REPORT

Central Térmica de Temane Project - Aquatic Biodiversity Report

Moz Power Invest, S.A. and Sasol New Energy Holdings (Pty) Ltd

Submitted to:

Ministry of Land, Environment and Rural Development (MITADER)

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Executive Summary

The Govuro River is the only perennial river in the Central Térmica de Temane (CTT) Study Area, flowing approximately 185 km parallel to the coast from south to north to the river mouth south of Nova Mambone.

Overall, the Govuro River is considered to be in a natural state, with the 2018 studies not differing significantly from the previous studies conducted within the same reach of river. Furthermore, the results collected in 2018, were comparable to studies completed between 2005 and 2016, with water quality parameters and biota found to be similar. The Govuro River system is considered to have high fish diversity, with the number of expected species varying with regards to marine vagrants and estuarine specialists. Fifty-two (52) fish species have been identified in literature to occur within the Project Area, of which 49 have been collected in various surveys for the Joint Venture project.

A general assessment of aquatic macroinvertebrates resulted in a rating of “fair” condition due to the lower sensitivity scores of the abundant air-breathing taxa found in an environment dominated by vegetation in slow/shallow habitats and lack of rocky riffle type habitats. Macroinvertebrates have not been well sampled across the different aquatic habitats, as a result of the naturally low diversity of instream habitats associated with a low gradient and largely uniform bed substrate comprised of fine sand and outcrops of calcrete cobbles and boulders that is typical of the Govuro River in the study area (ERM, 2016). As a result, the macro-invertebrate integrity scores and the habitat site scores reflect a high degree of similarity in habitats and associated invertebrates in the Govuro River. Furthermore, the tidal influence results in naturally high concentrations of salinity that are close to the upper tolerance limit for many freshwater species (ERM, 2016). The freshwater macroinvertebrate fauna therefore comprises mainly hardy taxa that are generally unsuitable for monitoring environmental change.

An assessment of the riparian and aquatic habitat indicated that the sites sampled along the Govuro River are largely unmodified. The Govuro River channel is dominated by emergent vegetation along the margins, comprising *Phragmites australis* (Reeds) and *Nymphaea sp*. (Water Lily), while the centre of the channel is typically open water with areas of sand and fine gravel. Although a few rocks were observed, no rapid or riffle habitats were noted. A comparison of the results from the 2004/5, 2014, 2015 and 2016 surveys showed consistency with the same categories being recorded during the June 2018 site visit. The only notable difference was at the upstream site at the Vilanculos Bridge (GV-SW00), which showed signs of the invasive *Salvinia molesta.*

In situ water quality measured during the June 2018 survey was not considered a limiting factor to aquatic biota. The results collected were comparable to those collected in February 2015 with the exception of temperature and dissolved oxygen, which were marginally below the summer mean. This was expected as the survey was conducted in different seasons, and dissolved oxygen is related to water temperature. When compared to the surface water baseline study (Golder Report: 1405502-13410-9), the analysis of the data of the present state of the water in the Govuro River reflects that quality of the water is good. The water quality is indicative of a fairly natural state with relatively low concentrations of most water quality parameters assessed.

Even though the Govuro River is considered to be in a natural state, the proposed CTT Project is not expected to have a significant impact to the water quality, habitat or biota of the aquatic ecosystems due to the type of development and small footprint thereof. During the construction phase, disturbance of the habitats within the localised area may impact on the aquatic biota. It is likely that fish species that occur at or near the sites will move away if disturbed. This will however, be localised and temporary, and thus the aquatic biota should recover quickly as the habitats are rehabilitated and re-colonisation takes place.

Regular water quality and habitat monitoring should be implemented with reference to a specified set of triggers, which will alert the ECO or environmental manager to any change or decrease in integrity. This will then prompt more detailed sampling of the biota (response indices) to determine what the effect on the overall aquatic health is so that appropriate interventions can be executed.

Table of Contents

TABLES

FIGURES

APPENDICES

ACRONYMS

Acronym	Definition
CPF	Central Processing Facility
CCGT	Steam turbines for Combined Cycle Gas Turbine
CPUE	Catch Per Unit Effort
CR	Critically endangered - IUCN
CTRG	*Central Térmica de Ressano Garcia*
CTT	*Central Térmica de Temane*
DD	Data deficient - IUCN
DO	Dissolved oxygen
DWA / DWAF	Department of Water Affairs, previously Department of Water Affairs and Forestry (South Africa)
EC	Electrical Conductivity
EDM	Electricidade de Mozambique
ESIA	Environmental and Social Impact Assessment
GSM	Gravel Sand & Mud Biotope
IHAS	Integrated Habitat Assessment System
IHIA	Intermediate Habitat Integrity Assessment
km	Kilometre
kV	Kilovolts
LC	Least concern - IUCN
MW	Mega Watt
NE	Not evaluated - IUCN
NT	Near threatened - IUCN
OCGE	Open Cycle Gas Engines
SASS	South African Scoring System
SIC	Stones-in-current Biotope

Acronym	Definition
SNE	Sasol New Energy Holdings (Pty) Ltd
SEPI	Sasol Exploration Production International
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
USGS	The United States Geological Survey
VEG	Vegetation Biotope

1.0 INTRODUCTION

The Mozambican economy is one of the fastest growing economies on the African continent with electricity demand increasing by approximately 6-8% annually. In order to address the growing electricity demand faced by Mozambique and to improve power quality, grid stability and flexibility in the system, Moz Power Invest, S.A. (MPI), a company to be incorporated under the laws of Mozambique and Sasol New Energy Holdings (Pty) Ltd (SNE) in a joint development agreement is proposing the construction and operation of a gas to power facility, known as the Central Térmica de Temane (CTT) project. MPI's shareholding will be comprised of EDM and Temane Energy Consortium (Pty) Ltd (TEC). The joint development partners of MPI and SNE will hereafter be referred to as the Proponent. The Proponent propose to develop the CTT, a 450MW natural gas fired power plant.

The proposed CTT project will draw gas from either the Sasol Exploration and Production International (SEPI) gas well field via the phase 1 development of the PSA License area, covering gas deposits in the Temane and Pande well fields in the Inhassoro District and the existing Central Processing Facility (CPF) or from an alternative gas source. Consequently, the CTT site is in close proximity to the CPF. The preferred location for the CTT is approximately 500 m south of the CPF. The CPF, and the proposed site of the CTT project, is located in the Temane/Mangugumete area, Inhassoro District, Inhambane Province, Mozambique; and approximately 40 km northwest of the town of Vilanculos. The Govuro River lies 8 km east of the proposed CTT site. The estimated footprint of the CTT power plant is approximately 20 ha (see Figure 1).

Associated infrastructure and facilities for the CTT project will include:

1) Electricity transmission line (400 kV) and servitude; from the proposed power plant to the proposed Vilanculos substation over a total length of 25 km running generally south to a future Vilanculos substation. [Note: the development of the substation falls outside the battery limits of the project scope as it is part of independent infrastructure authorised separately (although separately authorised, the transmission line will be covered by the Project ESMP, and the Vilanculos substation is covered under the Temane Transmission Project (TTP) Environmental and Social Management Plans) Environmental authorisation for this substation was obtained under the STE/CESUL project. (MICOA Ref: 75/MICOA/12 of 22nd May)]

2) Piped water from one or more borehole(s) located either on site at the power plant or from a borehole located on the eastern bank of the Govuro River (this option will require a water pipeline approximately 11km in length);

3) Access road; over a total length of 3 km, which will follow the proposed water pipeline to the northeast of the CTT to connect to the existing Temane CPF access road;

4) Gas pipeline and servitude; over a total length of 2 km, which will start from the CPF high pressure compressor and run south on the western side of the CPF to connect to the power plant or from an alternative gas source;

5) Additional nominal widening of the servitude for vehicle turning points at points to be identified along these linear servitudes;

6) A construction camp and contractor laydown areas will be established adjacent to the CTT power plant footprint; and

7) Transhipment and barging of equipment to a temporary beach landing site and associated logistics camp and laydown area for the purposes of safe handling and delivery of large oversized and heavy equipment and infrastructure to build the CTT. The transhipment consists of a vessel anchoring for only approximately 1-2 days with periods of up to 3-4 months between shipments over a maximum 15 month period early in

the construction phase, in order to offload heavy materials to a barge for beach landing. There are 3 beach landing site options, namely SETA, Maritima and Briza Mar (Figure 7). The SETA site is considered to be the preferred beach landing site for environmental and other reasons; it therefore shall be selected unless it is found to be not feasible for any reason;

8) Temporary bridges and access roads or upgrading and reinforcement of existing bridges and roads across sections of the Govuro River where existing bridges are not able to bear the weight of the equipment loads that need to be transported from the beach landing site to the CTT site. Some new sections of road may need to be developed where existing roads are inaccessible or inadequate to allow for the safe transport of equipment to the CTT site. The northern transport route via R241 and EN1 is considered as the preferred transport route (Figure 8) on terrestrial impacts; however, until the final anchor point is selected, and the barge route confirmed, the marine factors may still have an impact on which is deemed the overall preferable route.

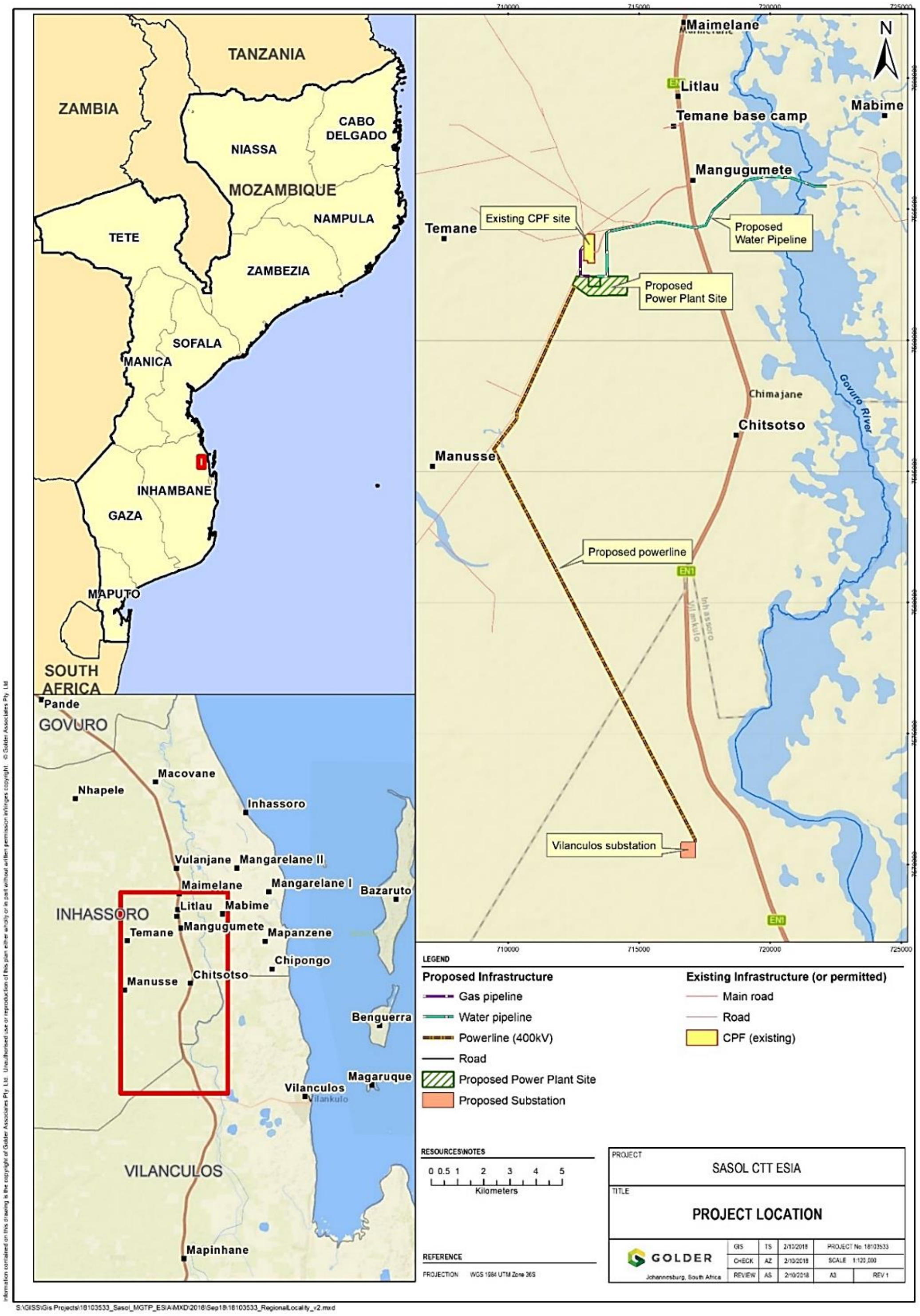

Figure 1: Project Location

2.0 DESCRIPTION OF THE KEY PROJECT COMPONENTS

The CTT project will produce electricity from natural gas in a power plant located 500m south of the CPF. The project will consist of the construction and operation of the following main components:

- Gas to Power Plant with generation capacity of 450MW;

- Gas pipeline (±2 km) that will feed the Power Plant with natural gas from the CPF or from an alternative gas source;
- 400kV Electrical transmission line (± 25 km) with a servitude that will include a fire break (vegetation control) and a maintenance road to the Vilanculos substation. The transmission line will have a partial protection zone (PPZ) of 100m width. The transmission line servitude will fall inside the PPZ;
- Water supply pipeline to a borehole located either on site or at borehole located east of the Govuro River;
- Surfaced access road to the CTT site and gravel maintenance roads within the transmission line and pipeline servitudes;
- Temporary beach landing structures at Inhassoro for the purposes of delivery of equipment and infrastructure to build the power plant. This will include transhipment and barging activities to bring equipment to the beach landing site for approximately 1-2 days with up to 3-4 months between shipments over a period of approximately 8-15 months;
- Construction camp and contractor laydown areas adjacent to the CTT power plant site; and
- Temporary bridge structures across Govuro River and tributaries, as well possible new roads and/or road upgrades to allow equipment to be safely transported to site during construction.

