dredging, the barging operations, the sites chosen for deposition of spoils (dredged material), and the investment in the country.

8.3 IMPACT OF THE PROJECT ON MOZAMBICAN SOCIETY (COST BENEFIT ANALYSIS)

8.3.1 Impact Assessment

Cost Benefit Analysis treats the national economy as an entity in and of itself. It assumes that what is demonstrably good for the economy as a whole is a reasonable approximation of what would be good for the majority of the people living and working in the country. For society as a whole it considers the costs versus benefit of a proposed project. When large investments are contemplated, decision makers need to know what impact the new investment would have on the economy as a whole and hence how much benefit can be assumed to accrue to the people of the country.

The economic Cost Benefit Analysis has been performed at two levels. The first level relates only to the costs and benefits of the Project (including Benga Mine). The second expands the analysis to include the potential benefits on the agricultural, fishing, mining and tourism related industries. The level of certainty, however, decreases as one moves from the Project level analysis to the broader national analysis. Therefore, the impact of the Project on the Benga mine is reported with a high degree of certainty but this level of certainty is reduced when the impact on agriculture, fishing and tourism is investigated. In both cases the only identified costs are the disruption to fishing during the capital and maintenance dredging phases. This is estimated to have a present value (PV) of $5.3M. Project related benefits total $4,499M. The net benefit (Net Present Value or NPV) of the project is the difference between the PVs of the benefits and the costs. At $4,494M (MZM161,783M) this is hugely positive and indicates that the project is of major benefit to the country.

The reason for this extremely high NPV is that the funds used in developing the project are all sourced from overseas and the only cost to the Mozambique economy is the potential disruption to a portion of the fishing industry. From an economic point of view this project is extremely beneficial to Mozambique, even when viewed just on a Project-only basis. The outcome of the cost benefit analysis is the reporting of a benefit cost ratio (BCR). However, for any project where the funds originate outside of the country the BCR tends to be high, so the NPV tends to be a better indicator of a project's value.

The consequence of including broader economic benefits increases total benefits from $4,499M to $12,684M. The NPV (PV of benefits minus the PV of costs) totals $12,679M (MZM456,448M).

One of the economic scenarios that needs to be considered is what the impact on Mozambique would be if Riversdale found over time that dredging the Zambezi River was too onerous. In this instance operations are curtailed after five years. The NPV of the Project under this scenario is $591M. Since the NPV is positive this still remains an economically efficient project, despite the loss of benefits that would have occurred after the five year period.

On the national scale, the magnitude of the impact is considered to be high, coupled with a likely probability, the significance of the impact is expected to be a *Major* positive.

8.3.2 Enhancement Measures

Enhancement Objective

To maximise the NPV.

Enhancement Measure(s)

Longer operation is likely to extend the benefits, increasing the NPV.

8.3.3 Residual Impact

The residual impact will remain as *Major*.

Table 8.1 Impact of the project on Mozambican Society (Cost Benefit Analysis)

	Without mitigation	Residual Impact (With mitigation)
	Construction and Operation	
Duration	Long -term	Long -term
Scale	National	National
Intensity	High	High
Magnitude	High	High
Likelihood	Likely	Likely
Significance	Major	Major

8.4 IMPACT OF THE PROJECT ON THE MACRO-ECONOMY (MACROECONOMIC ANALYSIS)

8.4.1 *Impact Assessment*

The macroeconomic analysis reports on Gross Domestic Product, Direct and Indirect Job Creation, Contribution to Taxes and Indirect Household Income. Gross Domestic Product is the total value of all final goods and services produced in the country. It is clearly fundamental to the economic quality of life of people in the country. It is also the most important and all encompassing measure of the macroeconomic effect of the dredging and barging project. This is different from the Cost Benefit Analysis above in that it looks at the monetary impact of spending on the macro-economy.

- The initial capital dredging is expected to contribute US$41m and US$81m to GDP in 2011 and 2012 respectively.

- The construction of facilities at Chinde is expected to contribute a further US$21m to GDP in 2012.

- Ongoing maintenance dredging is expected to contribute to US$30m in 2013 and this contribution is expected to increase to a steady US$51m per annum from 2018 onwards.

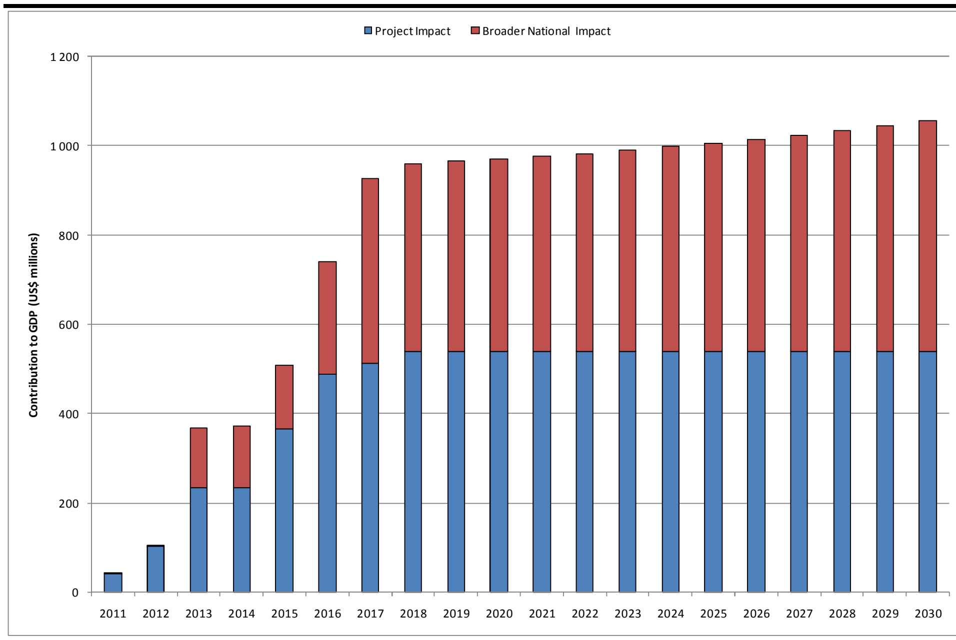
- Once the barging operations begin in earnest in 2013 this contribution is expected to increase steadily from US$28m in that year to US$195m by 2030.

- The increased operations at the Benga mine are also set to kick in from 2013 onwards and its contribution to GDP also increases steadily (in real terms) from US$175m in 2013 to US$292m by 2030.

The total contribution from the project impact therefore increases from US$41m in 2011 to US$539m per annum from 2018 onwards. The broader national impact takes a while longer to manifest but shows a similar total macroeconomic impact to the total project impact. The broader national impact is negative in 2011 and 2012 because of the detrimental impact dredging has on fishing, but then shows a significant increase to US$128m in 2013. This increase continues as mining production at the Zambeze and third coal mine in the area work towards full production, and as agriculture and tourism grow. The macroeconomic total from the broader national impact is then set to amount to US$515m by 2030.

There is a potential negative contribution from the fishing industry in 2011, 2012 and 2013. This is due to the interruption of the existing Zambezi River fishing industry due to the capital and maintenance dredging. The total contribution to GDP and relative sizes of each of the project impact, the broader national impact and the regional trade effects are illustrated in *Figure 8.1*. When looking at both the project level and broader national effects, the total contribution to GDP amounts to $36M (MZM1,290M) in 2011 and $97M (MZM3,495M) in 2012. This increases to $1,054M (MZM37,930M) by 2030. GDP is important not just because it is income but also because income has the capacity to add to wealth. Based on these projections, the proposed dredging and barging project would have made a cumulative contribution to GDP of $1.37 Billion (MZM49.5 Billion) by 2015 and of over $16 Billion (MZM577 Billion) by the end of 2030.

Figure 8.1 Contribution to GDP



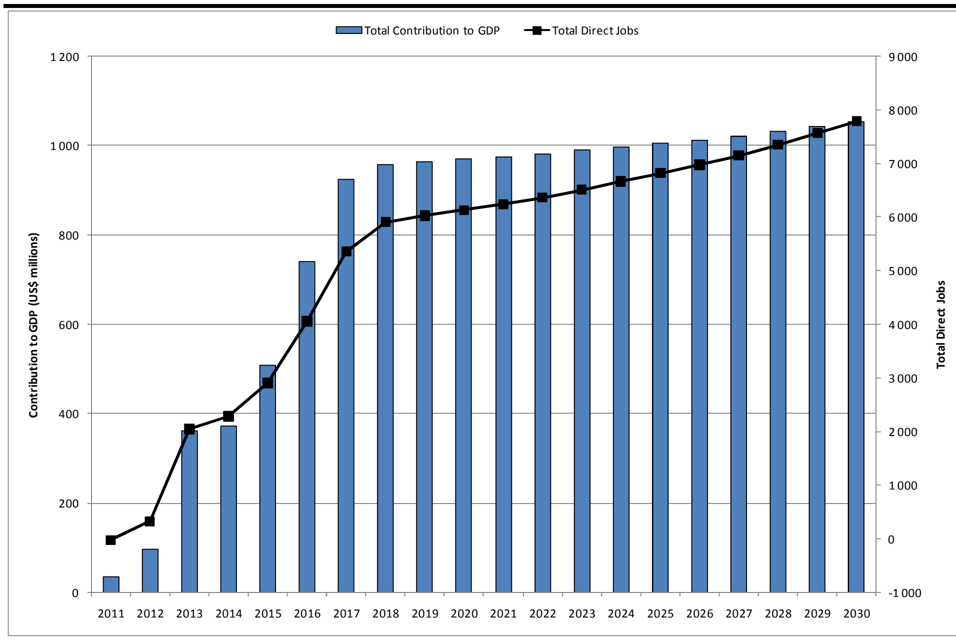
The dredging and barging project would result in changes to three types of jobs. The first are the direct jobs that would be created over the project period. These are jobs directly on dredging the river and operating the barges. The second type is those jobs that are created as a result of structural changes in the economy. These are the direct jobs created or lost in the mines, in agriculture, fishing and tourism as a result of the increased (or diminished) operations in those industries. The third type of jobs is the so-called indirect jobs that are due to multiplier effects of both the dredging and barging project and the increased operations in the identified industries.

- During the dredging period in 2011 and 2012 as many as 507 people could be directly employed as a result of the project, with a further 193 due to the construction of the facilities at Chinde. The project is expected to sustain 2,603 direct jobs from 2018 onwards.

