REPORT

Central Térmica de Temane Project - Surface Water 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

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 Electricidade de Mozambique E.P. (EDM) and Temane Energy Consortium (Pty) Ltd (TEC). The CTT project will use natural gas as feedstock and electrical power produced by the facility will be distributed to the National electricity grid. The CTT plant with generation capacity of approximately 450MW will include a facility with a power generation block, an outside battery limit and the plant infrastructure. The final selection of technology that will form part of the power generation block of the CTT project has not been determined at this stage. The two power technology options that are currently being evaluated are, closed cycles steam gas turbines (CCGT) or open circuit gas engines and generator sets (OCGE).

The preferred site for CTT project is located approximately 500 m south of the Sasol Central Processing Facility (CPF). The site is located approximately 40 km northwest of the town of Vilanculos and 30km southwest of the town of Inhassoro. The Govuro River lies 8 km east of the proposed CTT site.

The proposed project has been determined as 'Category A' in terms of Mozambique's environmental law (Decree 54/2015 of 31 December 2016). For 'Category A' projects, an Environmental and Social Impact Assessment (ESIA) must be prepared as a basis for whether or not environmental authorisation of the project is to be granted, and if so, under what conditions. This document represents the Surface Water Impact Assessment undertaken to support the ESIA.

The scope of work for the Surface Water Impact Assessment includes:

- A review of the stormwater management and water balance for the CTT plant based on the technical basis of design for the gas turbine option and the gas engine option.
- An impact assessment of the proposed project for both technology options on the surface water environment for the lifespan of the project.

An understanding of surface water hydrological conditions prior to project development is essential to assess changes in water availability that could affect local users and of the overall catchment. Changes in hydrology can also affect water quality and other resources such as fish habitat, vegetation and wildlife. Hydrological data is further required to design water facilities (e.g. culverts, channels and storage ponds).

The regional climate in the area is described as sub-tropical with a distinct wet and dry season and is moderately humid. Rainfall over the study area catchment varies between 800 mm to 1000mm / annum. This project area falls in the part of Mozambique that is typically subject to cyclones that generate strong winds and heavy rainfall. The proposed CTT plant site is situated within the Govuro River catchment. The surrounding topography is relatively flat, that dips gently towards the Govuro River.

A wide variety of aquatic and wetland habitats are present in the eastern Govuro area. These areas are considered sensitive habitats. In this area several seasonal streams occur in the rainy season, which feed the coastal lakes and the wetlands. These are used by local communities for consumption and agriculture. Inhabitants in the area primarily use surface water for domestic purposes. Due to the seasonality of the surface water resources, groundwater is the main source of water in the project area. Water quality of the Govuro River is considered to be good.

Water Balance

An analysis of the water balance at the CTT project site was undertaken based on the understanding of the baseline conditions, water reticulation and management system and basis of design requirements. The analysis highlighted that the key aspect of surface water management on site is the evaporation pond.

The followed can be concluded from the analysis:

- the water balance reflects that the facility has adequate water storage availability and water supply based on the proposed design criteria and operational scenarios for both technology options.
- the evaporation ponds (for both technology options), based on the design inflow rates of the various waste streams and the evaporation rate for the area, have approximately 356 days of capacity available for the CCGT option and 720 days available for the OCGE option. However certain factors are still unconfirmed at this stage that may influence the storage capacity:
  - evaporation rates based on monitored data;
  - the volume of non-compliant treated effluent (sewage and or oily water) that may report to the evaporation pond.
  - the frequency of desludging pending build-up of sludge and salts; and
  - the water qualities of the waste streams which may influence the sludge deposition rates.

  These factors will be important considerations in the management of the evaporation pond.
- Treated sewage effluent and oily water that will be used for onsite irrigation of vegetation requires regular monitoring to ensure that compliance to discharge water quality standards. Salinity standard of 500 mg/l must be complied with.
- Based on the distance of 8km to the Govuro River from the plant site, it is not likely that any potential spillages, discharges or irrigated effluent would report to the surface water resource. However monitoring of groundwater in the site area would be necessary to determine any influence on water quality.

Stormwater Management

The proposed conceptual stormwater system at the CTT project site was reviewed to determine as to whether it is able to meet the design objectives. The following can be concluded from the analysis:

- the clean stormwater/firewater sump and first flush sumps have adequate storage capacity based on the proposed design criteria for the runoff from 10minutes of a 100mm/hour rainfall event for both technology options.
- The clean stormwater/firewater sump will however discharge into the surrounding environment during wet season and rainfall events should the raw water reservoir have no capacity to accept the excess water.
- the stormwater management system is able to cater for the runoff from a 10minutes of 100mm/hour rainfall event. However the design does not cater for runoff from a 24hr storm event or continuous rainfall over a 2 to 3 day period. The stormwater/firewater sump will discharge in such events. Water quality discharge standards may not be compliant in such cases should clean stormwater be contaminated with oily water.
- Any stormwater water discharges will drain into the surrounding natural vegetation in the vicinity of the plant area. Regular monitoring would be required to confirm compliance to the water quality standards prescribed.