Figure 2: Examples of gas to power plant sites (source: www.industcards.com and www.wartsila.com)

The final selection of technology that will form part of the power generation component of the CTT project has not been determined at this stage. The two power generation technology options that are currently being evaluated are:

- Steam turbines for Combined Cycle Gas Turbine (CCGT); and
- Open Cycle Gas Engines (OCGE).

Please refer to Chapter 4 of the main ESIA document for further details on the technology option.

At this early stage in the project a provisional layout of infrastructure footprints, including the proposed linear alignments is indicated in Figure 1. A conceptual layout of the CTT plant site is shown below in Figure 3.

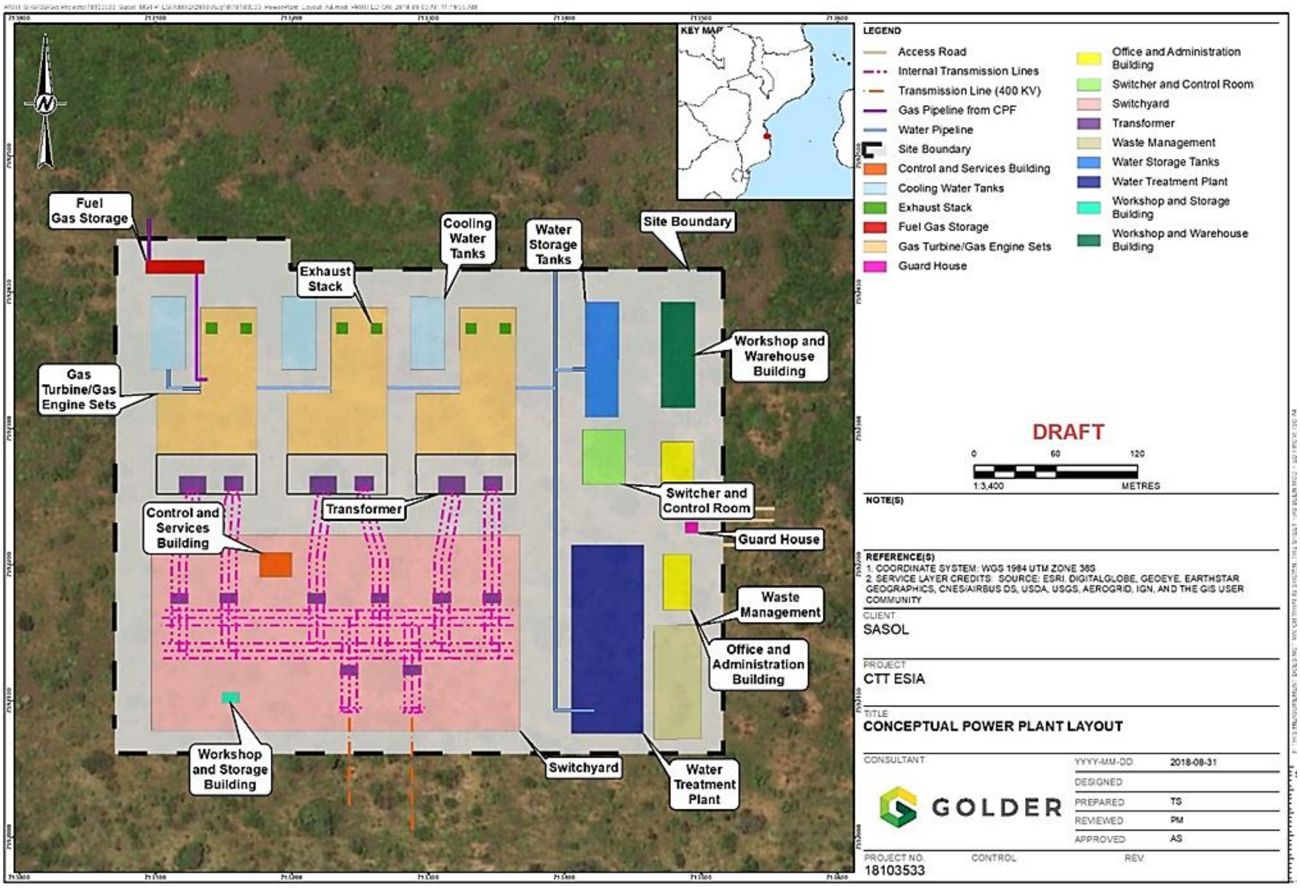

Figure 3: Conceptual layout of CTT plant site

2.1 Ancillary Infrastructure

The CTT project will also include the following infrastructure:

- Maintenance facilities, admin building and other buildings;
- Telecommunications and security;
- Waste (solid and effluent) treatment and/or handling and disposal by third party;
- Site preparation, civil works and infrastructure development for the complete plant;
- Construction camp (including housing/accommodation for construction workers); and
- Beach landing laydown area and logistics camp.

The heavy equipment and pre-fabricated components of the power plant will be brought in by ship and transferred by barge and landed on the beach near Inhassoro. The equipment and components will be brought to site by special heavy vehicles capable of handling abnormally heavy and large dimension loads. Figure 4, Figure 5 and Figure 6 show examples of the activities involved with a temporary beach landing site, offloading and transporting of large heavy equipment by road to site.

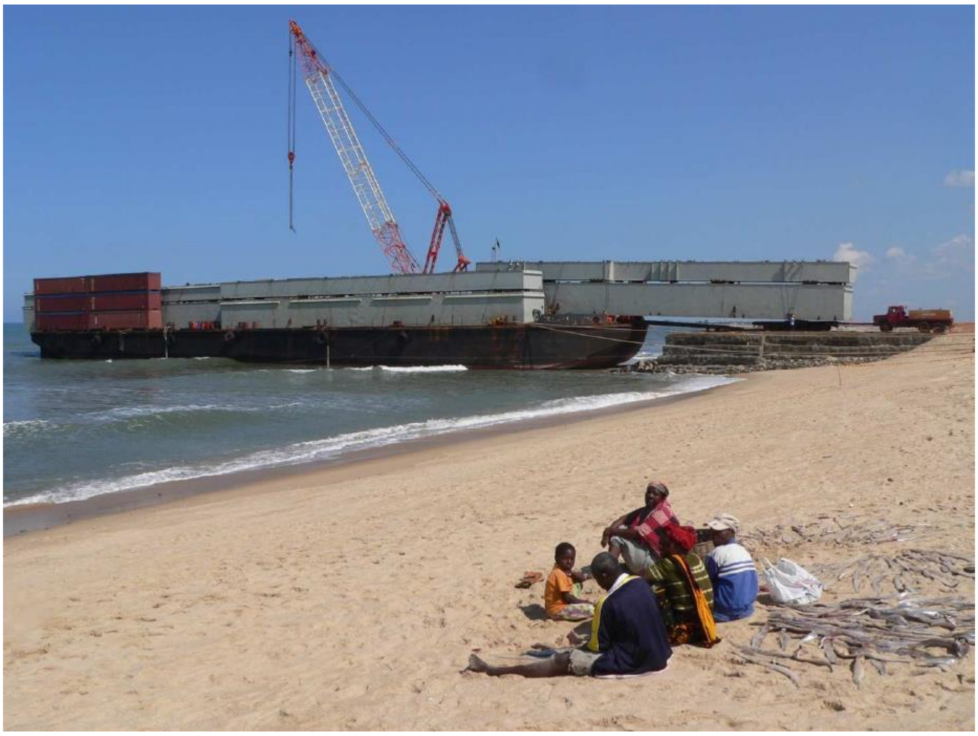

Figure 4: Typical beach landing site with barge offloading heavy equipment (source: Comarco)

Figure 5: Example of large equipment being offloaded from a barge. Note the levels of the ramp, the barge and the jetty (source: SUBTECH)

Figure 6: Heavy haulage truck with 16-axle hydraulic trailer transporting a 360 ton generator (source: ALE)

2.2 Water and electricity consumption

The type, origin and quantity of water and energy consumption are still to be determined based on the selected technology to construct and operate the CTT plant. At this stage it is known that water will be sourced from existing boreholes located on site or east of the Govuro River for either of the technology options below:

- Gas Engine: ± 12 m^3/day; or
- Gas Turbine (Dry-Cooling): ± 120 – 240 m^3/day.

2.3 Temporary Beach Landing Site and Transportation Route Alternative

As part of the CTT construction phase it was considered that large heavy equipment and materials would need to be brought in by a ship which would remain anchored at sea off the coast of Inhassoro. Equipment and materials would be transferred to a barge capable of moving on the high tide into very shallow water adjacent to the beach to discharge its cargo onto a temporary off-loading jetty (typically containers filled with sand) near the town of Inhassoro. As the tide changes, the barge rests on the beach and off-loading of the equipment commences.

Currently, the SETA beach landing site is the preferred beach landing site together with the road route option to be used in transporting equipment and materials along the R241 then the EN1 then via the existing CPF access road to the CTT site near the CPF. Figure 7 and Figure 8 indicate the beach landing site and route transportation option. The alternative beach landing sites of Maritima and Briza Mar are still being evaluated as potential options, as well as the southern transport route, which would also require road upgrades and a temporary bridge construction across the Govuro at the position of the existing pipe bridge. As part of the transportation route, the Govuro River bridge may need to be upgraded / strengthened to accommodate the abnormal vehicle loads. Alternatively, a temporary bypass bridge will be constructed adjacent to the existing bridge.