- The broader national impact should see the creation of around 1,023 jobs in 2013. Total jobs due to the broader national impact are set to increase to 5,184 by 2030. However, within these net job increases there could be job losses in the fishing industry. Under the scenarios assumed these could be as many as 214 during the capital dredging period and 54 as a result of the maintenance dredging.

- A macroeconomic analysis would typically report on the creation of indirect jobs. However because we are dealing with an area where subsistence agriculture and fishing is the predominant economic activity it is not possible to separate out changes in income from the creation of indirect jobs. There will certainly be the creation of some indirect jobs in places like Tete. However part of the indirect spending is likely to go on food produced by people who are currently largely subsistence farmers and fish from people who are currently largely subsistence fishers. This is less the creation of an indirect job and more the generation of income. As a result the estimated increase in income is reported. This is considered more accurate that attempting to estimate indirect jobs.

Figure 8.2 Total Contribution to GDP and Total Jobs



The total contribution to GDP (i.e. sum of the project impact, broader national impact and the regional trade effects) and total jobs (direct plus indirect) are presented in *Figure 8.2.*. The graph indicates the sustainable nature of the effects from the year 2017 onwards. Also evident from the graph is the increase in direct jobs in the agriculture sector as more subsistence farmers are brought into the commercial farming fold. The final two macroeconomic impacts that are reported on are the contribution to taxes and household income.

- The project impact contribution to taxes increases from $6M in 2011 to $168M by 2030. Over the same period the contribution to taxes from the broader national impact increases from $3M in 2013 to $173M by 2030. The majority of these taxes are indirect taxes and are created through the multiplier effect of the economy.
- The total contribution to taxes (direct plus indirect) is expected to increase from $6M (MZM217M) in 2011 to $341M (MZM12,269M) by 2030.
- The cumulative total over the 20 years is $5,296M (MZM190,665M).
- Total household income is estimated to increase from $15M (MZM540M) in 2011 to $1,572M (MZM56,595M) by 2030. The cumulative total over the 20 year period is set to exceed $24 Billion (MZM864 Billion)

On the national scale, the magnitude of the impact is considered to be high, coupled with a likely probability. The significance of the impact is expected to be a *Major* positive.

8.4.2 *Enhancement Measures*

None necessary.

8.4.3 *Residual Impact*

The residual impact will remain as *Major*.

Table 8.2 Impact of the project on Macro-economy

	Without mitigation	Residual Impact (With mitigation)
	Construction and Operation	
Duration	Long term	Long term
Scale	National	National
Intensity	High	High
Magnitude	High	High
Likelihood	Likely	Likely
Significance	Major	Major

8.5 *NOISE IMPACT OF BARGING ON RIVERSIDE COMMUNITIES*

8.5.1 *Impact Assessment*

Noise impacts will be felt to varying degrees depending on proximity to the source of the noise. Much of the study area is rural in nature with a low baseline noise level. In addition, the study area is largely sparsely populated which means that potential receptors for noise (noise receptors are inhabited dwellings) are limited.

The IFC Standards follow the WHO guidelines with respect to noise and allow for an increase in ambient noise levels of 3dB. The noise impact of normal barging operations will not be felt beyond a distance of 28m from the navigation channel during the day and 90m for night-time operations. At various points along the river there may be people within these distances. The table below indicates how people at varying distances from the navigable channel would experience the noise impact.

Table 8.3 Expected Exceedances over Ambient Noise Levels at Varying Distances from the Channel Centreline

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	28m	90m	Little to none	Change just discernible.
3 ≤ 5	22m	70m	Little	Change easily discernible.
5 ≤ 7	18m	55m	Little	Sporadic complaints may be received.
7 ≤ 10	12m	40m	Little to medium	Sporadic complaints may be received.
10 ≤ 15	7m	22m	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

These are worst-case conditions, based on the noise generated by a single pass-by of the barge convoy, corrected to be comparable with the maximum hourly $\mathbf{L_{eq}}$ as defined in the WHO guidelines. It should be noted that this occurs two or three times a day at a given point on the river and is not a continuous noise.

The impact of barging will only be felt during the operational phase of the Project. The impact will be long term, site specific and will have a low intensity, resulting in a low magnitude. The low intensity is due to the limited number of people who live closer than 90m to the navigable channel for the length of the Project area. Coupled with a likely probability, a *Minor* significance is expected.

8.5.2 Mitigation Measures

Mitigation Objective

To minimise noise impacts on receptors.

Mitigation Measure(s)

- Ensure that the pushboats are serviced regularly.
- Develop and implement a grievance mechanism.
-

8.5.3 *Residual Impact*

The residual impact is expected to remain as *Minor*.

Table 8.4 *Noise Impact of Barging on Riverside Communities*

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	The impact of barging will only be felt during the operational phase of the Project.	
	Operational Phase	
Duration	Long-term	Long-term
Scale	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	The impact of barging will only be felt during the operational phase of the Project.	

8.6 *NOISE IMPACT OF DREDGING ON RIVERSIDE COMMUNITIES*

8.6.1 *Impact Assessment*

An increase in noise of 3dB will be not be felt beyond a distance of 1km from the alignment of the navigation channel during the day and beyond 3.14m for night time operations. Depending on the actual channel alignment there may be dwellings indicated within these distances, especially with regard to the night-time impact. The table below indicates how people at varying distances from the navigable channel would experience the noise impact.

Table 8.5 *Expected Exceedances over Ambient Noise Levels at Varying Distances from the Channel Centreline*

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	710m	2.24km	Little to none	Change just discernible.
3 ≤ 5	550m	1.73km	Little	Change easily discernible.
5 ≤ 7	450m	1.41km	Little	Sporadic complaints may be received.
7 ≤ 10	280m	880m	Little to medium	Sporadic complaints may be received.
10 ≤ 15	155m	490m	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

As for the barging noise impacts these are worse case conditions, based on the noise generated by a single pass-by of the dredger, corrected to be comparable with the maximum hourly L_{eq} as defined in the WHO guidelines. It should be noted that dredging occurs at intervals along the alignment, not for every hour on a continuous basis at the same position.

The impact will be felt during the construction phase and the operational phase only. Given that more people are likely to be within the zone of impact, especially during night time, the likelihood of the impact occurring is definite. The magnitude is expected to be low given the fact that the impact will not be continuously felt and the relatively sparse population in the study area. The significance of the impact is likely to be *Minor* for the study area as a whole.

8.6.2 Mitigation Measures

Mitigation Objective

To minimise noise impacts on receptors.

Mitigation Measure(s)

- Ensure that the dredgers are serviced regularly.
- Notify potentially affected communities of impending dredging.
- Develop and implement a grievance mechanism.

8.6.3 Residual Impact

The residual impact is expected to remain as *Minor*.

Table 8.6 Noise Impact of Dredging on Riverside Communities

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Temporary	Temporary
Scale	On-site	On-site
Intensity	Low	Low

	Without mitigation	Residual Impact (With mitigation)
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	Minor	Minor
	Operational Phase	
Duration	Temporary	Temporary
Scale	On-site	On-site
Intensity	Low	Low
Magnitude	Low	Low
Likelihood	Definite	Definite
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	Dredging will only take place during the construction and operational phases.	

8.7 *NOISE IMPACT AT THE LOADOUT POINT AT BENGA*

8.7.1 *Impact Assessment*

During the construction phase, the dominant noise source is likely to be pile driving, especially if percussive piling is employed. Some noise will also be generated when the storage facilities are erected. Ambient noise levels would increase by more then 3dB within a distance of 3.2km from the piling as per the table below. Piling will not occur during the night and no night time noise impacts are expected. Some residents within a 3.2km radius of the piling will experience a noise impact for a short period. The short term, local and medium intensity result in a medium magnitude of impact. Coupled with a definite likelihood, the significance of the impact is expected to be *Moderate* during the construction phase.

Table 8.7 Expected Exceedances over Ambient Noise Levels at Varying Distances from the Pile Driving during Construction

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	3.2km	N/A	Little to none	Change just discernible.
3 ≤ 5	2.4km	N/A	Little	Change easily discernible.
5 ≤ 7	1.9km	N/A	Little	Sporadic complaints may be received.
7 ≤ 10	1.4km	N/A	Little to medium	Sporadic complaints may be received.
10 ≤ 15	750m	N/A	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

During the operational phase, the dominant noise will be from barge mooring and loading activities. The impact will not be felt beyond a distance of 72m during the day and 230m for night time operations. There are no sensitive noise receptors within 72m of the loadout point and hence the significance of this impact is considered to be *Negligible*.

Table 8.8 Expected Exceedances over Ambient Noise Levels at Varying Distances during Operation

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	72m	230m	Little to none	Change just discernible.
3 ≤ 5	55m	180m	Little	Change easily discernible.
5 ≤ 7	43m	140m	Little	Sporadic complaints may be received.
7 ≤ 10	32m	102m	Little to medium	Sporadic complaints may be received.
10 ≤ 15	17m	55m	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

8.7.2 Mitigation Measures

Mitigation Objective

To minimise noise impacts on receptors.

Mitigation Measure(s)

- Undertake pile driving activities between 8am and 5pm only.
- If possible, use vibration pile driving instead of percussive pile driving.
- Notify potentially affected communities prior to pile driving.
- Develop and implement a grievance mechanism.

8.7.3 Residual Impact

The residual impact is expected to remain as *Moderate* during construction and *Negligible* during operations.

Table 8.9 Noise Impact at the Loadout Point at Benga

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short –term	Short-term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite

	Without mitigation	Residual Impact (With mitigation)
Significance	Moderate	Moderate
	Operational Phase	
Duration	Long-term	Long-term
Scale	On-site	On-site
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no noise impact at the Loadout Point at Benga during this phase.	

8.8 *NOISE IMPACTS AT THE DONA ANA BRIDGE*

8.8.1 *Impact Assessment*

The dominant construction noise source during the construction phase of all riverside facilities is likely to be the pile driving, especially if percussive piling is employed.

Piling will not occur during the night and no night time noise impacts are expected. Residents within a 3.2km radius of the piling will experience a short term noise impact during the construction phase. The short term, local and medium intensity result in a medium magnitude of impact. Coupled with a definite likelihood, the significance of the impact is expected to be *Moderate* during the construction phase.

Table 8.10 Expected Exceedances over Ambient Noise Levels at Varying Distances from the Pile Driving

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	3.2km	N/A	Little to none	Change just discernible.
3 ≤ 5	2.4km	N/A	Little	Change easily discernible.
5 ≤ 7	1.9km	N/A	Little	Sporadic complaints may be received.
7 ≤ 10	1.4km	N/A	Little to medium	Sporadic complaints may be received.
10 ≤ 15	750m	N/A	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

During the operational phase noise impact will be associated with barge mooring, convoy fracturing and reassembly as well as top-up activities. Each barge in the convoy is pushed separately under the bridge by the vessel as well as being manoeuvred into place at the mooring buoys within this area for approximately 70% of the day. It is assumed that critical silencers will be used to reduce maximum noise levels to a maximum of 80 dB(A) at the rear deck of the tug (or 53 dB (A) at 160m away from the tug). In addition, 85% power is assumed for the upstream stretch, 50% power on the downstream stretch 50% power during the manoeuvring period. Manoeuvring is assumed to lie mid-way between the navigation channel and the holding station, i.e. 330m from the shore. The worst case scenario would be a pass-by at the nearest point which would yield a noise level of 58 dB(A) nominally at 160m, which is the minimum distance the barge convoy can come to the residential areas of Muturara on the east bank if a navigation channel through piers 7 to 9 is used. Allowances for the use of critical silencers lower noise levels generated by lower power requirements during part of the operation, and the increased distance of the tug for part of the operation, amount to approximately 9dB.

In the worst case, as described above, with no mitigating measures, there will be no impact beyond a distance of 60m from the navigation channel during the day and 180m from the channel during the night (as per *Table 8.11*). As most dwellings at Mutara are located more than 300m away from the navigable channel a low intensity impact is expected. Together with the long term, local extent of the impact a low to medium magnitude is expected. A low to medium magnitude coupled with a definite likelihood of occurrence results in a *Minor to Moderate* significance.

Table 8.11 Expected Exceedances over Ambient Noise Levels at Varying Distances from the Construction Activities

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	60m	180m	Little to none	Change just discernible.
3 ≤ 5	45m	140m	Little	Change easily discernible.
5 ≤ 7	36m	110m	Little	Sporadic complaints may be received.
7 ≤ 10	25m	80m	Little to medium	Sporadic complaints may be received.
10 ≤ 15	14m	45m	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

8.8.2 Mitigation Measures

Mitigation Objective

To minimise noise impacts on receptors.

Mitigation Measure(s)

- Undertake pile driving activities between 8am and 5pm only.
- If possible, use vibration pile driving instead of percussive pile driving.
- Notify potentially affected communities prior to pile driving.
- Consult with significantly impacted communities and include in Resettlement Action Plan, if required.
- Develop an implement a grievance mechanism.

8.8.3 Residual Impact

The residual impact is expected to reduce to as *Moderate* during construction and operations.

Table 8.12 Noise Impact at the Barge Mooring areas at Dona Ana Bridge

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short- term	Short-term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Moderate	Moderate
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Low	Low
Magnitude	Low to medium	Low to medium
Likelihood	Definite	Definite
Significance	Minor to Moderate	Minor to Moderate
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no noise impact at the Dona Ana Bridge during this phase.	

8.9 NOISE IMPACTS AT CHINDE

8.9.1 Impact Assessment

The dominant noise source during the construction phase is likely to be the piling operations, especially if percussive piling is employed. Other noise sources will be the construction of the buildings, storage facilities and erection of other support facilities.

No noisy construction activity (including piling) will occur during the night time and thus no night time noise impacts are expected. Residents within a 3.2km radius of the piling will experience a short term noise impact during the construction phase (*Tabel 8.13*). The short term, local and medium intensity result in a medium magnitude of impact. Coupled with a definite likelihood, the significance of the impact is expected to be *Moderate* during the construction phase.

Table 8.13 ***Expected Exceedances over Ambient Noise Levels at Varying Distances from the Construction Activities***

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	3.2km	10km	Little to none	Change just discernible.
3 ≤ 5	2.4km	7.9km	Little	Change easily discernible.
5 ≤ 7	1.9km	6.1km	Little	Sporadic complaints may be received.
7 ≤ 10	1.4km	4.5km	Little to medium	Sporadic complaints may be received.
10 ≤ 15	750m	2.4km	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

During the operational phase, noise will be generated by barge mooring, convoy fracturing and reassembly and potentially from loading a dedicated marine barge. This is planned to take place on the left bank of the river opposite Chinde. The closest dwellings are approximately 2km away.

It is assumed that each barge in the convoy is pushed separately out to the transloading station and that the convoy may be up to a maximum of eight barges. This worst case scenario necessitates 16 passes of Chinde town by the vessel as well as continuous manoeuvring activity in this area. The worst case continuous noise level is calculated to be 58dB(A) nominally at 160m. The daytime impact will not be felt beyond a distance of 160m from the navigation channel and beyond 500m for night time operations. Given the distance of the nearest dwellings a low magnitude and likely probability is expected. This results in a *Minor* significance impact during the operational phase.

Table 8.14 ***Expected Exceedances over Ambient Noise Levels at Varying Distances from the Operational Activities***

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
3	160m	500m	Little to none	Change just discernible.
3 ≤ 5	125m	390m	Little	Change easily discernible.
5 ≤ 7	100m	310m	Little	Sporadic complaints may be received.
7 ≤ 10	70m	225m	Little to medium	Sporadic complaints may be received.

Exceedance dB	Daytime	Night time	Intensity of Response from People	Impact Description
10 ≤ 15	40m	125m	Medium to strong	Change of 10dB perceived as 'twice as loud' leading to widespread complaints

8.9.2 *Mitigation Measures*

Mitigation Objective

To minimise noise impacts on receptors.

Mitigation Measure(s)

- Undertake pile driving activities between 8am and 5pm only.
- If possible, use vibration pile driving instead of percussive pile driving.
- Notify potentially affected communities prior to pile driving.
- Ensure all pushboats and tugboats are serviced regularly and maintained in good working order.
- Develop and implement a grievance mechanism.

8.9.3 *Residual Impact*

The residual impact is expected to remain as *Moderate* during construction and *Minor* during operations.

Table 8.15 Noise Impact at the Barge Mooring areas at Chinde

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Moderate	Moderate
	Operational Phase	
Duration	Long-term	Long-term
Scale	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no noise impacts at the Barge Mooring areas at Chinde during this phase.	

8.10 *IMPACT OF DREDGING ON ARTISANAL AND SEMI-INDUSTRIAL FISHING ACTIVITIES IN THE RIVER*

8.10.1 *Impact Assessment*

This impact will occur during the construction and operational phases of the Project. Impacts on fish populations are considered in the Fish Study; this impact refers to the physical disruption of fishing activities or damage to fishing equipment (fish nets etc). Dredging activity may disturb fishing operations in the vicinity of the dredging operations due to noise or may inhibit fishermen from fishing in certain areas of the river at certain times. An exclusion area will be maintained around the dredging operations – this is intended to prevent damage to fishing equipment. The impact will be local and felt intermittently for the duration of the Project. The intensity and magnitude of the impact are expected to be low during construction and operation with a likely probability of occurrence. Thus a *Minor* significance impact is anticipated.

8.10.2 *Mitigation Measures*

Mitigation Objective

To minimise physical disruption to fishing activities.

Mitigation Measure(s)

- Communicate dredging operations to potentially affected communities prior to commencing them.
- Replace fishing equipment that have been damaged or destroyed as a result of dredging.
- Develop and implement a grievance mechanism

8.10.3 *Residual Impact*

The residual impact is expected to remain as *Minor* during construction and operation.

Table 8.16 Impact of Dredging on Artisanal and Semi-industrial Fishing Activities

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely

	Without mitigation	Residual Impact (With mitigation)
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on artisanal and semi-industrial fishing activities during this phase.	

8.11 *IMPACT OF BARGING OPERATIONS ON ARTISANAL AND SEMI-INDUSTRIAL FISHING ACTIVITIES*

8.11.1 *Impact Assessment*

This impact will be felt in the operational phase only and refers to the physical disruption of fishing activities due to convoys moving up and down the river. Barging activity will be confined to the navigable channel, where fishing activity is very low (consultation with fishermen shows that they prefer not to fish in the deep channel of the river); most catches occur in the shallower sections of the river and in adjacent lagoons. Additionally, convoy traffic is not expected to be intense (up to an average of seven convoys passing a point on the river every 24 hours) so the disturbance will be temporary. An exclusion zone around moving convoys will be maintained to prevent damage to fishing equipment or injury to fishermen.

The impact is expected to be local and intermittent for the life of the Project. The intensity is low with a low magnitude. Couple with a likely probability of occurrence, the expected significance is *Minor*.

8.11.2 *Mitigation Measures*

Mitigation Objective

To minimise physical disruption to fishing activities.

Mitigation Measure(s)

- A timetable indicating barge convoys travel schedule must be produced and distributed at each major riverine locality and updated regularly.
- Replace fishing equipment (lines, nets or even canoes) that can be demonstrated to have been damaged or destroyed as a result of barging.
- Implement and enforce speed limits. Loaded barges moving downstream should not exceed 5 knots through the water. Light barges moving upstream should not exceed 7 knots through the water.

8.11.3 *Residual Impact*

The residual impact is expected to remain as *Minor*.

Table 8.17 Impact of Barging on Artisanal and Semi-industrial Fishing Activities

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on artisanal and semi-industrial fishing activities during this phase.	
	Operational Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on artisanal and semi-industrial fishing activities during this phase.	

8.12 IMPACT OF SAFETY EXCLUSION ZONES ON ARTISANAL FISHING AT CHINDE

8.12.1 *Impact Assessment*

During the construction phase safety exclusion zones will be established around the areas of construction to prevent accidents and entanglement of fishing gear with service craft operating in the construction areas or collisions between these craft and fishers. During the operational phase safety exclusion zones will be established around the barge berthing areas. For the purposes of this assessment the postulated extent of these exclusion zones are 500m radius around the construction areas and berthing areas. There are no estimates of the numbers of artisanal fishers who operate gill nets and other fishing gear in the relatively deep water within 500m radius of the Chinde marine facilities. On the assumption that fishing areas within the deep water channels in the Chinde River mouth area are equally productive (considered to be conservative) the exclusion areas will deny access to approximately 24%[1] of this in the construction and operational

[1] Channel length from upstream mooring site to mouth area including the south bank = ~14 500; exclusion length per Chinde River bank sites = 3,500m. Maria River site excluded from calculation.

phases, assuming that all three sites are developed concurrently or that all exclusion zones are maintained in place throughout construction and operation. The construction impact will not occur after the construction phase. The operational impact will not occur after the life of the Project.