Figure 7: The three beach landing site options and route options at Inhassoro

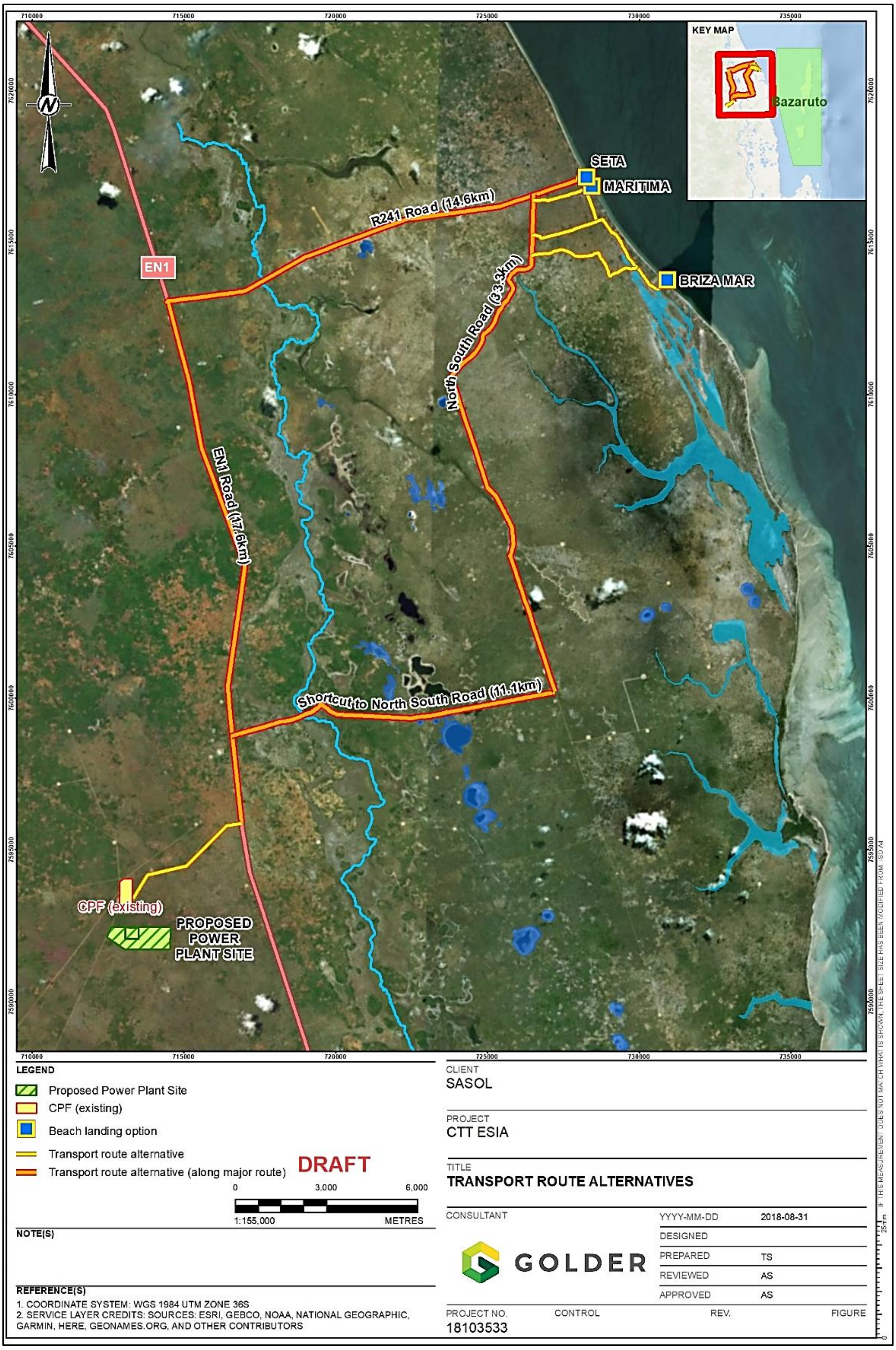

Figure 8: The two main transportation route alternatives from the beach landing sites to the CTT site

3.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The proposed project has been determined as ‘Category A’ in terms of Mozambique’s environmental law (Decree 54/2015 of 31 December, which has been in force since April 2016). For ‘Category A’ projects, an Environmental and Social Impact Assessment (ESIA) must be prepared by independent consultants as a basis for whether or not environmental authorisation of the project is to be granted, and if so, under what conditions. The final decision maker is the Ministry of Land, Environment and Rural Development (Ministério da Terra, Ambiente e Desenvolvimento Rural (MITADER) through the National Directorate of Environmental Impact Assessment (DNAIA). MITADER consults with other relevant government departments prior to making a decision.

This document represents the Aquatic Ecosystem Impact Assessment undertaken to support the ESIA. This study is undertaken in terms of the Mozambican environmental legislation as described below in Table 1 as well as the World Bank Group operational policies and general environmental health and safety guidelines. Further to this, the conventions pertaining to the protection of habitats and biological diversity are listed and briefly explained in Table 2. The study also took adherence of the requirements of International Finance Corporation (IFC) Performance Standard 6 (IFC PS6, 2012), supplemented by Guidance Note 6 (IFC GN6, 2012), that concern Biodiversity Conservation and Sustainable Management of Living Natural Resources.

Table 1: Mozambique principal legislation relevant to the CTT Project

Laws Protecting Biodiversity and Conservation Areas	
Environment Law (Law 20/97 of 1 October).	Articles 12 and 13 cover a set of general norms to protect biodiversity and the establishment of environmental protection areas.
Land Law (Law 19/97 of 1 October) and Land Law Regulations (Decree 66/1998 of 8 December).	This law establishes total or partial protection zones. The former are designated as those reserved for nature conservation activities and the defence and security of the State, whereas partial protection zones include, among others, the beds of inland water courses, territorial waters, the exclusive economic zone, the continental shelf as well as the coastline, islands, bays and estuaries measured at the maximum high tide mark up to 100 m inside the country.
Law on Forest and Wildlife (Law 10/99 of 7 July).	Articles 11 and 13 of the law establish conservation areas such as national parks, nature reserves and areas of historical and cultural importance.
Law on Effluent Standards (Decree 18/2004 of 2 June).	The law prescribes standards for the discharge of treated domestic wastewater into the environment as well as standards for the release of industrial wastewater from petroleum refineries.

Table 2: Conventions on habitats and biological diversity

Habitats and Biological Diversity	
1968	African Convention on the Conservation of Nature and Natural Resources.
1979	Convention on Migratory Species of Wild Animals 1979 and its amendments.
1985	Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern Africa Region, 1985, and the Protocol concerning Protected Areas and

Habitats and Biological Diversity	
	Wild Life Fauna and Flora in the Eastern Africa Region; and the Protocol for Cooperation in Fighting Pollution in Emergency Region; and the Protocol for Cooperation in Fighting Pollution in Emergency Situations.
1992	United Nations Convention on Biological Diversity (CBD).
1999	SADC Protocol on Wildlife Conservation and Law Enforcement.
2001	SADC Protocol on Fisheries.
2002	SADC Protocol On Forestry Activities.
2003	African Convention on the Conservation of Nature and Natural Resources. Revised version.

4.0 BASELINE CONDITIONS

4.1 Scope of Study

The ecological attributes of the region surrounding Sasol's activities within the Inhassoro area (Northern Inhambane Province) have been comprehensively studied during baseline data gathering surveys to inform the assessment of potential impacts of their gas exploration and gas to power generation programmes. Data from these studies span more than a decade and were used in conjunction with the findings of two targeted field surveys of the proposed CTT project conceptual layouts (conducted in 2015 and 2018) to inform the current assessment. These data were used to develop and update the baseline aquatic ecosystem characterisation for this impact assessment. A brief summary of study methods is presented in Section 4.2. For more detailed information refer to the updated aquatic ecology baseline report (Golder (2018).

The scope of the aquatic ecosystems' assessment was focused around the Govuro River, which runs in a northerly direction parallel to the coast for approximately 185 km and is the only perennial river in the Study Area. The coastal plain catchment area is approximately 11,200 km^2 and has an average elevation of 80 masl[1] (Mark Wood Consultants, 2001). The low-lying areas of the Govuro River valley are poorly drained and characterised by open woodlands with an herbaceous layer, comprising hygrophytic[2] grassland and grass and sedge marshes (Golder Report: 1302793-10712-12).

The potential impacts of the proposed river crossings indicated in Figure 1 and Figure 8 were assessed.

4.2 Study Methodology

4.2.1 Desktop review of available information

A comprehensive literature review was conducted as part of the initial baseline studies. These data, together with the baseline data from the 2015 studies (REF), the regional ESIA (REF) and FSO river crossing assessment, were reviewed to contextualise the aquatic ecosystems of the Study Area. The review considered confirmed species records, the likelihood of occurrence of aquatic biota of conservation concern, and general habitat requirements/suitability for species of concern with potential to occur within the Study Area.

[1] **Metres above sea level**

[2] requiring an abundance of water

4.2.2 Field Study Methods

The approach to the July 2018 site visit was to confirm whether the previously described baseline conditions were still accurate, as well as to asses any new drivers of change that may have emerged within the system since the previous data collection period. To achieve this, representative sampling was conducted at previously assessed sites. Baseline data gathered between 2015 and 2018 during the regional biodiversity sensitivity mapping and Regional ESIA conducted in June 2015 and December 2016 respectively, as well as the FSO Recon site visit conducted in September 2015, were consolidated into a full aquatic ecosystem dataset for the study area.

For coordinates and of sampling sites and descriptions, please refer to the complete aquatic baseline report (Golder, 2018). A map of the sampling locations in relation to the CTT Project infrastructure is presented below in Figure 9.

In-situ water quality

In situ water quality measurements (total dissolved solids [TDS], pH, dissolved oxygen and temperature) were determined on site as a component of the habitat and biotic surveys, and to determine if these were within range of historical values. These data were collected in day light hours. This information was cross-referenced with the surface water monitoring results to ensure consistency.

Habitat Assessment

Habitat availability and diversity are major attributes for the biota found in a specific ecosystem, and thus knowledge of the quality of habitats is important in an overall assessment of ecosystem health. Habitat assessment can be defined as the evaluation of the structure of the surrounding physical habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour *et al.*, 1999). Both the quality and quantity of available habitat affect the structure and composition of resident biological communities (USEPA, 1998). Habitat quality and availability plays a critical role in the occurrence of aquatic biota. For this reason, habitat evaluation was conducted simultaneously with biological evaluations in order to facilitate the interpretation of results.

In addition to an index-based habitat (availability) characterisation, a general description of the habitat was conducted. This was aided by the use of underwater video, which has been used for both habitat descriptions and habitat preferences of fish (Han *et al.,* 2000). From the underwater video observations on the flow, substrate and linkages between these could be made.

Aquatic Macroinvertebrates

Aquatic macroinvertebrates were collected using a standard qualitative sampling technique, however due to the nature of the river, it did not prove to be a good indicator of aquatic health. Samples were collected using the South African Scoring System, Version 5 (SASS5) developed by Mark Chutter (Dickens & Graham, 2002). This methodology was designed to incorporate all available biotypes at a given site and standardise collection. Once collected the samples from the placed in a separate tray per biotope and analysed for 15 min each. The number of invertebrate families were counted per sample and the individual's families recorded. The abundance of each invertebrate family was scored based on predefined classes.

Fish

Ichthyofaunal samples were collected by means of electrofishing, netting and video. Electrofishing is the use of electricity to catch fish. The electricity is generated by a system whereby a high voltage potential is applied between two electrodes placed in the water (USGS, 2004). The responses of fish to electricity are determined largely by the type of electrical current and its wave form. These responses include avoidance, electrotaxis (forced swimming), electrotetanus (muscle contraction), electronarcosis (muscle relaxation or stunning) and death (USGS, 2004). Electrofishing is regarded as the most effective single method for sampling fish communities in wadeable streams (Plafkin *et al.*, 1989).

During electrofishing variables such as conductivity (Hill and Willis, 1994; Pusey *et al.*, 1998), stream width (Kennedy and Strange, 1981), fish size (Zalewski, 1985), temperature (Regis *et al.*, 1981), and operator experience (Hardin and Connor, 1992) have been shown to affect the capture efficiency in fish. The conductivity of the water affects the efficiency of sampling in two ways. Firstly under low conductivity (>100 µs/cm), the effective area of the electrical field is limited by the increased resistance of the water and the corresponding decrease in electrical current (Nelson and Little, 1987). As a result, the electrical field is confined to the area immediately surrounding the electrode. Secondly water with a high conductivity has less resistance than that of the fish, and as a result the current tends to 'flow' around or have little to no effect on the fish (Reynolds, 1983). The Smith-Root LR24 is rated for a conductivity range of 10 – 1500 µs/cm (www.smith-root.com). As a result of the conductivity and the depth of the Govuro River, electrofishing was not considered the best method of fish capture. Various netting techniques yielded higher diversity.

Diatoms

Diatoms are a unicellular algal group widely used as indicators of river health as they provide a rapid response to specific physico-chemical conditions in the water and are often the first indication of environmental change. The presence or absence of indicator taxa can be used to detect specific changes in environmental conditions namely, eutrophication, organic enrichment, salinization and pH variation (De La Rey *et al.*, 2004; Kelly and Whitton, 1995). Benthic diatoms are present in all-natural watercourses and because of their microscopic nature, are generally not limited by available habitat. Research has provided a good record of diatom species and their water quality tolerances, making them useful for inferring integrated water quality conditions and river health classes. Diatoms are also useful for determining historical water quality conditions as their silica frustules (shells) remain behind once they die, leaving a record of past conditions. Diatom samples were collected according to the prescribed protocol in (Taylor *et al.*, 2006) and results interpreted according to the Specific Pollution sensitivity Index (SPI) to assess the "health status" of each river. Diatom laboratory procedures were carried out according to the methodology described by Taylor *et al.* (2005). Diatom samples were prepared for microscopy by using the hot hydrochloric acid and potassium permanganate method. Approximately 300 to 400 diatom valves were identified and counted to produce semi-quantitative data for analysis. Prygiel *et al.* (2002) found that diatom counts of 300 valves and above were necessary to make correct environmental inferences. The taxonomic guide by Taylor *et al.* (2007) was consulted for identification purposes.