The local extent and long term duration of this impact together with the medium intensity result in a medium magnitude. Coupled with a definite probability, a *Moderate* significance impact is expected.

8.12.2 Mitigation Measures

Mitigation Objective

To minimise the total area of the exclusion zones.

Mitigation Measure(s)

During the operational phase, remove the exclusion zones whenever it is safe to do so (when no berthing is occurring).

8.12.3 Residual Impacts

Implementing the exclusion zones only when required will reduce the magnitude of this impact and is likely to result in the significance being reduced to *Minor* during the operational phase.

Table 8.18 Impact of Safety Exclusion Zones on Artisanal Fishing at Chinde

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short Term	Short Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Minor	Negligible
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Definite	Definite
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project exclusion zones will be removed	

8.13 *Impact of Safety Exclusion Zone on Offshore Semi-Industrial and Industrial Fishing*

8.13.1 *Impact Assessment*

During the operational phase there will need to be safety exclusion zones around the offshore ship-loader as well as demarcated approach and departure shipping lanes for the bulk carriers that load coal there. The size of the exclusion zone around the ship-loader is not yet specified but should be at least 500m radius. Similarly, if there are specified approach and departure routes safety zones these should also be ~500m wide but possibly ~1,800m long. The estimated total area of exclusion zones will therefore be 2.6km^2. Two possible positions have been specified for the offshore installation, one ~15 km and the other ~20 km from the coast. Both are located in active trawling areas and therefore there will be implications for fishing. According to this figure the level of interference will be less for the further offshore site especially if the navigation routes to and from the facility are oriented offshore (away from the coast) as opposed to long-shore.

Semi-industrial and industrial fishing is distributed over a very large area and the exclusion zones are negligible in comparison. However, the zones will be in force for the project duration. This local and long term impact will likely be of negligible intensity due to the small area affected. The negligible magnitude coupled with the definite likelihood results in a *Negligible* significance impact. This impact will not occur during the construction and decommissioning and closure phases.

8.13.2 *Mitigation Measures*

Mitigation Objective

To minimise disruption of fishing.

Mitigation Measure(s)

Ensure adequate communications with fishermen so as to alert them to transloading activities.

8.13.3 *Residual Impacts*

This impact will remain *Negligible*.

Table 8.19 *Impact of Exclusion Zone on Offshore Semi-industrial and Industrial Fishing*

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a

	Without mitigation	Residual Impact (With mitigation)
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	n/a	n/a
	Operational Phase	
Duration	Long Term	Long Term
Scale	Local	Local
Intensity	Negligible	Negligible
Magnitude	Negligible	Negligible
Likelihood	Definite	Definite
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	After the life of the Project exclusion zones will be removed	

8.14 *IMPACT OF CHANGES TO WATER LEVELS ON AGRICULTURAL ACTIVITY ON RIVER MARGINS AND ISLANDS*

8.14.1 *Impact Assessment*

The Project has the potential to modify flows during the construction and operational phases due to dredging and possibly wake effects. The results of the wake and wash investigation are used to assess this potential impact. The wash and wake study indicate that barge traffic is likely to have only a minor impact on riparian habitats with appropriate speed management. While there may be barge related bank erosion, the rate of erosion is unlikely to be significantly greater than the current rate.

The Environmental Flow Study indicates that changes in water level as a result of dredging are minor and that patterns of inundation are likely to remain materially unchanged. This means that any flow-related effects on marginal agriculture are likely to be minimal. The dredging is not expected to remove islands so island agriculture is expected to remain largely unchanged.

Given the natural river dynamics, farmers are generally mobile and move the agricultural plots in response to river changes. Thus any impact is likely to have a low intensity with a short term, local nature. The magnitude would be low with an unlikely probability of occurrence. This results in a *Negligible* significance. This impact may become more significant should Riversdale request Cahora Bassa Dam to release greater flows in the dry season. This is not expected to be the case and even should Riversdale request additional flows, this is likely to be in the dry season and only to get the river to the lowest flow required for barging (2,600m^3/s). This flow is will not result in flooding of marginal agricultural plots.

8.14.2 *Mitigation Measures*

Mitigation Objective

To prevent dredging or barging from affecting island or marginal agriculture.

Mitigation Measure(s)

- As far as possible ensure that barging occurs within the current flow regime. Do not request Cahora Bassa to release additional flows to support the barging operation.

8.14.3 *Residual Impact*

The residual impact is expected to remain as *Negligible*.

Table 8.20 Impact of Flow Changes on Agricultural Activity

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on the flow changes on agricultural activity.	

8.15 *IMPACT OF BARGING ON RIVER SAFETY*

8.15.1 *Impact Assessment*

Potential safety impacts will be felt during the operational phase. During the daily barge operations there is the possibility that people on the river in canoes or water taxis may capsize due to collisions or due to the wake caused by the passing convoy. Barging 24 hours a day, seven days a week increases the potential for collisions between the barges and canoes or water taxis, especially at night. It is envisaged that the risk of collisions or capsizing will decrease over time as people get used to the barging operations. The probability of collision is unlikely as most canoes and water taxis stick to the shallow river margins. Wake effects on canoes are more likely to be a safety concern than collisions. In the worst case scenario, death due to drowning or attack by crocodiles or hippos would occur.

Should the worst case scenario occur the magnitude of the impact will be high. However, given the unlikely probability of the impact occurring, a *Moderate* significance is expected.

8.15.2 Mitigation Measures

Mitigation Objective

To prevent any injury or death to local communities as a result of the Project.

Mitigation Measure(s)

- A timetable indicating barge convoys travel schedule must be produced and distributed at each major riverine locality.

- Implement speed limits on convoys so as to limit wake effects and to allow people in canoes enough time to move to safety when they see the convoy approaching. Loaded barges moving downstream should not exceed 5 knots through the water. Light barges moving upstream should not exceed 7 knots through the water.

- Convoys must make their presence conspicuous through use of sound and light signals, in order to make river users aware of their approach.

- Establish a grievance process with the local communities and develop and management plan to address issues.

8.15.3 Residual Impact

The residual impact is expected to become *Minor* should the proposed mitigation measures be implemented.

Table 8.21 Impact of Barging on River Safety

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact of barging on River Safety during the construction phase.	
	Operational Phase	

	Without mitigation	Residual Impact (With mitigation)
Duration	Temporary	Temporary
Scale	On-site	On-site
Intensity	High	Low
Magnitude	High	Low
Likelihood	Unlikely	Unlikely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact of barging on river safety during this phase.	

8.16 *IMPACT OF CONVOY WAKES ON RIVER MARGIN ACTIVITIES (WASHING, BATHING, WATER COLLECTING)*

8.16.1 *Impact Assessment*

This impact will occur during both construction and operational phases when the passage of dredgers and or convoys may create wakes that travel to the river margins. Due to proximity of main channel to the margins, it is possible that the convoy's wake could disrupt some normal routines, namely disturbing objects (dishes, cups, etc.) and clothing drying or piled on water edge for washing. This effect was observed during scouting trip along the river, raising some protests from people involved in washing in the margins. For both construction and operational phases the impact magnitude is expected to be low with a likely probability of occurrence. For both phases the expected significance of the impact is *Minor*.

8.16.2 *Mitigation Measures*

Mitigation Objective

To minimise wake effects.

Mitigation Measure(s)

- Appropriate barge design measures should be in place to limit wake generation.

- A timetable indicating barge convoys travel schedule must be produced. This time table should have information on expected sail-through time by each major riverine locality, and must be distributed for public knowledge.

- Implement speed limits on convoys so as to limit wake effects and to allow people in canoes enough time to move to safety when they see the convoy approaching. Loaded barges moving downstream should not exceed 5 knots through the water. Light barges moving upstream should not exceed 7 knots through the water.

- Convoys must make their presence conspicuous through use of sound and light signals, in order to make river users aware of their approach.

- Establish a grievance process with the local communities and develop and management plan to address issues.

8.16.3 Residual Impact

The residual impact is expected to remain *Minor* for both construction and operational phases.

Table 8.22 Impact of Wakes on River Margin Activities

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Temporary	Temporary
Scale	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Temporary	Temporary
Scale	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impacts of wakes on river margin activities during this phase.	

8.17 IMPACT OF ACCIDENTAL FUEL SPILLS ON RIVER MARGIN ACTIVITIES (WASHING, BATHING, WATER COLLECTING)

8.17.1 Impact Assessment

This impact could occur during both the construction phase and operational phase. Accidental coal or fuel spills have the potential to cause water quality impact at river margins. As discussed in *Section 9.12* even in the worst case scenario a fuel spill would have a minor impact. The same applies for any coal spillages (*Sections 9.5, 9.23 and 9.24*). The unlikely probability of a major spill and the fast flowing water in the navigable channel means that spills are more likely to dissipate and move away then be deposited on river banks. Should a spill occur near the river bank the risk of disrupting river margin activities will increase. Such an impact is expected to be localised and short-lived. Thus in the context of the study area, the potential impact is expected to have a local extent, short term duration, and low intensity. The magnitude is expected to be low with a probability of unlikely to likely. Thus the expected significance would *Minor*.

8.17.2 Mitigation Measures

Mitigation Objective

To avoid spilling any coal or fuel in the river during routine barging operations.

Mitigation Measure(s)

- Ensure all barges, transloaders, pushboats and tugboats are serviced regularly and maintained in good working condition;
- Adequate spillage prevention procedures must be applied during loading and transport;
- Water quality sampling should be undertaken in the even of a major fuel spill to inform remediation measures.

8.17.3 Residual Impact

The residual impact is expected to reduce to *Minor* for both construction and operational phases.

Table 8.23 Impact of Accidental Spills on River Margin Activities

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Unlikely – Likely	Unlikely
Significance	Negligible – Minor	Negligible
	Operational Phase	
Duration	Temporary	Temporary
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Unlikely – Likely	Unlikely
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impacts of accidental spills from barging during this phase.	

8.18 *IMPACT ON COMMUNITY HEALTH*

8.18.1 *Impact Assessment*

This impact could occur in both construction and operational phases of the Project. Interaction resulting from intensified influx of construction workers to key project spots, namely Mutarara and Chinde, where infrastructure will be built may result in an increase in the transmission of sexually transmitted diseases (STDs) like AIDS. During the operational phase there may be continued interaction between Project personnel and local people at key project locations (namely Benga, Mutarara and Chinde). This could extend the impact making it long term. The intensity of the impact is likely to be medium with a medium magnitude. The probability of occurrence is likely. The significance of the impact is expected to be *Moderate* without mitigation measures.

8.18.2 *Mitigation Measures*

Mitigation Objective

To minimise the spread of disease and particularly STDs.

Mitigation Measure(s)

- Undertake AIDS and STD awareness campaigns within communities at the Benga loadout point, at Mutarara and Sena and at Chinde. Such campaigns should be undertaken in partnership with local authorities.

- Project personnel should also undergo periodic health training.

- Free distribution of condoms must be available for Project personnel.

8.18.3 *Residual Impact*

The residual impact is expected to reduce to *Minor* for both construction and operational phases.

Table 8.24 Impact on Community Health

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local- Regional	Local
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local- Regional	Local

	Without mitigation	Residual Impact (With mitigation)
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impacts on community health during this phase.	

8.19 *IMPACT OF AN INCREASE IN SOCIAL ILLS (CRIME, PROSTITUTION) ON CHINDE POPULATION*

8.19.1 *Impact Assessment*

This impact could commence during the construction phase and extend into the operational phase.

As the point of exit for the Project, Chinde will be the recipient of a considerable investment in infrastructure and will be an attractive location for local entrepreneurs. An influx of people looking for job opportunities will, therefore, be likely. This influx of job-seeker as well as those looking to provide support services can result in an increase of social pathologies such as crime and prostitution within the Chinde community. This impact will be site-specific, have a short term duration during construction and long term duration during the operational phase. Both intensity and magnitude would be low in the construction phase and medium in the operational phase. Coupled with a likely probability of occurrence the expected significance is *Minor* in the construction phase and *Moderate* in the operational phase.

8.19.2 *Mitigation Measures*

Mitigation Objective

To minimise the spread of social ills.

Mitigation Measure(s)

- In order to avoid excessive expectations that can fuel the influx of people to Chinde, the project should disseminate realistic information about labour requirements and about the project's recruitment policy.

- Where possible the Project should support local police in addressing such challenges.

8.19.3 *Residual Impact*

The residual impact is expected to remain as *Minor* for construction and range from *Moderate to Minor* during the operational phase.

Table 8.25 Impact on Social Ills at Chinde

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	On-site	On-site
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Operational Phase	
Duration	Long-term	Long-term
Scale	On-site	On-site
Intensity	Medium	Low
Magnitude	Medium	Low
Likelihood	Likely	Likely
Significance	Moderate	Moderate - Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on social ills at Chinde during this phase.	

8.20 Impact of the Project on Social Infrastructure in Chinde

8.20.1 *Impact Assessment*

During the construction phase, the construction personnel would rely on local services for supply of potable water. Riversdale may supplement this water supply by providing bottled water. Portable sanitation facilities would be supplied by Riversdale. Electricity for construction would be via generators. Thus any impacts on existing social infrastructure during the construction phase would have a negligible magnitude with an unlikely probability of occurrence. The expected significance is *Negligible* during construction.

During the operational phase, the Project may come to rely more heavily on Chinde social infrastructure (roads, water supply, electricity supply, etc.) Riversdale will provide a small clinic to see to their employees' minor health needs while more serious issues would be addressed at suitable facilities outside of Chinde. Thus there is unlikely to be any pressure on Chinde's health services. Accordingly, any impact on Chinde's social infrastructure is expected to be of low intensity and magnitude. Coupled with a likely probability of occurrence, a *Minor* significance impact is expected during the operational phase.

8.20.2 *Mitigation Measures*

Mitigation Objective

To minimise the pressure on existing social infrastructure.

Mitigation Measure(s)

- In order to avoid excessive expectations that can fuel the influx of people to Chinde, the project should disseminate realistic information about labour requirements and about the project's recruiting policy.

- The project proponent should meet with local authorities to discuss the best ways to support local offer on social services under the projects Social Responsibility programme.

8.20.3 *Residual Impact*

The residual impact is expected to remain as *Negligible* for construction and *Minor* during the operational phase.

Table 8.26 Impact on Social Infrastructure at Chinde

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Negligible	Negligible
Likelihood	Unlikely	Unlikely
Significance	Negligible	Negligible
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Minor
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact of the project on social infrastructure during this phase.	

8.21 *IMPACT OF THE POTENTIAL LOSS OF PROPERTY IN BENGA AND IN CHINDE NORTH BANK*

This impact will occur during the construction phase but last up to the end of the operational phase. There are some agricultural plots in Benga that might be disturbed by the building of storage facilities. In Benga, this situation has already been addressed through a Resettlement Action Plan (RAP). At Chinde, there are a number of small huts used as temporary shelters by fishermen at the area where Project infrastructure will be built. No agricultural plots have been noticed in Chinde north bank during site visit or through aerial imagery analysis.

Due to the implementation of the RAP at Benga, the impact is not assessed further here. At Chinde the loss of temporary shelters is considered to be of low intensity as there are remaining open areas for those shelters to move to. The probability of occurrence is considered to be likely, resulting in a *Minor* significance impact.

8.21.1 Mitigation Measures

Mitigation Objective

To minimise the impact of land take.

Mitigation Measure(s)

- Replacement land should be provided and/or compensation should be paid to owners.
- Local authorities must be involved in negotiation process.
- In case of loss of agricultural land, replacement land of same or superior quality must be provided, according to World Bank and IFC recommendations

8.21.2 Residual Impact

The residual impact is expected to reduce to *Negligible* for construction and operational.

Table 8.27 Impact of the Potential loss of Property in Benga and in Chinde North bank

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Long term	Long term
Scale	Site specific	Site specific
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely
Significance	Minor	Negligible
	Operational Phase	
Duration	Long-term	Long term
Scale	Local	Site specific
Intensity	Low	Negligible
Magnitude	Low	Negligible
Likelihood	Likely	Likely

	Without mitigation	Residual Impact (With mitigation)
Significance	Minor	Negligible
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact of the project on social infrastructure during this phase.	

8.22 *IMPACT OF BARGING OPERATIONS ON SENSE OF PLACE*

8.22.1 *Impact Assessment*

This likely to be predominantly an operational phase impact. This is a difficult impact to assess as it is by nature quite subjective. Different people view the river differently and experience the river in different ways. This impact is assessed from the point of view of the potential change in the rural landscape. For those who see the river as a cultural or heritage resource that should be protected from change, any change results in strong objections. The intensity is expected to be low with a low to medium magnitude. For such observers the likelihood of the impact occurring is definite. This results in a *Minor* to *Moderate*. It is expected that the significance of this impact would decrease over time as people become used to the Project.

For those who are seeking jobs, who view signs of development positively, a positive impact is expected. The positive impact is likely to have a low intensity with a low to medium magnitude. Coupled with a definite probability of occurrence a *Minor* to *Moderate positive* impact is expected.

8.22.2 *Mitigation Measures*

Mitigation Objective

To minimise the Project's intrusive impact on sense of place.

Mitigation Measure(s)

- Establish a grievance process with the local communities and develop and management plan to address issues

8.22.3 *Residual Impact*

The residual impact is not likely to change.

Table 8.28 Impact on Sense of Place

	Without mitigation		Residual Impact (With mitigation)	
		Construction Phase		
Duration	n/a		n/a	
Scale	n/a		n/a	
Intensity	n/a		n/a	
Magnitude	n/a		n/a	
Likelihood	n/a		n/a	
Significance	There will be no impact of the project on social infrastructure during this phase.			
		Operational Phase		
Duration	Long-term	Long-term	Temporary	Temporary
Scale	Local	Local	Local	Local
Intensity	Low	Low	Low	Low
Magnitude	Low-Medium	Low-Medium	Low	Low
Likelihood	Definite	Definite	Likely	Likely
Significance	Minor-Moderate	+Minor Moderate	Minor-Moderate	+Minor Moderate
		Decommissioning and Closure Phase		
Duration	n/a		n/a	
Scale	n/a		n/a	
Intensity	n/a		n/a	
Magnitude	n/a		n/a	
Likelihood	n/a		n/a	
Significance	There will be no impact of the project on social infrastructure during this phase.			

8.23 *IMPACT OF THE PROJECT ON THE POTENTIAL FOR RIVER-CENTERED TOURISM*

8.23.1 *Impact Assessment*

During the operational phase, the Project has the potential to affect tourism activities. Currently, there is no significant river-centred tourism activity on the area. However, the Zambezi River has the potential for tourism. Conditions for some eco-tourism activities, such as bird watching, are present in large stretches of the river. The barging project could have both positive and negative impacts on tourism.

In the case of a positive impact, establishing and maintaining a navigable channel has the potential to facilitate river-based tourism. Tourism operators would be able to take boats up the Zambezi and the increased access could spark the development of lodges along the river. This *positive* impact would be long term, local in extent and low in intensity. The resultant low magnitude coupled with a likely probability means that a *Minor positive* significance is expected.

In the case of the negative impact, changing modifying the sense of place and transporting coal (sometimes viewed as "dirty") has the potential to hinder the future development of river-based tourism. Given that river-based tourism is not currently being undertaken and is not in the governments strategic planning for the short to medium term, this impact is likely to be of low intensity and magnitude. Coupled with a likely probability of occurrence, a *Minor* significance impact is expected.

8.23.2 *Mitigation Measures*

Mitigation Objective

To facilitate potential future river-based tourism.

Mitigation Measure(s)

- Establish a grievance process with the local communities and develop and management plan to address issues

8.23.3 *Residual Impact*

The residual impact is not likely to change.

Table 8.29 Impact on the Potential for River-based Tourism

	Without mitigation		**Residual Impact (With mitigation)**	
		Construction Phase		
Duration	Short-term		Short-term	
Scale	Local		Local	
Intensity	Low		Negligible	
Magnitude	Low		Negligible	
Likelihood	Likely		Likely	
Significance	Minor		Negligible	
		Operational Phase		
Duration	Long-term	Long-term	Long-term	Long-term
Scale	Local	Local	Local	Local
Intensity	Low	Low	Negligible	Low
Magnitude	Low	Low	Negligible	Low
Likelihood	Likely	Likely	Likely	Likely
Significance	Minor	+ Minor	Minor	+
		Decommissioning and Closure Phase		
Duration	n/a		n/a	
Scale	n/a		n/a	
Intensity	n/a		n/a	
Magnitude	n/a		n/a	
Likelihood	n/a		n/a	
Significance	There will be no impact of the project on the potential for river-centered tourism during this phase.			