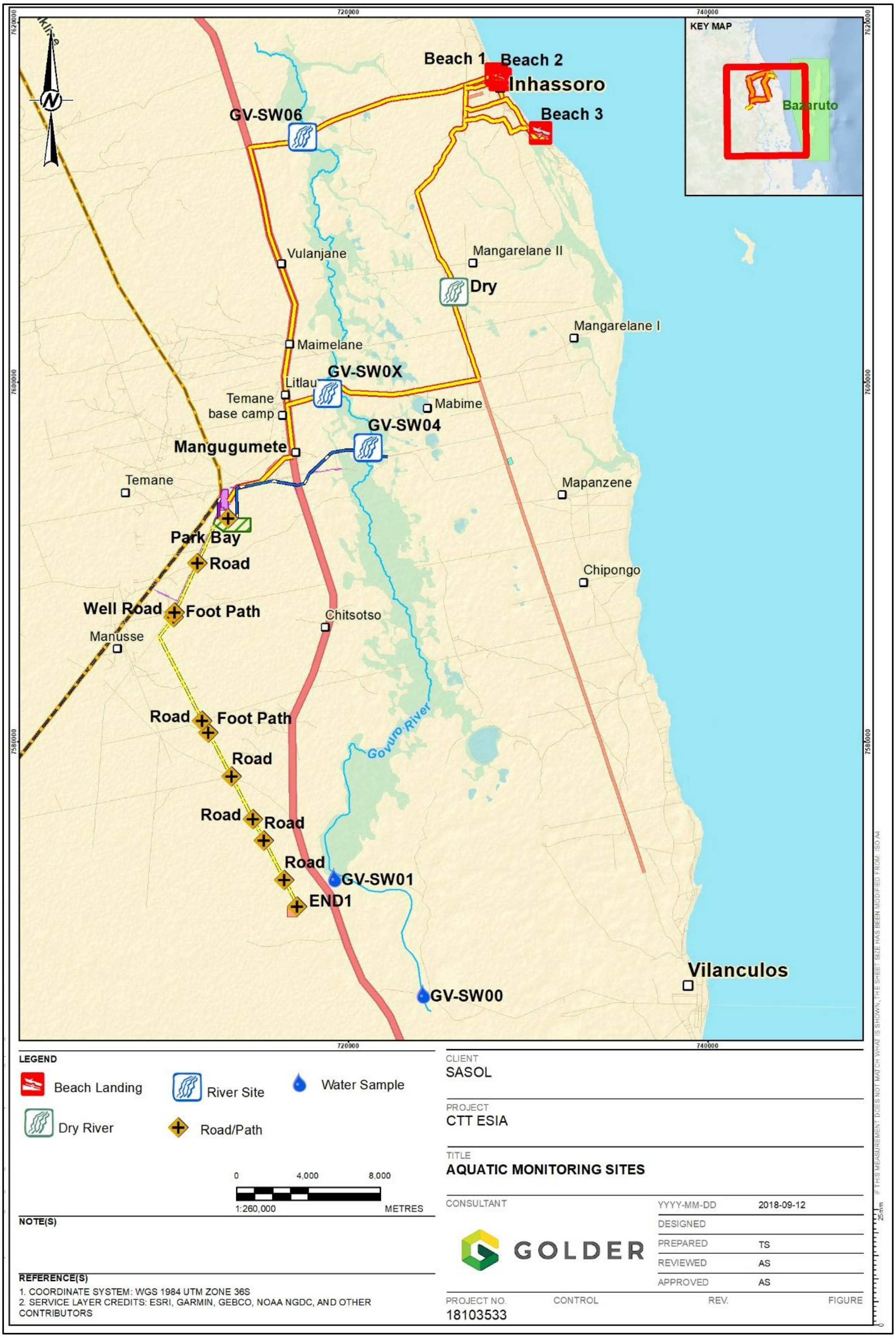

Figure 9: Aquatic sampling sites, with water sampling points and beach landing sites represented for context

4.3 Results and Findings

4.3.1 Desktop Review

The Study Area falls within the larger Zambezian Lowveld Freshwater Ecoregion (Thieme *et al.*, 2005). Extending from Chimoio in the north to KwaZulu Natal (South Africa) in the South, and west towards Gaborone (Botswana). The Zambezian Lowveld exhibits a wide range of habitats and abundant aquatic diversity, with approximately 159 freshwater fish species present (García *et al.*, 2010).

The Govuro River system is considered to have high fish diversity (ERM, 2016), and is expected to have in excess of 60 species due to the interaction of the marine environment. Fifty-otwo (52) fish species have been identified in literature or have been sampled within the Govuro River system (Skelton, 2001; Golder Report: 1302793-10712-12; ERM, 2016). For a detailed synopsis of these species, their current status, habitat preferences and whether or not they have been sampled before, please refer to APPENDIX A or the stand-alone aquatic baseline report (Golder, 2018). It should be noted that is this list would not be considered complete with regards to marine vagrants and estuarine specialists, as these species sporadically move through the system.

Fourteen fish species were recorded by EcoSun (2004 & 2005), 21 by Golder (2014), 16 by Bok (2015), during a site visit to Nhangonzo critical habitat area, 25 by ERM (2015 and 2016) and 19 by Golder in 2015 and 2016. No endemic or restricted-range fish species were recorded during these surveys; however, four species of conservation concern were confirmed within the Project Area. The most noteworthy species was the Painted-fin Goby, *Oligolepis acutipennis* (Data Deficient, IUCN), located in close proximity to the Govuro Estuary (ERM, 2016). The Mozambique Tilapia (*Oreochromis mossambicus)* is under serious threat from hybridization with the rapidly spreading introduced species *O. niloticus* (Nile tilapia) (IUCN, 2017). Oxeye tarpon (*Megalops cyprinoides*), is currently listed as Data deficient (DD), and was confirmed in the PSA area in 2014 and 2018, where it is found in the Govuro River system. The Leopard Stingray (*Himantura uarnak*), which is listed as vulnerable by the IUCN was recorded in a fisherman's catch in the Govuro Estuary at a fishing camp in February 2016 (ERM, 2016).

Both the Near Threatened (NT) Bull Shark (*Carcharhinus leucas*), and the Critically Endangered (CR) Smalltooth Sawfin (*Pristis microdon*), may potentially occur within the Project Area. Both are marine species, and as such are not expected in the shallower waters of the Govuro River and its tributaries on a frequent basis. Neither have been recorded during surveys to date.

Included in the expected species list are several estuarine or marine species, such as the Oxeye Tarpon (*Megalops cyprinoides*), Round Moony *(Monodactylus argenteus)*, Butterfly Fish (*Chaetodon sp*.), Rock Flagtail (*Kuhlia rupestris*), Longspine Glassy *(Ambassis producta),* Riverbream *(Acanthopagrus berda),* Flathead Mullet *(Mugil cephalus)* and Largescale Mullet (*Liza macrolepis*) (Figure 10 and Figure 11). The presence of these species indicates the long reach of these species into the Govuro River as well as the salinity.

Further to this the African Lungfish (*Protopterus annecten*) and various killifish (*Nothobranchius sp*.) are known to be present within non-perennial waterbodies west of the Govuro River (Figure 12 and Figure 13). Both of these species have been previously collected in the Study Area by Golder in 2016, and by Rob Palmer (ERM, 2016). Both the African Lungfish (*Protopterus annectens*) and Killifish species (*Nothobranchius sp.*) live in isolated temporary pan systems and have an inactive phase of several months. Lungfish form a cocoon in the mud, whilst killifish eggs lie dormant but viable in the dry bed of the pan. As a result, disturbance of even dry depressions can have an impact on these species.

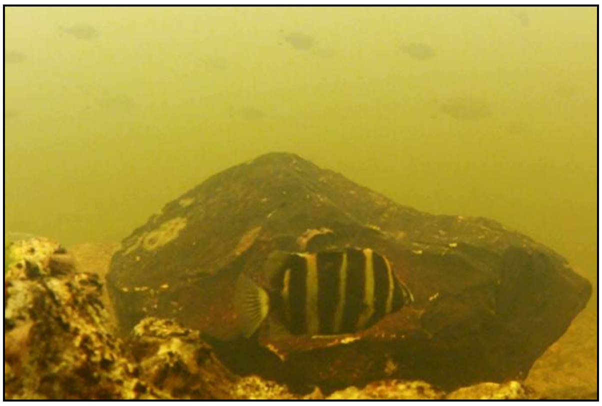

Figure 10: Butterfly fish (*Chaetodon sp.*) with rock Flagtails (*Kuhlia rupestris*) in the background

Figure 11: Shoal of Round Moony (*Monodactylus argenteus*), with a Butterfly fish (*Chaetodon sp.*) on the right

Figure 12: African Lungfish (*Protopterus annectens*)

Figure 13: Spotted killifish (*Nothobranchius orthonotus*)

It should be noted that the Redbreast Tilapia formerly known as *Tilapia rendalli* was reclassified in 2013 as *Coptodon rendalli* (Dunz and Schliewen, 2013; Skelton, 2016). Furthermore, the genera *Barbus* and *Aplocheilichthys* have been updated to *Enteromius* (African Barbs) and *Micropanchax* (Topminnows) respectively (Skelton, 2016). These records from previous reports have been updated and carried through this report.

The conservation status of all fish species mentioned above was assessed using the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2017). The full assessment is detailed in the comprehensive baseline report (Golder, 2018).

Of the 52 fish species expected to occur in the sample area:

- Fourteen (14) have not yet been evaluated against the criteria (IUCN, 2017);
- Thirty-two (32) are currently listed as Least Concern (LC). Species in this category are widespread and abundant;
- Two (2) species, the Oxeye tarpon (*Megalops cyprinoides*) and Painted-fin Goby (*Oligolepis acutipennis)* are currently listed as Data deficient (DD);
- One (1) species, the Leopard Stingray *(Himantura uarnak)* is currently listed as Vulnerable (VU);
- Two (2) species are listed as Near Threatened (NT):
  - *Oreochromis mossambicus* - Mozambique tilapia is currently listed as Near Threatened (NT). A species in listed as NT when it does not currently qualify for Critically Endangered, Endangered or

Vulnerable status, but is close to qualifying for or is likely to qualify for a threatened category in the near future (IUCN, 2017);

- *Carcharhinus leucas* – Bull shark, is currently listed as Near Threatened (NT); and

- One species (*Pristis microdon*- Smalltooth sawfish) is currently listed as Critically Endangered (CR).

The most serious threat facing *O. mossambicus* is hybridization with the rapidly spreading introduced species *Oreochromis niloticus* (Nile tilapia) (IUCN, 2017). Hybridization has already been documented throughout the northern part of the species' range, with most of the evidence coming from the Limpopo River catchment (IUCN, 2017). Given the rapid spread of *O. niloticus* it is anticipated that *O. mossambicus* will qualify as threatened under Criterion A due to rapid population decline through hybridization (IUCN, 2017). Species in this category (Criterion A) have been highlighted as taxa that have undergone a significant decline in the near past, or are projected to experience a significant decline in the near future (IUCN, 2017). It should be noted that *O. niloticus* are freely available in Vilankulo and used in small scale aquaculture ventures.

Both *Carcharhinus leucas* (Bull Shark) and *Pristis microdon* (Smalltooth Sawfish) are marine species and as such are not expected to be resident in the shallower waters of the Govuro River and its tributaries within the Study Area. Leopard Stingray *(Himantura uarnak)* was observed at the Govuro River mouth during the 2016 field surveys.

4.3.2 Field Studies

The survey was conducted in June 2018 (dry season). In the Vilanculos / Inhassoro area, the least amount of rain occurs in July, with an average of 17mm. Most precipitation falls in February, with an average of 166 mm (climate-data.org, 2018).

Water Quality

In situ water quality measurements (TDS, pH, dissolved oxygen and temperature) collected in June 2018 were comparable to those collected in February 2015 with the exception of temperature and dissolved oxygen, which were marginally below the summer mean. This was expected as the survey was conducted in different seasons, and dissolved oxygen is related to water temperature.

As with the historical data collected, the concentration of TDS showed an increase in a downstream direction along the Govuro River and was considered 'freshwater' (Johnson, 2008). Even with the increased concentrations recorded in the Govuro River, TDS doesn't appear to be limiting the presence of aquatic biota, but rather was a driver (function of salinity) of the diversity observed, which included a number of marine migrants.

Although dissolved oxygen concentrations showed fluctuations between sites, the scale of fluctuation was not of concern and was likely driven by water temperatures and the large amount of vegetation and detritus present within the channel.