8.24 IMPACT OF THE PROJECT ON DIRECT JOB CREATION

8.24.1 *Impact Assessment*

During the construction phase, the Project will result in the need for skilled, semi-skilled and unskilled labour. It is envisaged that much of the semi-skilled and unskilled labour requirement will be filled by local communities (Chinde and surrounds, Mutarara and surrounds, Benga and surrounds). It is estimated that circa 680 direct jobs [1] can be generated in the construction phase. This positive impact will be localised in nature,

(1) Barry Standish et al., SES Economic specialist study, Table 9.

short term in duration and will have a medium to high intensity. The magnitude is expected to medium with a likely probability of occurrence, resulting in an overall *Moderate positive* significance during construction.

Although not in large scale, the operational phase will generate a number of local jobs associated with convoy crews (estimated 15 crew members per convoy), mooring operations, barges charge/discharge, infrastructure maintenance and ancillary services. In total, it has been estimated that 193 direct job positions might be created by early 2013 (estimated start of barging operation in case of project approval), expanding to 2,176 direct job positions by 2015 and 3,078 direct job positions by 2030 [(1)]. During the operational phase, this positive impact will be felt over a long term with a medium to high intensity and medium to high magnitude. Couple with a likely probability of occurrence this *positive* impact is expected to steadily increase in significance from *Moderate* to *Major* over time.

8.24.2 *Enhancement Measures*

Enhancement Objective

To maximise job creation.

Enhancement Measure(s)

- Priority should be given to the hiring and training of local labour. In order to spread the benefits through riverine communities, a system of quotas can be considered. It is also strongly advisable that local authorities should be involved in the recruiting process. Also, whenever possible, tasks should be allocated to local companies and/or subcontractors.

8.24.3 *Residual Impact*

The residual impact is expected to remain as *Moderate* to *Major* and *positive*.

Table 8.30 Impact on Job Creation

	Without mitigation	**Residual Impact (With mitigation)**
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Medium-High	High
Magnitude	Medium	High
Likelihood	Likely	Likely
Significance	Moderate	Moderate - Major
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Medium-High	High

(1) Barry Standish et al., SES Economic specialist study, Table 9.

	Without mitigation	Residual Impact (With mitigation)
Magnitude	Medium-High	High
Likelihood	Likely	Likely
Significance	Moderate-Major	Moderate-Major
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on job creation during this phase.	

8.25 IMPACT OF SKILLS TRANSFER ON LOCAL MOZAMBICANS

8.25.1 *Impact Assessment*

During the operational phase, expatriate river pilots would transfer their skills to Mozambican pilots. This transfer of technological know-how will be an important factor in creating a highly qualified Mozambican work force. These skills could be put to use in navigation project in and out of Mozambique, thus creating more opportunities for locals. The skills transfer and training is expected to increase over time, resulting in an intensity and magnitude of medium to high. With a likely probability of occurrence, the expected significance is *Moderate to Major* and *positive*.

8.25.2 *Enhancement Measures*

Enhancement Objective

To maximise skills transfer.

Enhancement Measure(s)

- Riversdale should develop and implement a skills transfer programme.

8.25.3 *Residual Impact*

The residual impact is expected to remain as *Moderate to Major* and *positive*.

Table 8.31 Impact on Skills Transfer

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Medium-High	High
Magnitude	Medium-High	High
Likelihood	Likely	Likely
Significance	Moderate -Major	Moderate -Major
	Operational Phase	
Duration	Short-term	Short-term
Scale	Local	Local
Intensity	Medium-High	High

	Without mitigation	Residual Impact (With mitigation)
Magnitude	Medium-High	High
Likelihood	Likely	Likely
Significance	Moderate -Major	Moderate -Major
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact on job creation during this phase.	

8.26 *IMPACT OF LOCAL PROCUREMENT AT BENGA, MUTARARA AND CHINDE*

8.26.1 *Impact Assessment*

During the operational phase, infrastructure development at key location (Benga, Mutarara and Chinde) may result in benefits for local communities as they could provide good and services at these locations. Given that Chinde would have more development (in the form of offices, support services etc.) it will contribute more than the other locations to supporting a local micro-economy. Such a contribution will be local scale, long term in duration and have a low to medium intensity. The magnitude would be medium to high with a likely probability of occurrence, resulting in a *Moderate to Major positive* impact.

8.26.2 *Enhancement Measures*

Enhancement Objective

To maximise local benefits.

Enhancement Measure(s)

- As far as possible, source goods and services locally.
- Social responsibility initiatives aimed at benefiting local population in key project locations (e.g. maintenance or repair of small peers or ramps for community use) can be implemented.

8.26.3 *Residual Impact*

The residual impact is expected to remain as *Moderate to Major* and *positive*.

Table 8.32 Impact of Development at Benga, Mutarara and Chinde

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a

	Without mitigation	Residual Impact (With mitigation)
Likelihood	n/a	n/a
Significance	There will be no impact of development at Benga during the construction phase.	
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Low-Medium	Medium
Magnitude	Medium-High	High
Likelihood	Likely	Likely
Significance	Moderate-Major +	Moderate-Major +
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact of development at Benga during this phase.	

8.27 *IMPACT OF CREATING A NAVIGABLE CHANNEL ON BUSINESS OPPORTUNITIES AND INDIRECT JOB CREATION*

8.27.1 *Impact Assessment*

During the operational phase, the opening of an all-year round navigable channel could result additional economic opportunities (including potential for export of agricultural produce) who may wish to explore new business opportunities such as public river transport businesses, thus increasing the level of services offered to local populations and generating new employment. It has been estimated that indirect job creation could range from approximately 3,000 by 2012 to 39,000 by 2030 [(1)]. This impact would be felt over a long term, with a local extent and medium intensity. The magnitude is expected to be medium with a likely probability. Thus a *Moderate positive* impact is anticipated.

8.27.2 *Enhancement Measures*

No particular enhancement measures were identified. Normal functioning of market forces and entrepreneurial activity is the usual vehicle for this sort of impact.

8.27.3 *Residual Impact*

The residual impact is expected to remain as *Moderate* and *positive*.

(1) Barry Standish et al., SES Economic specialist study, Table 10.

Table 8.33 Impact of Creating a Navigable Channel on Business Opportunities and Indirect Jobs

	Without mitigation	Residual Impact (With mitigation)
	Construction Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact during the construction phase.	
	Operational Phase	
Duration	Long-term	Long-term
Scale	Local	Local
Intensity	Medium	High
Magnitude	High	High
Likelihood	Likely	Likely
Significance	Moderate	Moderate
	Decommissioning and Closure Phase	
Duration	n/a	n/a
Scale	n/a	n/a
Intensity	n/a	n/a
Magnitude	n/a	n/a
Likelihood	n/a	n/a
Significance	There will be no impact during the decommissioning phase.	

9 *CUMULATIVE IMPACTS*

Cumulative impacts occur when a Project activity act together with other activities (other projects) to impact on the same environmental or social receptor. For purposes of this report, cumulative impacts have been defined as "the changes to the environment caused by an activity in combination with other past, present, and reasonably foreseeable future human activities". Past and present activities were considered in developing the environmental and social baseline against which the Project is assessed. For example, the baseline benthic fauna takes into account past coal loading activities that have modified benthic habitat and resulted in a drop in the number of benthic fauna species. Thus the impact on benthic fauna as a result of the Project inherently considers the past activity, and therefore the impact assessment incorporates this cumulative effect. Over and above the past and present activities, we have identified the following "reasonably foreseeable" activities that could act together with the Project to cumulatively affect the environment:

- The construction and operation of the Mphanda Nkuwa Dam and Hydropower Plant.
- The expansion of Cahora Bassa Dam.
- The construction and operation of the Lupata Dam and Hydropower Plant.
- The construction and operation of the Boroma Dam and Hydropower Plant.
- Use of the river by other coal companies or projects as a transport route.
- Ongoing development.

9.1 *CUMULATIVE IMPACT OF DAMS AND THE BARGING PROJECT*

9.1.1 *The Issue*

The dams identified above could act together with the Project to modify river and sediment flows, exacerbating environmental and social impacts on the Zambezi River and delta, on the Ramsar and other riparian wetlands/ habitats, on riparian agriculture and on artisanal and semi-industrial fishing.

The lower reaches of the Zambezi River have been altered significantly by the development of the Kariba and Cahora Bassa Dams. These large dams have resulted in an attenuation of the flows in the Zambezi River; largely eliminating the large flood events and very low dry season flows. The flows are now more stable to support hydropower generation. This has led to the river downstream of Cahora Bassa being more geomorphologically stable, with a narrower active channel, less braiding and less sediment transport than was historically the case. The result is that the river's geomorphologic and ecological systems downstream of the dams have been dramatically modified from their natural state. Inundation of the delta is now reliant on regional rain run-off and/ or releases from Cahora Bassa (Beilfuss and Brown, 2006).

9.1.2 Assessment and Mitigation

Because specific dam operating scenarios are unknown at this stage, quantifying the potential cumulative impact is not possible. The Environmental Flow study for this proposed Project shows that the Project will have a negligible incremental effect on water level and flood patterns in the river relative to present day conditions and the Project will not remove any sediment from the river system. Thus, in light of these results, it is reasonable to assume that the Barging Project's contribution to potential cumulative impacts on river flow and sediments is likely to be very low compared to that of the proposed dams. By their nature, dams are the primary influence on river and sediment flows.

In line with international good practice, RML's mitigation should be commensurate with its level of contribution to the cumulative impact. In this regard, the appropriate mitigation is for RML to share data and information with third parties to facilitate a regional strategic assessment of development on the lower Zambezi River. There is a strong need to foster collaboration among the mining and power sectors as well as between these sectors and the Mozambican government and NGOs.

9.2 CUMULATIVE IMPACT OF RIVER TRANSPORT BY OTHER COAL COMPANIES AND PROJECTS

9.2.1 Issue

The creation and maintenance of the navigable channel for the proposed Project could result in other companies and projects (including coal companies, transport companies or even tourist companies) using the river as a means of transport. This has the potential to result in cumulative impacts on environmental and social aspects like water quality, safety of current river users, riparian habitats and riparian agriculture.

9.2.2 Assessment and Mitigation

As with the dams, there is insufficient information available to quantify the potential future use of the river by other companies or projects. Should these future users comply with RML's channel design parameters (ie utilise RML's channel without additional dredging or widening) and operational parameters (speed of vessels, safety standards, pollution prevention measures, emergency response procedures etc), then the cumulative impacts on the river environment and those communities using the river is likely to be low. However the cumulative impact on river safety due to increased traffic on the river will be higher, depending on the number of additional vessels using the river and depending on the level of intervention by the appropriate authority.

The main mitigation measure is for RML together with future users to work with the Mozambican government in complying with regulatory requirements for river transport. As a minimum all users should comply with standards of operation described in this ESIA Report, ESMP and any regulations defined by the appropriate government authority.

9.3 *Cumulative Impact of Ongoing Development*

9.3.1 *Issue*

In addition to the specific reasonably foreseeable projects listed above, development in the Tete area (primarily throughmining) is resulting in an increase in population and increasing pressure on infrastructure and services. These population and development pressures may lead to further investigation of the river as a transport route or as a source of water. This in turn could cumulatively affect the ecological functioning, and dependent socio-economic activities, of the lower Zambezi.

9.3.2 *Assessment and Mitigation*

While these developments will add significantly to the economic growth of Tete Province and Mozambique as a whole, it is likely the functioning of the lower Zambezi, as an important source of livelihood and economic development in its own right, will be impacted and changed. The government of Mozambique needs to consider the trade-offs of growth in the mining, industrial and energy sectors and the associated benefits to the economy and the people of Mozambique against the potential long term and cumulative impacts on the functioning of the Zambezi Basin. This is important considering the role that the Zambezi River plays in economies outside of its catchment, namely its contribution to the fishing and prawn industry (through provision of breeding areas, food and shelter and linkages to the Sofala Bank), to marginal and island agriculture and potentially to ecotourism in the future.

While the cumulative impacts are difficult to quantify, ongoing monitoring will be key to provide the government of Mozambique with information to inform its strategic planning for the lower Zambezi River. In this regard collaboration among the mining and power sectors as well as between these sectors and the Mozambican government and NGOs will promote a more comprehensive understanding of the lower Zambezi River system.

10 *FRAMEWORK ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN*

10.1 *OVERVIEW AND SCOPE*

10.1.1 *Introduction*

This chapter provides the framework Environmental and Social Management Plan (ESMP) for RML's Zambezi River Coal Barging Project. Elements of this provisional plan will be taken forward and incorporated into a comprehensive project EMP that will be used to deliver the Project's Environmental, Health and Social (EHS) regulatory compliance objectives and other related commitments.

This ESMP is a delivery mechanism for environmental and social mitigation measures made in the ESIA Report. The purpose of the ESMP is to ensure that these recommendations are translated into practical management actions which can be adequately resourced and integrated into the project phases. The EMP is, therefore, an environmental management tool used to ensure that undue or reasonably avoidable adverse impacts of construction and decommissioning are prevented and that the positive benefits of the projects are enhanced [(1)].

The framework ESMP can be found in *Annex D.*

10.1.2 *Scope*

The ESMP is intended to cover those activities described in *Chapter 4* of this ESIA report. It covers project activities during construction and operations and will be subject to thorough reviews prior to the commencement of activities to ensure completeness.

10.2 *ENVIRONMENTAL MANAGEMENT ORGANISATION*

RML is committed to provide resources essential to the implementation and control of the ESMP. Resources include the appropriate human resources and specialised skills. RML will have a dedicated personnel competent on the basis of appropriate education, training, and experience that will manage and oversee the EHS aspects of project construction.

10.2.1 *Training and Awareness*

RML will identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact upon the environment

(1) Lochner, P. 2005. Guideline for Environmental Management Plans. CSIR Report No. ENV-S-C 2005-053 H.RSA, Provincial Government of the Western Cape, Department of Environmental Affairs and Development Planning, Cape Town.

or social conditions. The project recognises that it is important that employees at each relevant function and level are aware of the project's environmental and social policy; potential impacts of their activities; and roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal training process. Employee training will include awareness and competency with respect to:

- environmental and social impacts that could potentially arise from their activities;

- necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts; and

- roles and responsibilities to achieve that conformity, including with regard to change management and emergency response.

The EHS coordinator is responsible for coordinating training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The EHS coordinator will also periodically verify that staff are performing competently through discussion and observation.

Employees responsible for performing site inspections will receive training by drawing on external resources as necessary. Training will be coordinated by the EHS coordinator prior to commissioning of the facilities. Upon completion of training and once deemed competent by management, staff will be ready to train other people.

Similarly the project will require that each of the subcontractors institute training programmes for its personnel. Each subcontractor is responsible for site EHS awareness training for personnel working on the job sites. The subcontractors are also responsible for identification of any additional training requirements to maintain required competency levels.

The subcontractor training program will be subject to approval by the project and it will be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- competency is being verified.

10.2.2 Communication

RML will maintain a formal procedure for communications with the regulatory authorities and communities. The EHS coordinator is

responsible for communication of EHS issues to and from regulatory authorities whenever required.
Meetings will be held, as required, between the RML and the appropriate regulatory agency and community representatives to review EHS performance, areas of concern and emerging issues. Dealings will be transparent and stakeholders will have access to personnel and information to address concerns raised.

RML have appointed a Community Liaison Officer (CLO). The CLO is responsible for disseminating information and coordinating community communications through the course of the Project.

The Project will develop and implement a Grievance Mechanism whereby community members can raise any issues of concern. Grievances may be verbal or written and are usually either specific claims for damages/injury or complaints or suggestions about the way that the project is being implemented. When a grievance has been brought to the attention of the project team it will be logged and evaluated. The person or group with the grievance is required to present grounds for making a complaint or claiming loss so that a proper and informed evaluation can be made.

Where a complaint or claim is considered to be valid then steps are required to be undertaken to rectify the issue or agree compensation for the loss. In all cases the decision made and the reason for the decision will be communicated to the relevant stakeholders and recorded. Where there remains disagreement on the outcome then an arbitration procedure may be required to be overseen by a third party (eg government official). Local community stakeholders will be informed on how to implement the grievance procedures.

10.2.3 Emergency Preparedness and Response

RML will prepare plans and procedures to identify the potential for and response to environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them.

Emergency preparedness and response will be reviewed by RML on at least an annual basis and after the occurrence of any accidents or emergency situations to ensure that lessons learnt inform continuous improvement. Emergency exercises will be undertaken on a regular basis to confirm adequacy of response strategies. Investigations of accidents or incidents will follow formal documented procedures.

10.2.4 Managing Changes to Project Activities

Changes in the Project may occur due to unanticipated situations. Adaptive changes may also occur during the course of final design, commissioning or even operations. The project will implement a formal procedure to manage changes in the project that will apply to all project activities.

The objective of the procedure is to ensure that the impact of changes on the health and safety of personnel, the environment, plant and equipment are identified and assessed prior to changes being implemented.

The management of change procedure will ensure that:

- proposed changes have a sound technical, safety, environmental, and commercial justification;

- changes are reviewed by competent personnel and the impact of changes is reflected in documentation, including operating procedures and drawings;

- hazards resulting from changes that alter the conditions assessed in the EIA have been identified and assessed and the impact(s) of changes do not adversely affect the management of health, safety or the environment;

- changes are communicated to personnel who are provided with the necessary skills, via training, to effectively implement changes; and

- the appropriate RML person accepts the responsibility for the change.

As information regarding the uncertainties becomes available, the project ESMP will be updated to include that information in subsequent revisions. Environmental and social, as well as engineering feasibility and cost, considerations will be taken into account when choosing between possible alternatives.

10.3 *CHECKING AND CORRECTIVE ACTION*

10.3.1 *Introduction*

Checking includes inspections and monitoring as well as audit activities to confirm proper implementation of checking systems as well as effectiveness of mitigations. Corrective actions include response to out-of-control situations, non-compliances, and non-conformances. Actions also include those intended to improve performance.

10.3.2 *Inspection*

EHS inspections will be conducted weekly on an ad hoc basis and formally at least once every six months. The results of the inspection activities will be reported to RML to be addressed.

10.3.3 *Monitoring*

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. Monitoring parameters are included in the Framework ESMP in Annex D.

10.3.4 *Auditing*

Beyond the routine inspection and monitoring activities conducted, audits will be carried out internally by RML to ensure compliance with regulatory requirements as well as their own EHS standards and policies. Audits to be conducted will also cover the subcontractor self-reported monitoring and inspection activities. The audit shall be performed by qualified staff and the results shall be reported to RML to be addressed.

The audit will include a review of compliance with the requirements of the ESIA and ESMP and include, at minimum, the following:

- completeness of EHS documentation, including planning documents and inspection records;
- conformance with monitoring requirements;
- efficacy of activities to address any non-conformance with monitoring requirements; and
- training activities and record keeping.

There will be a cycle of audits into specific areas of the project such as waste management. The frequency of audits will be risk based and will vary with the stage of the project and will depend on the results of previous audits.

10.3.5 *Corrective Action*

Investigating a 'near miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future.

RML will implement a formal non compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental or social non-compliances. This will ensure coordinated action between RML and its subcontractors. The EHS coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non-conformances and non-compliances.

10.3.6 *Reporting*

Throughout the Project, RML will keep regulatory authorities informed of the project performance with respect to EHS matters by way of written status reports and face-to-face meetings. RML will prepare a report on environmental and social performance and submit it to MICOA. The frequency of this reporting will be agreed upon between RML and MICOA.

If required, RML provide appropriate documentation of EHS related activities, including internal inspection records, training records, and reports to relevant authorities. Subcontractors are also required to provide EHS performance reporting to RML on a regular basis through weekly and monthly reports. This will be used as input to the above.

11 CONCLUSIONS

The proposed Project is the first of its kind in Mozambique in terms of scale and complexity. Given the ecological and social significance of the Zambezi River as well as the major developments (primarily dams) that have significantly altered the Zambezi hydrological regime, it is expected that the Project will be scrutinised heavily by stakeholders. Thus RML embarked on an ESIA process that will have spanned close to two years at completion in order to thoroughly understand the key issues.

The key issues that were raised several times through the process by external stakeholders and by internal specialists are listed below:

- Potential water level changes with associated implications for riparian habitats and marginal socio-economic activities.
- Potential for coal and fuel spills to affect ecosystem functioning and social interactions with the river.
- Safety of current river users.
- Potential implications for fish populations and for fishing.
- Potential implications for the delta and the Ramsar wetland.
- Cumulative impacts (future dam projects on the river).

All measures to mitigate and manage impacts as well as to monitor implementation and success of the measures are presented in the framework EMP (*Annex D*). A summary of all assessed impacts is provided in the table below.