Previous analysis of the water quality in the Govuro River (see surface water baseline study (Golder Report: 1405502-13410-9) indicated that quality of the water was good. The water quality was indicative of a *fairly natural state* with relatively low concentrations of most water quality parameters assessed. Most inorganic parameters were within guideline limits, the trace metals present were compliant with Mozambican effluent/discharge standards and the pH of the water was within the acceptable guidelines and can be described as slightly basic. The nutrient (nitrate and ortho-phosphate) concentrations in the river were low. However, salinity levels were elevated and increased along the river towards the lower reaches. The presence of naphthalene detected between 2014 and 2015 in the Govuro River was found to no longer be present in 2018 (Golder Report: 1405502-13410-9).

Habitat Assessment

The Govuro River system consists of the flowing river (aquatic) and the associated floodplain (riparian). The Govuro River channel is dominated by emergent vegetation comprising *Phragmites australis* (Common Reed) and *Nymphaea sp*. (Water Lily) (Figure 14). Figure 15 shows how the margins of the channel are dominated by detritus and submerged lilies. Organic debris not only provides a variety of structure, but also contributes to the transfer of nutrients within the system, being an allochthonous[3] source of food.

The centre of the channel is typically open water, with a sand and fine gravel substrate (Figure 14 and Figure 16). Although a few rocks were observed, no rapid or riffle habitats were noted or sampled. These attributes resulted in two main hydraulic units being present, Slow Shallow (SS) and Slow Deep (SD). Backwaters along the edges of the floodplain are seasonally-inundated and with emergent vegetation create favourable habitat for smaller fish, fish fry, amphibians and other species. The riparian habitats consist mostly of inundated floodplain habitats. Riparian trees are scarce as the riverine zone rapidly merges into the terrestrial woodland system.

Figure 14: Govuro River Channel (GV-SW00)

Figure 15: Submerged *Nymphaea sp.* (Water Lily)

Figure 16: Sandy substrate in the centre of the Govuro River channel

Figure 17: Rock habitat at site GV-SW06

[3] denoting a deposit or formation that originated at a distance from its present position

During the June 2018 survey, large amounts of Kariba Weed (Salvinia molesta) were observed at site GV-SW00. This was the first time that large quantities of this invasive species were observed at this site (Figure 18).

Figure 18: Kariba Weed (Salvinia molesta)

The IHAS is often used in rapid biological monitoring assessments to numerically reflect the quantity, quality and diversity of biotopes available for macroinvertebrates to inhabit at a sampling site (Dallas, 2000; McMillan, 1998; Ollis *et al.*, 2006). Due to the homogeneity of sandy substrate, accompanied by the lack of stones-in-current, vegetation and uniform flow velocities, the IHAS index did not prove to be applicable for the Govuro River as the scores ranked all of the sites similarly, and classified all as 'poor', which is considered a misrepresentation of the current status of the Govuro River within the study area, which remains in a largely natural condition. Therefore, a more general approach to physical conditions was adopted.

No stones-in-current were present and the substrate, flow, depth and vegetation were considered homogenous across all sites (Figure 19).

GV-SW00 *GV-SW04* *GV-SW0X* *GV-SW06*

Figure 19: Photographs of sites to illustrate homogeneity (2015 and 2018)

The riparian and aquatic habitats along the Govuro River are largely unmodified (falling within a habitat integrity class of Category A (natural) or B (near-natural)). Human use of the area for harvesting of reeds (*Phragmites sp.*) and saw grass (*Cladium mariscus*) has had limited impact and is currently considered to be at sustainable levels.

The instream and riparian IHIA scores and classes for each of the sites are presented in Table 3. These assessments are of a broad-scale nature and are intended to provide a general indication of the condition of the river reaches sampled within the Study Area.

Figure 20: Harvesting of grasses from the Govuro River

Table 3: Intermediate Habitat Integrity Scores and Classes recorded during the June 2018 survey

Site	Final Weighted Score	Mean Habitat Integrity Class	Description
GV-SW04	95	A	Unmodified, natural.
GV-SW0X	96	A	Unmodified, natural.
GV-SW06	94	A	Unmodified, natural.

The intermediate habitat integrity results (Table 3) indicate that all the sites are largely unmodified and in a natural state, with the current anthropogenic impacts present being insignificant. Site GV-SW04 is slightly removed from any settlement with limited access and as a result scored 95 (Class A). Site GV-SW0X is located at the metal bridge, and is remote from any major settlements. The downstream sampling point (GV-SW06) is located on the Inhassoro main road, as a result, there is easy access and people utilise the river in this area, furthermore these are a few subsistence crops within the area. Despite this, the overall class remained in a Class A.

A comparison of the results from the 2004/5, 2014 and 2015 surveys showed consistency with the same categories being recorded during the June 2018 site visit (Table 4).

Table 4: Historical habitat assessment scores

Site		Habitat						
		2014			EcoSun 2004/2005		2015	
		IHAS* %	IHIA%	IHIA Class	IHIA%	IHIA Class	IHIA%	IHIA Class
Site 1	GV-SW04	67	98	**A**	83-90	**A/B**	**-**	**-**
Site 2		66	97	**A**	90-98	**A**	96.9	**A**

Site		Habitat						
		2014			EcoSun 2004/2005		2015	
		IHAS* %	IHIA%	IHIA Class	IHIA%	IHIA Class	IHIA%	IHIA Class
Site 3	GV-SW0X	68	95	**A**	85-87	**B**	88.0	**B**
	GV-SW06	**-**	**-**	**-**	**-**	**-**	89.4	**B**

*0-55 = Poor 55-65 = Adequate/Fair 65-100 = Good

Macroinvertebrates have not been well sampled across the different aquatic habitats as a result of the, naturally low diversity of instream habitats associated with a low gradient and largely uniform bed substrate comprised of fine sand and outcrops of calcrete cobbles and boulders that is typical of the Govuro River in the study area (ERM, 2016). As a result, the macroinvertebrate integrity scores and the habitat site scores reflect high degree of similarity in habitats and associated invertebrates in the Govuro River.

It should be noted that the SASS5 index was designed specifically for the evaluation of perennial streams and rivers and is not suitable for assessment of impoundments, isolated pools, wetlands, pans or canals (Dickens and Graham, 2002). Due to the physical stream characteristics of the Govuro River, the SASS5 index is therefore not well suited for the characterisation of aquatic macroinvertebrates, and was not used for the current assessment.

A general assessment of aquatic macroinvertebrates resulted in a rating of “fair” condition, due to the lower sensitivity scores of the abundant air-breathing taxa recorded at the sampled locations, which were dominated by vegetation in slow/shallow habitats and lack of rocky riffle type habitats. Furthermore, the tidal influence results in naturally high concentrations of salinity that are close to the upper tolerance limit for many freshwater species (ERM, 2016). The recorded freshwater macroinvertebrate fauna therefore comprises mainly hardy taxa that are generally unsuitable for monitoring environmental change.

Sampling of the floodplain and inland depressions during 2016 showed a high diversity and abundance of beetles and crustaceans respectively, with an overall moderately high diversity. The floodplain depressions were indicative of a stable system with high secondary productivity, while the inland depressions were considered unstable (ERM, 2016).

Zebra snail, *Neritina natalensis* was common in the vicinity of the proposed pipeline crossing (ERM, 2016). This species has a restricted distribution and is classified by the IUCN as Near Threatened. The species is easy to identify and collect, and would be a good indicator species for purposes of long-term monitoring (ERM, 2016). *Septaria borbonica* (Neritidae), a small gastropod that was recorded on the stems of *Nymphaea nouchaii* within the Govuro River is listed as Endangered and should also be targeted for future monitoring programmes.

In addition, dragonflies and the damselflies (Odonata) can be used to monitor any changes within the system. Odonata are an order of carnivorous insects, that are typically associated with both aquatic and terrestrial ecosystems with the larval stage centred around the aquatic ecosystems. Odonata are well studied and are used globally as an indicator species (Clark and Samways 1996; Foote & Hornung 2005).

Figure 21 shows a selection of some of the Odonata observed onsite during February 2015.

Pseudagrion sp. (Green-naped Sprite)

Crocothemis sp. (Little Scarlet)

Figure 21: Selection of Odonata species observed

In addition to the standard sampling techniques utilised, underwater video was also used to observe fish in their natural habitat. The video footage was recorded to simply observe habitat preferences and gain insight into the underwater environment. Figure 22 to Figure 25 illustrate examples of fish recorded underwater. Figure 22 shows an *Oreochromis mossambicus* and a *Coptodon rendalli*. Figure 23 shows a large school of various *Enteromius* species (>100 individuals), while only 53 individuals were captured at all sites using different sampling techniques. Taking the sampling conditions into account, this video footage confirms that there is a larger fish population than what was sampled. Figure 24 shows a school of *Kuhlia rupestris.* Figure 25 shows an *Enteromius trimaculatus* swimming through a school of *O. mossambicus*.

Figure 22: *Oreochromis mossambicus* and a *Coptodon rendalli*

Figure 23: Various *Enteromius* species

Figure 24: Rock Flagtails (*Kuhlia rupestris*)

Figure 25: *Oreochromis mossambicus* and *Enteromius trimaculatus*

A total of 17 fish species were recorded or observed in the project area during the June 2018 site visit (Table 5). Sixteen (16) of these species have previously been recorded, with one species being added to the overall species list. The Johnston's topminnow (*Micropanchax johnstoni*), which is expected to occur within the Govuro River, was captured with a dip net in the marginal vegetation. The distribution and identification of this species needs to be confirmed as it has not been sampled before. An eighteenth species, the White-spotted puffer (*Arothron hispidus*) was seen on underwater video footage, however could not be confirmed via direct sampling and as such was not added to the observed species list.

Figure 26: Seine netting at site GV-SW0X

Fish assemblages characterised by a continuous salinity gradient are very diverse and comprise of marine, estuarine, freshwater and migrating species (Fairbridge, 1980, Henderson, 1988; Lobry *et al*., 2003); as one would expect in a system such as the Govuro River, the species recorded to date have had a bias towards marine species.

Table 5: Fish species during the June 2018 survey, as well as the record of if these species have previously been recorded in the Govuro River

Fish Species	Fish sampled in the Govuro River during June 2018			Fish sampled in the Govuro River during previous survey
	GV-SW00	GV-SW0X	GV-SW06	
Broadstriped barb *(Enteromius annectens)*	OBS	40		Sampled 2014, 2015 & 2016
Bowstripe barb *(Enteromius viviparus)*		5		Sampled 2005, 2014, 2015 & 2016
East-coast barb *(Enteromius toppini*)		2		2016
Threespot barb (*Enteromius trimaculatus*)	OBS			Sampled 2005, 2014 & 2016
Sickle-fin barb (*Enteromius haasianus*)			1	Sampled 2014, 2015 & 2016
Butterfly fish (Chaetodon sp.)		OBS		Sampled 2005
Beira barb *(Enteromius radiatus)*		4		Sampled 2005, 2014, 2015 & 2016
Straightfin barb (Enteromius paludinosus)			1	Sampled 2014 & 2016
Silver robber *(Micralestes acutidens)*		5		Sampled 2014, 2015 & 2016
Johnston's topminnow (Micropanchax johnstoni)			21	
Southern mouthbrooder *(Pseudocrenilabrus philander)*	OBS	24		Sampled 2005, 2015 & 2016
Redbreast tilapia *(Coptodon rendalli)*	OBS	3		Sampled 2005, 2014, 2015 & 2016
Mozambique tilapia *(Oreochromis mossambicus)*	OBS	15	OBS	Sampled 2005, 2014, 2015 & 2016
Round moony *(Monodactylus argenteus)*		12		Sampled 2005, 2014, 2015 & 2016
Rock flagtail (*Kuhlia rupestris*)		53		Sampled 2005, 2015 & 2016

Fish Species	Fish sampled in the Govuro River during June 2018			Fish sampled in the Govuro River during previous survey
	GV-SW00	GV-SW0X	GV-SW06	
Oxeye tarpon (Megalops cyprinoides)		2	1	Sampled 2014
River goby (*Glossogobius callidus)*		1		Sampled 2005, 2015 & 2016

In general, all the fish sampled were considered healthy and free from parasites. The approach of a visual assessment is based on the principle that even under unimpaired conditions, a small percentage of individuals can be expected to exhibit some anomalies (Kleynhans, 1999). Based on the observations made during the February 2015 and June 2018 surveys, the fish population appears healthy.

Several diatom samples were collected during the November 2015 survey by scrubbing *Nymphaea* leaves as per the protocol set out by Taylor *et al*. (2005, 2007). Samples from the Govuro River indicated a Specific Pollution Index (SPI) Score of 16.4, which was rated as Good (Category B). The presence of *Nitzschia amphibia* indicated elevated salinity, while the overall diatom community generally reflected species with a preference for good clean water with elevated salinity (ERM, 2016). No indicators of anthropogenic impact were observed. No deformities in diatom valve structure were noted, reflecting metal toxicity was absent or below detection limits (ERM, 2016).

The beach and near shore are utilised by local fishermen who pull seine nets commercially and collect sand worms as a source of bait. Depending on the season, fishermen can be observed pulling up large seine nets onto the beach, with a non-selective variety of fish. Once on the beach, fish are sorted and sold (Figure 27 to Figure 30).

Figure 27: Beach seine catch being sorted for market, Inhassoro

Figure 28: Sorted fish are placed into separate piles based on species and size

Figure 29: Local fisherman digging for sand worms, Inhassoro

Figure 30: Sand worms

5.0 IMPACT ASSESSMENT

5.1 Assessment methodology and rating criteria

Potential impacts are assessed according to the direction, intensity (or severity), duration, extent and probability of occurrence of the impact. These criteria are discussed in more detail below:

Direction of an impact may be positive, neutral or negative with respect to the particular impact. A positive impact is one which is considered to represent an improvement on the baseline or introduces a positive change. A negative impact is an impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.

Intensity / Severity is a measure of the degree of change in a measurement or analysis (e.g. the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none, negligible, low, moderate or high. The categorisation of the impact intensity may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment). The specialist study must attempt to quantify the intensity and outline the rationale used. Appropriate, widely-recognised standards are used as a measure of the level of impact.

Duration refers to the length of time over which an environmental impact may occur: i.e. transient (less than 1 year), short-term (1 to 5 years), medium term (6 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project) or permanent.

Scale/Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international. The reference is not only to physical extent but may include extent in a more abstract sense, such as an impact with regional policy implications which occurs at local level.

Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40 % to 60 % chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

Impact significance will be rated using the scoring system shown in Table 6 below. The significance of impacts is assessed for the two main phases of the project: i) construction ii) operations. While a somewhat subjective term, it is generally accepted that significance is a function of the magnitude of the impact and the likelihood (probability) of the impact occurring. Impact magnitude is a function of the extent, duration and severity of the impact, as shown in Table 6.

Table 6: Scoring system for evaluating impacts

Impact Magnitude			Impact Probability
Severity	Duration	Extent	
10 (Very high/don't know)	5 (Permanent)	5 (International)	5 (Definite/don't know)
8 (High)	4 (Long-term – longer than 15 years and impact ceases after closure of activity)	4 (National)	4 (Highly probable)
6 (Moderate)	3 (Medium-term- 6 to 15 years)	3 (Regional)	3 (Medium probability)
4 (Low)	2 (Short-term - 1 to 5 years)	2 (Local)	2 (Low probability)

Impact Magnitude			Impact Probability
Severity	**Duration**	**Extent**	
2 (Minor)	1 (Transient – less than 1 year)	1 (Site)	1 (Improbable)
1 (None)			0 (None)

After ranking these criteria for each impact, a significance rating was calculated using the following formula:

SP (significance points) = (severity + duration + extent) x probability.

The maximum value is 100 significance points (SP). The potential environmental impacts were then rated as of High (SP >75), Moderate (SP 46 – 75), Low (SP ≤15 - 45) or Negligible (SP < 15) significance, both with and without mitigation measures in accordance with Table 7.

Table 7: Impact significance rating

Value	Significance	Comment
SP >75	Indicates **high** environmental significance	Where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. Impacts of high significance would typically influence the decision to proceed with the project.
SP 46 - 75	Indicates **moderate** environmental significance	Where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value. Such an impact is unlikely to have an influence on the decision. Impacts may justify significant modification of the project design or alternative mitigation.
SP 15 - 45	Indicates **low** environmental significance	Where an effect will be experienced, but the impact magnitude is small and is within accepted standards, and/or the receptor is of low sensitivity/value or the probability of impact is extremely low. Such an impact is unlikely to have an influence on the decision although impact should still be reduced as low as possible, particularly when approaching moderate significance.
SP < 15	Indicates **negligible** environmental significance	Where a resource or receptor will not be affected in any material way by a particular activity or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels. No mitigation is required.
+	**Positive impact**	Where positive consequences / effects are likely.

In addition to the above rating criteria, the terminology used in this assessment to describe impacts arising from the current project are outlined in Table 8 below. In order to fully examine the potential changes that the project might produce, the project area can be divided into Areas of Direct Influence (ADI) and Areas of Indirect Influence (AII).

- Direct impacts are defined as changes that are caused by activities related to the project and they occur at the same time and place where the activities are carried out i.e. within the ADI.
- Indirect impacts are those changes that are caused by project-related activities, but are felt later in time and outside the ADI. The secondary indirect impacts are those which are as a result of activities outside of the ADI.

Table 8: Types of impact

Term for Impact Nature	Definition
Direct impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (i.e. between an effluent discharge and receiving water quality).
Indirect impact	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (i.e., pollution of water placing a demand on additional water resources).
Cumulative impact	Impacts that act together with other impacts (including those from concurrent or planned activities) to affect the same resources and/or receptors as the Project.

5.2 Identified impacts

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT, 2002). To this end, a discussion guiding impact characterisation is provided in the sections below, with the rating calculations shown in the accompanying tables.

Alterations of the natural variation of flow by river regulation through altering or impeding the flows can have a profound influence upon almost every aspect of river ecological functioning (Davies and Day, 1998). Furthermore, community composition is determined by water quality and the types of habitat (biotopes) available for them to utilise (Dallas and Day, 2004).

The following potential impacts of the proposed CTT Project on the aquatic ecosystems are discussed in relation to construction activities across the Govuro River:

- Impacts on water quality;
- Aquatic habitat loss and alteration (*macro-channel and in-stream*); and
- Loss of aquatic biota of conservation concern.

The identified impacts were primarily assessed in the context of the Govuro River. The non-perennial bodies of water west of the EN1 and the drainage lines / floodplain depressions located between the Govuro River and coast were also considered. Although the Govuro River is the primary watercourse affected by this development, small non-perennial bodies of waters, such as drainage canals and defunct borrow pits have been shown to host Lungfih (*Protopterus annectens*) and Killifish species (*Nothobranchius sp.*). Furthermore, the backwaters along the edges of the floodplain depressions that are seasonally inundated, provide favourable habitat.

5.2.1 Construction phase impacts

5.2.1.1 Impacts on water quality

Water quality at or below the watercourse crossing sites, may be impacted on as a result of in-stream and bank disturbances during the construction phase, as well as the potential contamination as a result of poorly maintained heavy machinery. Fluctuations in the *in situ* water quality parameters (pH, Electrical Conductivity (EC), TDS, DO, and temperature) as well as water chemistry (e.g. hydrocarbons) will in turn have impacts on the biotic communities. Due to the localised extent of the development, the impact significance of water quality impairment was rated low along the Govuro River, whilst the non-perennial waterbodies and floodplain depressions were rated as moderate prior to the implementation of mitigation measures. By implementing the mitigation hierarchy, the post mitigation impact significance of water quality impairment was rated as low.

Impacts on water quality are likely to result from the following activities:

- Riparian vegetation removal, leading to increase erosion and runoff. This will result in sedimentation and siltation of habitats downstream of the construction. Within the Govuro River, this will be transported downstream, while in the waterbodies with no flow, this silt with settle out and smother habitats;
- Flow impediment. During the construction, earthworks may impede the free movement of water, or water may need to be purposefully diverted in order allow construction with a permanently saturated area;
- Construction materials being utilised on site such as concrete, as well as oils from generators and vehicles, may come into contact with surface water, resulting in contamination; and
- Building of access roads to the site and servitudes along the pipeline and transmission route, resulting in large areas of vegetation being cleared and large quantities of topsoil being removal. This could lead to possible increased erosion potential and dust. Both of these would result in the sedimentation and siltation of habitats.

5.2.1.1.1 Proposed Mitigation Measures

In order to minimise the impacts during construction of the proposed CTT Project on the aquatic ecosystems, it is necessary to minimise the impacts on water quality, including contamination, flow and sedimentation. This can be accomplished by the following means:

- Where possible, place construction activities as close to the existing road servitudes as possible to limit unnecessary clearing;
  - Avoid non-perennial bodies of water such as flooded borrow pits / drainage canals and floodplain depressions where possible.
- Construct the Govuro River crossings during the dry season so as to limit the amount of impact on the sites, particularly in terms of flow diversion and surface water runoff following rainfall.
- Implement low-impact construction techniques to minimise the impact on the river system, especially during the diversion of any water during construction (if required).
  - *E.g. low-impact construction techniques are those that make use on-site construction waste (i.e. rock substrate, topsoil) for use as non-structural fills or landscaping materials.*
- Where possible, keep construction activities out of the riparian areas, floodplain and inland depressions, and clearly demarcate no-go areas;
  - Limit movement of construction vehicles and activities (e.g. spoil heaps) to the demarcated zone only; and
  - Restrict vehicles to service roads.
- Monitor the water quality downstream of the river crossing sites during construction on an at least bi-annual basis. Information from this monitoring can be used to quickly implement management actions

should a significant decrease in water quality downstream of the crossings be observed. More frequent surface water quality monitoring may be required during construction; this should be implemented in agreement with the mitigation measures set out in of the surface water impact assessment chapter (Golder, 2018).

- To ensure that any adverse impacts are reduced, the project team must ensure that any accidental spillages or impacts to the aquatic and riparian ecosystems are cleaned up and rehabilitated immediately in accordance with the Engineering, Procurement and Construction (EPC) spill management plans.
- In line with the terrestrial ecological impact assessment report, vegetation clearing and rehabilitation mitigation measures should be implemented.

5.2.1.2 Habitat changes

Macro-channel habitat and riparian vegetation loss or alteration (incl. backwaters and depressions)

The most significant impact on the macro-channel and riparian vegetation is expected to occur during the construction phase as this is when earth moving machinery will be active. The backwaters and margins of the waterbodies are rich with emergent vegetation, which provide favourable habitat for smaller fish, fish fry, amphibians and other species such as waterfowl. Construction activities may result in possible bank destabilisation, increased erosion potential and exotic vegetation encroachment (see detailed consideration under the *Establishment and spread of alien invasive plant species* in the terrestrial ecology report). Due to the important role these habitats play, the impact of losing or altering them was rated as moderate prior to implementing any mitigation measures. Due to the expected small footprint and nature of the development, it is believed that with the correct management, the significance of the impact can be reduced to low.

The following proposed activities will impact on the macro-channel and riparian vegetation during this phase:

- Riparian vegetation removal (*See terrestrial ecology chapter for detailed information on vegetation removal*).
- Riparian vegetation is important for bank stabilization, habitat, flood control and is an important supporting feature within the food chain.Building of access roads to the site and servitudes along the pipeline and transmission route, resulting in large areas of vegetation being cleared and large quantities of topsoil being removed. This could lead to increased erosion potential and dust. Both of these would result in the sedimentation and siltation of habitats, as the vegetated nature of the riparian systems is associated with decreased flow velocity, facilitating settling of particulates. Furthermore, the vegetation provides a larger surface area for the build-up of silt, resulting in the habitat being smothered.
- Bank disturbances from heavy machinery gaining access to the river.

In-stream channel habitat loss or alteration

The road upgrade and pipeline crossings are expected to result in minimal bed damage and degradation downstream of the crossing points. In contrast to vegetated areas, sediments that make their way into the in-stream channel are likely to be carried downstream and flushed under periods of high flow.

The main in-stream disturbances are expected to occur as a result of earthworks within the channel. Earthworks are expected to include the footings of the bridge pillars. The application of the required mitigation measures is predicted to reduce the significance of predicted impacts to negligible, as a result of the reduced intensity and probability of this impact.

5.2.1.2.1 Proposed Mitigation Measures

In order to minimise the impacts on the in-stream habitats during construction of the proposed CTT Project, the following mitigation measures are required:

- The construction of the Govuro River crossings should take place during the dry season so as to limit the intensity of impact, particularly in terms of flow diversion and runoff of sediments.
- Implement low impact construction techniques to minimise the impact on the river system, especially during the diversion of any water during construction.
- Where possible, keep construction activities out of the riparian areas, floodplain, inland depressions and macro-channel.
  - Vegetation clearing should be restricted to the proposed development footprints only, with no clearing permitted outside of these areas.
  - Areas to be cleared should be clearly demarcated to prevent unnecessary clearing outside of these sites.
  - *See mitigation measures detailed in the terrestrial ecology report*.
- The alignment of the road should be routed to avoid impacting the adjacent floodplain and inland depressions and any non-perennial bodies of water.
- A suitable rehabilitation programme should be developed and implemented in all disturbed areas. The programme should include active re-vegetation, using locally-occurring indigenous grass and tree species.