Table 11.1 Summary of Impacts

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Impact of dredging and spoil deposition on the Zambezi delta and Ramsar wetland	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of dredging and spoil deposition on benthic habitat	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Routine Coal Spillage on Freshwater Aquatic Invertebrates	Operation	**Minor**	**Negligible**
	Decommissioning & Closure	**Minor**	**Negligible**
Impact of accidental fuel spills on aquatic invertebrates	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of bank collapse on aquatic invertebrates	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Dredging on Turbidity and Fish	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Accidental Fuel Spills on Fish	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of accidental Coal Spills on Fish	Operation	**Negligible**	**Negligible**
Impact of Changes in the Hydrology and Flooding Pattern on Fish	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of Dredging on Injuries to Fish	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact on Depth Classes due to Dredging	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Benga land based facilities on terrestrial ecology and habitat	Construction, ,	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
	Decommissioning & Closure	**Minor**	**Negligible**
Impact of Chinde land based facilities on mangroves	Construction,	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
	Decommissioning & Closure	**Minor**	**Minor**
Disturbance to riparian habitats due to dredging and spoil deposition	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of accidental fuel spills on riparian habitats	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Increase in rate of erosion of riparian habitats due to wakes from barges and push boats	Operation	**Moderate**	**Minor**
Changes to hippopotamus behaviour and an increase in human animal conflict	Construction	**Minor**	**Negligible to Minor**
	Operation	**Minor**	**Negligible to Minor**
Impact of human and vehicle traffic on salt marsh habitat	Construction a	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Noise on River and Estuarine Fauna	Construction	**Minor**	**Negligible**
Impact of dredging of the offshore sand bar on sea bed benthic organisms	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of dredging of the offshore sandbar on seawater quality	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of Anchoring of Transloaders and OGVs on the Sofala Bank Sea Bed	Operation	**Minor**	**Negligible**
Impact of coal dust on vegetation and water quality in the estuary	Operation	**Minor**	**Minor**
Impact of operational coal spillage on the estuary environment	Operation	**Minor**	**Minor**
Impact of coal dust and operational coal spillage on the marine environment	Operation	**Negligible**	**Negligible**
Impact of operational discharges from OGVs on the marine and estuarine environment	Operation	**Minor**	**Minor**
Impact of accidental discharge of liquid hydrocarbons during fuel transfers	Operation	**Minor**	**Low**
Impact of ballast water discharges on the marine environment	Operation	**Minor**	**Minor**
Impact of groundings and/or collisions of barges and/ or tugs in the River	Construction	**Minor**	**Minor**
	Operation	**Moderate**	**Minor**
	Decommissioning & Closure	**Minor**	**Minor**
Impact of collisions of barges and/ or tugs in the marine environment	Operation	**Minor**	**Minor**
Impact of salinity intrusion on the estuary due to dredging of the offshore sandbar	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of dredging the offshore sandbar on littoral drift sediment dynamics and beach erosion	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Land-based Facilities on Bird Habitat	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of Noise on Birds	Construction	**Minor**	**Minor**
Impact of Disturbances on Island Bird Habitats due to Dredging	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Accidental Fuel Spills on Birds and Bird Habitats	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Impact of Bird Hunting by Workers during the Construction and Operational Phases	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**

Impact	Project Phase	Significance (Pre Mitigation/ Enhancement Measures)	Residual Impact (Post Mitigation/ Enhancement Measures)
Impact of Spoil Deposition on High Flow Distributaries and Bird Feeding and Breeding	Construction	**Minor**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact of Dredging on Bird Food Sources	Construction	**Minor to Moderate**	**Minor**
	Operation	**Moderate**	**Minor**
Groundwater Impact on Gorongosa National Park	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of the project on Mozambican national economy (Cost Benefit Analysis)	The Project	**Major**	**Major**
Impact of the project on the macro-economy	Construction	**Major**	**Major**
	Operation	**Major**	**Major**
Noise impact of barging on riverside communities	Operation	**Minor**	**Minor**
Noise impact of dredging on riverside communities	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Noise impact at the loadout point at Benga	Construction	**Moderate**	**Moderate**
	Operation	**Negligible**	**Negligible**
Noise impact at the barge mooring areas at Dona Ana Bridge	Construction	**Moderate**	**Moderate**
	Operation	**Minor to Moderate**	**Minor to Moderate**
Noise impact at the barge mooring areas at Chinde	Construction	**Moderate**	**Moderate**
	Operation	**Minor**	**Minor**
Impact of dredging on artisanal and semi-industrial fishing activities in the river	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of barging operations on artisanal and semi-industrial fishing activities	Operation	**Minor**	**Minor**
Impact of safety exclusion zones on artisanal fishing at Chinde	Construction	**Minor**	**Negligible**
	Operation	**Moderate**	**Minor**
Impact of safety exclusion zone on offshore semi-industrial and industrial fishing	Operation	**Negligible**	**Negligible**
Impact of changes to flows on agricultural activity on river margins and islands	Construction	**Negligible**	**Negligible**
	Operation	**Negligible**	**Negligible**
Impact of barging on river safety	Operation	**Moderate**	**Minor**
Impact of convoy wakes on river margin activities (washing, bathing, water collecting)	Construction	**Minor**	**Minor**
	Operation	**Minor**	**Minor**
Impact of accidental fuel spills on river margin activities (washing, bathing, water collecting)	Construction	**Negligible**	**Negligible**
	Operation	**Minor**	**Negligible**
Impact on community health	Construction	**Moderate**	**Minor**
	Operation	**Moderate**	**Minor**

<table>
<tr><th>Impact</th><th>Project Phase</th><th colspan="2">Significance (Pre Mitigation/ Enhancement Measures)</th><th colspan="2">Residual Impact (Post Mitigation/ Enhancement Measures)</th></tr>
<tr><td rowspan="2">Increase in social ills (crime, prostitution) on Chinde population</td><td>Construction</td><td colspan="2">Minor</td><td colspan="2">Minor</td></tr>
<tr><td>Operation</td><td colspan="2">Moderate</td><td>Moderate</td><td>Minor</td></tr>
<tr><td rowspan="2">Impact of the project on social infrastructure in Chinde</td><td>Construction</td><td colspan="2">Negligible</td><td colspan="2">Negligible</td></tr>
<tr><td>Operation</td><td colspan="2">Minor</td><td colspan="2">Minor</td></tr>
<tr><td rowspan="2">Potential loss of Property in Benga and in Chinde North bank</td><td>Construction</td><td colspan="2">Minor</td><td colspan="2">Negligible</td></tr>
<tr><td>Operation</td><td colspan="2">Minor</td><td colspan="2">Negligible</td></tr>
<tr><td rowspan="2">Impact of the project on river-centered tourism</td><td>Construction</td><td colspan="2">Minor</td><td colspan="2">Negligible</td></tr>
<tr><td>Operation</td><td>Minor</td><td>+Minor</td><td>Minor</td><td>+Minor</td></tr>
<tr><td>Impact of barging operations on sense of place</td><td>Operation</td><td>Minor-Moderate</td><td>+Minor - Moderate</td><td>Minor-Moderate</td><td>+Minor - Moderate</td></tr>
<tr><td rowspan="2">Impact of the project on direct job creation</td><td>Construction</td><td colspan="2">Moderate</td><td colspan="2">Moderate - Major</td></tr>
<tr><td>Operation</td><td colspan="2">Moderate</td><td colspan="2">Moderate - Major</td></tr>
<tr><td>Impact of skills transfer on local Mozambicans</td><td>Operation</td><td colspan="2">Moderate - Major</td><td colspan="2">Moderate - Major</td></tr>
<tr><td>Impact of development at Benga, Mutarara and Chinde</td><td>Operation</td><td colspan="2">Moderate - Major</td><td colspan="2">Moderate – Major</td></tr>
<tr><td>Impact of creating a navigable channel on business opportunities and indirect jobs</td><td>Operation</td><td colspan="2">Moderate</td><td colspan="2">Moderate</td></tr>
</table>

From the table it can be seen that the proposed Project described in this report would predominantly have a relatively minor impact on the status quo of the Zambezi River. The primary reason for this is that the impacts of the proposed dredging on the hydraulics of, and habitats in, the lower Zambezi River are expected to be muted by the sheer size of the Lower Zambezi ecosystem relative to the proposed dredged channel and influence of spoil disposal.

Pre-mitigation *Moderate* negative are expected for:

- Impact of dredging on benthic habitat (construction and operation).
- Impact of accidental spills on riparian habitats (construction and operation).
- Impact of exclusion zones on artisanal fishermen (operation).
- Impact of grounding or collisions in the estuary (operation).
- Impact of dredging the offshore sandbar on littoral drift sediment dynamics and beach erosion (construction and operation).
- Impact of noise at the loadpoint at Benga (construction).
- Impact of noise at the barge mooring area at Chinde (construction).
- Impact of barging on river safety (operation).
- Impact on community health (construction and operation).
- Impact of increasing social ills at Chinde (operation).
- Impact of safety exclusion zones on artisanal fishing at Chinde (construction)
- Increase in the rate of erosion of riparian habitats due to wakes from barges and pushboats (operation)
- Impact of accidental fuel spills on fish (construction and operation).
- Impact of accidental fuel spill on birds and bird habitats (construction and operation)
- Impact on bird food sources (construction and operation).
- Impact of noise at the Dona Ana Bridge (construction)

A Major negative impact is expected for:
- Impact of noise at the Dona Ana Bridge (operation).

With the exception of noise impacts at the loadout point at Benga, at Dona Ana Bridge and at Chinde, all the above impacts can be mitigated to be of *Minor* significance.

The Project is also expected to have *Moderate* to *Major* positive impacts with respect to:

- The Benefit Cost Ratio (benefits outweigh the costs for Mozambican society).
- Contribution to GDP and the macro-economy.
- Generation of direct and indirect jobs.
- Skills Transfer.
- Local procurement of goods and services.

- Creating a navigable channel on business opportunities

Should the magnitude of the Project's dredging remain unchanged from that described in this report, and should the proposed mitigation measures be implemented, there are unlikely to be any fatal flaws from an environmental and social perspective. Should the Project be approved, it is recommended that RML works closely with the Mozambican government to monitor the ongoing activities, to:

- add to the body of knowledge regarding the river;
- evaluate the success of the mitigation and management measures;
- to better understand the requirements for maintenance dredging and hence determine if the EF Study needs to be updated; and
- to assist with strategic planning for the river, particularly focussing on cumulative impacts.

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