5.2.1.3 Loss of aquatic biota of conservation concern

During the construction phase, disturbance of the habitats within the localised area will impact on the aquatic biota. It is likely that fish species that occur at or near the sites will move away if disturbed. This will, however, be localised and temporary, and thus the aquatic biota should recover quickly as the habitats are rehabilitated and re-colonisation takes place. It should be noted that the Vulnerable (VU) Leopard Stingray (*Himantura uarnak*) has been observed in the lower reaches of the Govuro River. The Leopard Stingray is often found off sandy beaches, in sandy areas of coral reefs, in shallow estuaries and lagoons, and may even enter freshwater (Vaudo and Heithaus 2009, Gutteridge 2012). The Mozambique tilapia (*Oreochromis mossambicus*), listed as Near Threatened (NT) occurs in all but fast-flowing waters. This species thrives in standing waters and can tolerate fresh, brackish or marine waters.

The Zebra snail, *Neritina natalensis,* classified as Near Threatened (NT), was commonly encountered during the 2016 survey (ERM, 2016). The gastropod *Septaria borbonica* (Neritidae) which was recorded on the stems of *Nymphaea nouchaii* within the Govuro River, is listed as Endangered (EN).

The impact significance of losing any species of conservation concern is rated as moderate prior to mitigation. This impact was reduced to low based on the probability, provided that the required mitigation measures are successfully implemented.

5.2.1.3.1 Proposed Mitigation Measures

Monitor the water quality and habitat downstream of the river crossing sites during construction on an at least bi-annual basis (see Surface Water chapter), and implement an early warning system that would trigger a survey of the biological responses, should water quality or habitat alterations warrant this.

Table 9: Impact assessment table – construction phase

CONSTRUCTION PHASE											
Indicator of potential impact		**Pre-mitigation**					**Post-mitigation**				
		Intensity	Duration	Geographic Extent	Probability	Significance	Intensity	Duration	Geographic Extent	Probability	Significance
Impacts on Water Quality	Temporary bridge structures across Govuro River and tributaries	6	2	2	3	30	6	2	2	2	20
	Govuro River pipeline	6	2	2	3	30	6	2	2	2	20
	Inland, floodplain depressions / Non-perennial waterbodies	8	5	3	3	48	8	2	2	2	24
Habitat Changes	Macro-channel habitat and riparian vegetation loss or alteration	6	2	1	5	45	4	2	1	4	28
	In-stream channel habitat loss or alteration	4	2	2	3	24	4	2	1	2	14
Loss of aquatic biota of conservation concern		8	5	4	3	51	8	5	4	2	34

5.2.2 Operational phase impacts

5.2.2.1 Impacts on water quality

Once operational, the CTT project is not expected to have a significant impact on the associated aquatic ecosystems. The current road crossings, although utilised by local people for access to the Govuro River, do not appear to be severely impacted. No people were seen bathing or washing clothes at Govuro River crossings, likely due to the brackish nature of the water. Once recovered, the water pipeline crossing of the Govuro River will pose little threat as a leak would result in groundwater entering the river. Contamination of surface water entering the watercourse is possible, particularly around the power plant where hydrocarbons have the potential to spill.

Impacts on water quality during operation are likely to result from the following activities:

- Service roads and traffic may contribute to increased sediment inputs from erosion and dust; and
- Spills into the aquatic ecosystem occurring from operational incidents.

5.2.2.1.1 Proposed Mitigation Measures

During the operational phase, the following mitigation measures and response plans are required to avoid and minimise contamination of the Govuro River and any other aquatic resources:

- Monitor the pipelines for leaks and spills on a regular basis;
- Repair damaged structures immediately to avoid excessive spills;
- Contain spills to avoid degrading water quality downstream;
- Any accidental spillages or impacts to the aquatic and riparian ecosystems must be cleaned up and rehabilitated – a spillage management plan should be in place to address such situations;
- Maintain service roads to avoid erosion and excessive dust formation; and
- Design and implementation of a suitable long-term water and habitat monitoring programme, as well as an aquatic biomonitoring programme.

5.2.2.2 *Loss of aquatic biota of conservation concern*

Aquatic biota diversity and abundance

During the operational phase, disturbance to the instream biota is expected to be minimal. It is expected that after construction, aquatic biota should recover quickly as the habitats are rehabilitated and re-colonisation takes place. Rejuvenation of the site will result in fish moving back into the area. As no major flow modifications are expected, stream connectivity will remain the same, and allow for the free movement/migration of fish species to, from and within the Study Area.

5.2.2.2.1 Proposed Mitigation Measures

A monitoring plan should be implemented to assess any changes in biological responses downstream of the river crossing sites.

Table 10: Impact assessment table - operational phase

OPERATIONAL PHASE											
Indicator of potential impact		Pre-mitigation					Post-mitigation				
		Intensity	Duration	Geographic Extent	Probability	Significance	Intensity	Duration	Geographic Extent	Probability	Significance
Impacts on Water Quality	Govuro River crossings	4	4	2	3	30	4	4	1	2	18
	Inland, floodplain depressions / Non-perennial waterbodies	6	4	4	3	42	6	2	4	2	24
Loss of aquatic biota of conservation concern		8	5	4	2	34	8	5	3	2	32

5.2.3 Decommissioning phase impacts

It is unlikely that decommissioning activities (e.g. dismantling infrastructure) are likely to cause additional disturbances to the aquatic ecosystems associated with the CTT Project that are not discussed above. If access into the river channel, the riparian zone or any of the backwaters or depressions is required to remove infrastructure, the same activities and mitigation measures detailed during the construction phase would apply. Furthermore, the Govuro River crossing is likely to remain in place, as local villagers will utilise this to cross the river.

Therefore, it is recommended that continued control of alien invasive plant species should form part of the regular monitoring, in line with the terrestrial ecology mitigation measures.

6.0 ENVIRONMENTAL ACTION PLAN

Recommended environmental actions to address identified impacts on aquatic ecology are presented in Table 11.

Table 11: Environmental Action Plan

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
Construction Phase				
Aquatic Ecosystems	Impacts on water quality as a result of the construction of the temporary bridge structures across Govuro River Macro-channel and instream habitat and riparian vegetation loss or alteration Loss of aquatic biota of conservation concern	■ Riparian vegetation removal. ■ Flow impediment. ■ Construction materials as well as oils from generators and vehicles may come into contact with surface water. ■ Building of access roads to the site and servitudes along the pipeline and transmission route, resulting in large areas of vegetation being cleared and large quantities of topsoil being removed.	■ Ensure mitigation measures are implemented and adhered to. ■ Ensure construction plans are followed and on schedule (within dry season). ■ Implement a response plan so that if any of the monitoring criteria are exceeded, action can be taken immediately.	Environmental Manager
Operational Phase				
Aquatic Ecosystems	Impacts on water quality	■ Service roads.	■ Monitor the pipelines for leaks and spills on a regular basis.	Environmental Manager

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
	Loss of flora species of conservation concern	■ Spills from operational incidents.	■ Contain spills to avoid degrading water quality downstream. ■ Ensure that repairs to damaged structures are completed immediately. ■ Rehabilitate all disturbed areas, and ensure the establishment of viable coverage of indigenous vegetation. ■ Implement a suitable long-term water and habitat monitoring programmes as well as an ecological biomonitoring programme.	
Decommissioning Phase				
Aquatic Ecosystems	Establishment and spread of alien invasive plant species	Vegetation clearing and earth works during construction phase	■ Continue to implement the alien invasive plant species control programme. ■ Rehabilitate all disturbed areas	Environmental Manager

7.0 MONITORING PROGRAMME

A proposed monitoring programme to gauge the effectiveness of recommended interventions and potential new impacts or impact sites is presented in Table 12.

Table 12: Monitoring programme

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Construction Phase				
Ensure there is no degradation in water quality within the Govuro River.	Implement a detailed surface water monitoring program (*Refer to surface water monitoring program*).	Up and downstream of river crossings.	Refer to surface water monitoring program	Environmental Manager
Ensure there is no change in the biological responses within the Govuro River.	Implement an aquatic biomonitoring program looking at the drivers and responses that may deviate as a result the construction activities.	River crossing locations.	Bi-annually during construction (*unless any significant changes in water quality [surface water] or habitat [terrestrial monitoring] are noted*).	Environmental Manager / Appointed Aquatic Biologist
Operational Phase				
Ensure there is no degradation in water quality within the Govuro River	Implement a surface water monitoring program (*Refer to surface water monitoring program*	Up and downstream of river crossings.	Refer to surface water monitoring program.	Environmental Manager
Ensure there is no change in the biological responses within the Govuro River	Implement an aquatic biomonitoring program looking at the responses that may originate from operational activities.	River crossing locations.	Annually for a period of two years (*unless any significant changes in water quality [surface water] or habitat [terrestrial monitoring] are noted*).	Environmental Manager / Appointed Aquatic Biologist
Decommissioning Phase				
Ensure there are no long-term residual impacts as a result of the operational activities.	In line with the terrestrial ecology report, implement a vegetation monitoring plan, with a focus on alien invasive plan species.	All rehabilitated areas	Annually	Environmental Manager

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
	Conduct visual inspections at river crossings to ensure no erosion is forming.	All rehabilitated areas / crossing points.	Annually	

8.0 CONCLUSIONS

The Govuro River is the only perennial river in the Central Térmica de Temane (CTT) Study Area, flowing approximately 185 km parallel to the coast from south to north to the river mouth south of Nova Mambone.

Overall, the Govuro River is considered to be in a natural state, with the 2018 studies and does not differ significantly from the previous studies conducted within the same reach of river. Furthermore, the results collected in 2018, were comparable to studies completed between 2005 and 2016, with water quality parameters and biota found to be similar, which showed comparable results. The Govuro River system is considered to have high fish diversity, with the number of expected species varying with regards to marine vagrants and estuarine specialists. Fifty-two (52) fish species have been identified in literature to occur within the Project Area, of which 49 have been collected in various surveys for the Joint Venture Sasol project. A general assessment of aquatic macroinvertebrates resulted in a rating of “fair” condition, due to the lower sensitivity scores of the abundant air-breathing taxa found in an environment dominated by vegetation in slow/shallow habitats and lack of rocky riffle type habitats. Macroinvertebrates have not been well sampled across the different aquatic habitats, as a result of the naturally low diversity of instream habitats associated with a low gradient and largely uniform bed substrate comprised of fine sand and outcrops of calcrete cobbles and boulders that is typical of the Govuro River in the study area (ERM, 2016). As a result, the macroinvertebrate integrity scores and the habitat site scores reflect high degree of similarity in habitats and associated invertebrates in the Govuro River. Furthermore, the tidal influence results in naturally high concentrations of salinity that are close to the upper tolerance limit for many freshwater species (ERM, 2016). The freshwater macroinvertebrate fauna therefore comprises mainly hardy taxa that are generally unsuitable for monitoring environmental change.

An assessment of the riparian and aquatic habitat indicated that the sites sampled along the Govuro River are largely unmodified. The Govuro River channel is dominated by emergent vegetation along the margins, comprising common reed *(P. australis*) and water lilies (*Nymphaea sp*.), while the centre of the channel is characterised by open water with areas of sand and fine gravel. Although a few rocks were observed, no rapid or riffle habitats were noted. A comparison of the 2018 results with the 2004/5, 2014, 2015 and 2016 surveys showed consistency with the same categories being recorded throughout. The only notable difference in 2018 was at the upstream site at the Vilanculos Bridge (GV-SW00), which showed signs of the invasive *Salvinia molesta.*

In situ water quality measured during the June 2018 survey was not considered a limiting factor to aquatic biota. The results collected were comparable to those collected in February 2015, with the exception of temperature and dissolved oxygen, which were marginally below the summer mean. This was expected as the survey was conducted in different seasons, and dissolved oxygen is related to water temperature. When compared to the previous surface water baseline study (Golder Report: 1405502-13410-9), the analysis of the data of the present state of the water in the Govuro River reflects that quality of the water is good. The water quality is indicative of a fairly natural state with relatively low concentrations of most water quality parameters assessed.

Even though the Govuro River is considered to be in a natural state, the proposed CTT Project is not expected to have a significant impact to the water quality, habitat or biota of the aquatic ecosystems due to the type of development and small footprint thereof. During the construction phase, disturbance of the habitats within the localised area may impact the aquatic biota. It is likely that fish species that occur at or near the sites will move away if disturbed. This impact will however be localised and temporary, and thus the aquatic biota should recover quickly as the habitats are rehabilitated and re-colonisation takes place.

Regular water quality and habitat monitoring should be implemented, with a defined set of triggers, to alert the ECO or environmental manager to any future change or decrease in integrity. This will then prompt more detailed sampling of the biota (response indices) to determine what the effect on the overall aquatic health is so that additional interventions can be executed.

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APPENDIX A

Fish species recorded within the aquatic systems of the Govuro River

Fish species recorded within the aquatic systems of the Govuro River

Family	Fish Species	IUCN, 2016.2	Habitat Preference	EcoSun, 2005	Golder, Feb & May 2014	Golder, Feb 2015	ERM, Nov 2015	ERM, Jan 2016	Golder, Dec 2016
Alestidae	Silver robber *(Micralestes acutidens)*	LC	Very adaptable species which is found in both still and running water. Clear open water. Shuns excessively muddy or heavily silt-laden waters. Shoals migrate upstream after the first summer rains.		X	X		X	
Ambassidae	Longspine glassy *(Ambassis producta)*	NE	Tolerant to freshwater over a wide range of temperature and tends to be more tolerant of lower temperatures in water of low salinity than in seawater. Feeds mainly at night on crustaceans, fish fry and larvae of insects.	X	X				
Ambassidae	Commerson's glassy perchlet (*Ambassis ambassis*)	LC	Prefers estuarine environments but it may enter into freshwater system. It is mainly found in the ascending rivers and brackish water lakes				X	X	
Anabantidae	Many-spined climbing perch *(Ctenopoma multispine)*	LC	Occurs in vegetated riverine backwaters, floodplain lagoons, swamps and isolated pans. Can endure warm stagnant waters and leave the water and move overland to alternative sites in wet weather or at night.		X	X		X	
Anguillidae	Longfin eel *(Anguilla mossambica)*	LC	Elvers (juveniles): cobble riffles. Young eels: Rocky rapids and riffles. Adults: Deep rocky pools. Inhabits deep rocky pools and is active at night. The leptocephalus larvae are found both offshore and in brackish water.	X				X	
Carangidae	Giant Kingfish (Caranx ignobilis)	LC	Pelagic and occur to depths exceeding 100 m. Juveniles occur in small schools over sandy inshore bottoms and occasionally in turbid estuaries.					X	
Carangidae	Indian threadfish (*Alectis indicus*)	NE	Juveniles solitary, found in surface waters and in estuaries					X	
Cichlidae	Southern mouthbrooder *(Pseudocrenilabrus philander)*	NE	Wide variety of habitats from flowing waters to lakes and isolated sinkholes.	X		X	X	X	X

Family	Fish Species	IUCN, 2016.2	Habitat Preference	EcoSun, 2005	Golder, Feb & May 2014	Golder, Feb 2015	ERM, Nov 2015	ERM, Jan 2016	Golder, Dec 2016
Cichlidae	Redbreast tilapia *(Coptodon rendalli)*	LC	Quiet, well-vegetated water along river littorals or backwaters, floodplains and swamps. Nest is situated in shallow water or gently sloping banks.	X	X	X	X	X	
Cichlidae	Eastern river bream (*Astotilapia calliptera*)	NE	Occurs in a wide variety of riverine and marshy habitat.		X			X	
Cichlidae	Mozambique tilapia *(Oreochromis mossambicus)*	NT	Occurs in all but fast-flowing waters. Thrives in standing waters. Tolerant of fresh, brackish or marine waters Spawning occurs in summer, as early as September. Moves up tributary rivers to spawn, and if conditions are right will spawn during movement upriver.	X	X	X	X	X	X
Cichlidae	Nile Tilapis *(Oreochromis niloticus)*	NE	Occur in a wide variety of freshwater habitats like rivers, lakes, sewage canals and irrigation channels			X		X	X
Cichlidae	Black tilapia *(Oreochromis placidus)*	LC	Well-vegetated, sheltered habitats in margins of mainstreams, in floodplain lagoons and coastal lakes.					X	
Clariidae	Sharptooth catfish *(Clarias gariepinus)*	LC	Occurs in almost any habitat but favours floodplains, large sluggish rivers, lakes and dams. Can endure harsh conditions – high turbidity, or desiccation. Last or only inhabitants of diminishing pools of drying rivers or lakes, where it may form burrows. Migrating into inundated pans during summer months, struggling through grass in water that barely covers their bodies. Moves overland under damp conditions if necessary by extending the pectoral spines and crawling. Completely omnivorous - preys, scavenges or grubs on virtually any available organic food source including fish, birds, frogs, small mammals, reptiles, snails, crabs, shrimps, insects, other invertebrates and plant matter such as seeds and fruit, and is even capable of straining fine plankton if necessary. May hunt in packs, herding and trapping	X	X	X	X	X	

Family	Fish Species	IUCN, 2016.2	Habitat Preference	EcoSun, 2005	Golder, Feb & May 2014	Golder, Feb 2015	ERM, Nov 2015	ERM, Jan 2016	Golder, Dec 2016
			smaller fishes. Spawning takes place during summer after rains, large numbers of mature fishes migrate to flooded grassy places inundated by flood waters of high oxygen content. Eggs are laid on vegetation in shallow grassy verges of rivers and lakes.						
Clariidae	Blunttooth catfish *(Clarias ngamensis)*	LC	Favours vegetated habitats in swamps and riverine floodplains. Breeds during the summer rainy season, large numbers of fishes moving into shallow flooded drainage channels to spawn.		X				
Clupeidae	Estuarine round herring (*Gilchristella aestuaria*)	LC	Present in open and closed estuaries, lower reaches of some large rivers just above estuary heads and some permanent coastal, freshwater lakes.				X		
Cyprinidae	Broadstriped barb *(Enteromius annectens)*	LC	Slow-flowing streams with vegetation.		X	X	X	X	
Cyprinidae	Sickle-fin barb *(Enteromius haasianus)*	LC	Inhabits swamps and floodplains in well-vegetated habitats.		X			X	X
Cyprinidae	Bowstripe barb *(Enteromius viviparus)*	LC	Vegetated pools of streams and rivers and lake margins.	X	X	X	X	X	
Cyprinidae	East-coast barb *(Enteromius toppini)*	LC	Shallow, well-vegetated streams and pans.					X	
Cyprinidae	Beira barb *(Enteromius radiatus)*	LC	Marshes and marginal vegetation of streams, rivers and lakes. Active in subdued light and at night.	X	X	X	X	X	
Cyprinidae	Threespot barb *(Enteromius trimaculatus)*	LC	Wide variety of habitats, especially where vegetation occur.	X	X			X	

Family	**Fish Species**	**IUCN, 2016.2**	**Habitat Preference**	**EcoSun, 2005**	**Golder, Feb & May 2014**	**Golder, Feb 2015**	**ERM, Nov 2015**	**ERM, Jan 2016**	**Golder, Dec 2016**
Cyprinidae	Straightfin barb *(Enteromius paludinosus)*	LC	Hardy, preferring quiet, well-vegetated waters in lakes, swamps and marshes. Also marginal areas of larger rivers and slow-flowing streams.		**X**			**X**	
Dasyatidae	Leopard Stingray *(Himantura uarnak)*	VU	Often found off sandy beaches, in sandy areas of coral reefs, in shallow estuaries and lagoons, and may even enter freshwater.				**X**		
Duleidae	Rock flagtail (*Kuhlia rupestris*)	LC	Brackish or fresh water.	**X**		**X**			
Eleotridae	Dusky sleeper *(Eleotris fusca)*	LC	Commonly found under logs and rootstocks in muddy reaches of estuaries and mangrove swamps and freshwater streams leading into coastal lagoons.			**X**	**X**	**X**	
Gobiidae	Tank goby (*Glossobius giuris)*	NE	Quiet, usually sandy, zones of streams and backwater habitats and floodplain pans. Main breeding activity is during summer rainy season, eggs on underwater plants. Poor swimmer and is not found in torrential parts of rivers.				**X**		
Gobiidae	River goby (*Glossogobius callidus)*	LC	In pools on the bottom amongst cover such as cobbles and vegetation.	**X**		**X**		**X**	
Gobiidae	African mudhopper (*Periopthalmus koelreuteri*)	NE	Amphibious and inhabits muddy water, estuarine shores and mangrove swamps.				**X**	**X**	
Gobiidae	Painted-fin Goby (*Oligolepis acutipennis)*	DD	Occurs inshore, enters lagoons. Found in muddy estuaries and coastal bays. Enters lower reaches of freshwater streams.					**X**	
Gobiidae	Bull goby (*Redigobius balteatops*)	NE	-				**X**	**X**	
Hemiramphidae	Tropical halfbeak (*Hyporhamphus affinis*)	NE	Found chiefly around coral reefs and islands.					**X**	

Family	Fish Species	IUCN, 2016.2	Habitat Preference	EcoSun, 2005	Golder, Feb & May 2014	Golder, Feb 2015	ERM, Nov 2015	ERM, Jan 2016	Golder, Dec 2016
Leiognathidae	Striped ponyfish (*Aurigequula fasciata*)	LC	Found in shallow (usually, but reported to occur to 120 m) coastal waters over mud, rocky, mangrove and estuarine habitats.				X	X	
Lutjanidae	River snapper (*Lutjanus argentimaculatus*)	NE	Juveniles common in estuaries, among mangroves and also in freshwater. Ambush predator.			X			
Megaolopidae	Oxeye tarpon (*Megalops cyprinoides*)	DD	Found in coastal waters and estuaries, enters rivers. In freshwater, they occur in rivers, lagoons, lakes, and swampy backwaters. Known to breathe air, rising regularly to the surface to do so.		X				
Monodactylidae	Round moony *(Monodactylus argenteus)*	NE	Large schools, often frequenting vegetation. Juveniles enter freshwater.	X	X	X	X	X	
Mugilidae	Flathead mullet *(Mugil cephalus)*	LC	Tolerates a wide range of salinity from sea water to above sea-water concentrations. Breeds at sea near mouths or estuaries during the winter. Juveniles enter estuaries and, to a lesser extent, rivers, mainly during the winter months.		X				
Mugilidae	Large-scale mullet *(Liza macrolepis)*	LC	Bottom-feeder.	X					
Nothobranchiidae	Killifish (*Nothobranchius kadleci)*	NE	Temporary pans and pools.					X	
Nothobranchiidae	Spotted killifish (*Nothobranchius orthonotus)*	LC	Temporary pans, pools, floodplains and ditches normally					X	X
Nothobranchiidae	Rainbow killifish (*Nothobranchius pienaari)*	LC	Marshes on coastal plain.					X	
Poeciliidae	Johnston's Topminnow	LC	Strictly a floodplain or marsh-loving species. *Distribution needs to be confirmed.*						

Family	Fish Species	IUCN, 2016.2	Habitat Preference	EcoSun, 2005	Golder, Feb & May 2014	Golder, Feb 2015	ERM, Nov 2015	ERM, Jan 2016	Golder, Dec 2016
	(Micropanchax johnstoni)								
Pomacentridae	Sooty damsel (*Neopomacentrus fuliginosus*)	NE	Adults inhabit inshore areas on soft bottoms around rock outcrops and weed beds.					X	
Protopteridae	Lungfish (*Protopterus annectens)*	LC	Seasonal pans with a thick layer of black mud that; pools dry up seasonally.		X			X	X
Scatophagidae	Scatty (*Scatophagus tetracanthus*)	NE	Common in harbors and estuaries, also found in rivers and lagoons.	X			X	X	
Schilbeidae	Silver catfish *(Schilbe intermedius)*	LC	Shoals in standing or slowly flowing open water with emergent or submerged vegetation. Breeds during the rainy season. May be either single or a multiple spawners in different localities, laying eggs on vegetation. Flood plain spawning.		X	X			
Sparidae	Riverbream *(Acanthopagrus berda)*	LC	Common in estuaries, relatively uncommon in freshwaters. Feeds on a wide variety of polychaete worms, mussels, shrimps, crabs and small fish. Breeds in winter at sea.		X				
Syngnathidae	Short-tail pipefish *(Microphis brachyurus)*	LC	Estuarine and freshwater.				X		
Terapontidae	Tiger perch (*Terapon jarbua*)	LC	Lives in marine, coastal areas, estuaries, freshwater and some coastal lagoons.					X	
Tetraodontidae	White-spotted puffer (*Arothron hispidus*)	LC	Inhabits outer reef slopes, inner reef flats, and lagoons to depths of at least 50 metres. Juveniles are common in weedy areas of estuaries.					X	

Critically endangered (CR) – Extremely high risk of extinction in the wild.

Near threatened (NT) – Likely to become endangered in the near future.

Least concern (LC) – Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category.

Data deficient (DD) – Not enough data to make an assessment of its risk of extinction.

Not evaluated (NE) – Has not yet been evaluated against the criteria.

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