Impact Assessment

The potential impacts of the project during the construction phase, operation and decommissioning phases are listed and ranked in the tables below.

Potential impacts during the construction phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Increased erosion and runoff volumes	8	2	2	4	48	4	2	2	3	21
Sedimentation in the Govuro River	8	2	3	4	52	4	2	3	3	21
Altering the river banks and bed through the upgrade of the Govuro bridge	10	3	3	5	80	8	3	3	4	56
Spillage of oils, fuel and chemicals polluting water resources	8	2	3	4	52	4	2	2	2	16
Construction camp - Sewage wastewater	8	2	2	4	48	8	2	2	2	24

Potential impacts during the operational phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Catchment Water Balance	4	4	2	4	40	2	4	2	2	16
Water supply impact on River baseflow	8	4	3	3	45	6	4	3	2	26
Irrigation of effluents	10	4	2	4	64	6	4	2	2	28
Spills from the evaporation pond	10	4	2	5	80	8	4	2	4	56
Desludging	8	4	2	4	56	6	4	2	2	24
Spills from the first flush pump	8	3	2	4	52	8	3	2	2	26

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Discharge from the clean stormwater sump	6	3	2	3	**33**	4	3	2	2	**18**

Potential impacts during the decommissioning phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Magnitude	Duration	Geographic Extent	Probability	Significance	Magnitude	Duration	Geographic Extent	Probability	Significance
Soil contamination	8	2	2	4	**48**	8	2	2	2	**24**
Spillage of oils, fuel and chemicals	8	2	2	4	**48**	6	2	2	2	**20**
Increased Erosion and Sedimentation	8	2	2	4	**48**	6	2	2	2	**20**
Disturbances to the Govuro River bed and banks	10	2	2	4	**56**	8	2	2	3	**36**

The following conclusions can be drawn from the outcome of the impact assessment for both the OCGT and OCGE options, *viz*.

- Alteration of the bed and banks of the Govuro River during the construction phase and the spillages and/or liner failure from the evaporation pond during the operational phase are impacts rated as high significance. However both are reduced to a moderate significance with implementation of mitigation measures, and necessary protocols in place, but if not adequately addressed the impacts can be severe.
- Stormwater management can be considered the most ‘important’ impact that requires intervention during all three phases of the project. It has moderate significance for each of the phases, but is reduced to low with the necessary mitigation. The stormwater management across all phases requires separation of clean stormwater from potentially contaminated stormwater, as well construction of the necessary stormwater channels, drainage structures, collection systems and diversion berms to limit impacts. These are easily achievable to mitigate impacts. Management of the impacts also requires that potentially contaminated stormwater be treated, if necessary, prior to release to the environment.
- Impacts related to potential pollution and effluent management, *i.e.* sewage and treated oily water are also of importance in terms of the receiving surface water environment and are both rated as moderate significance pre-mitigation. Irrigation of the effluents is linked to effluent management and must comply with the discharge standards. Achievement of compliance reduces the impacts to a low significance.

- The impacts of low significance include the catchment water balance, impact of the water supply on baseflow and spillages from the clean stormwater sump.

Mitigation measures proposed for the Construction phase include:

- **Sewage water management:** Any discharge from sewage works should meet the Mozambican and IFC Environmental, Health and Safety (EHS) Guidelines for treated sanitary sewage discharge quality.
- **Stormwater management:** Construction of stormwater collection channels, drainage control berms, sediment traps and control dams, and other means shall be used as necessary. It is recommended that all major earthworks be undertaken during the dry season.

  Potentially contaminated stormwater shall be kept separate from other drainage at camp sites. Potentially contaminated stormwater shall, if necessary, be tested and treated to remove contaminants before being released into the environment.
- **Maintenance of the integrity of the Govuro River system**: It is necessary that management actions and interventions to limit vegetation removal, disturbance of habitats and ecosystems and changes to water quality and flow are implemented. The footprint area should be kept as small as possible. Water quality and flow upstream and downstream of the construction area shall be monitored to assess changes. Upgrade and/or pipeline construction of the pipeline across the Govuro River should only happen in the dry season. The affected river reach shall be restored by appropriate rehabilitation measures.

Mitigation measures proposed for the Operational phase include:

- **Environmental flow requirements to be maintained:** Flow monitoring programme in place to monitor changes to river baseflow. Compliance with the environmental flow requirements for the Govuro River to be met. Alternate water supply must be available, should restriction be placed on abstraction from the floodplain.
- **Prevention of surface water pollution by effluent management:** Effluent streams must comply with the Mozambican and IFC discharge water quality standards for treated effluents. Continuous analysis of quality of the effluent streams prior to irrigation to determine compliance to discharge standards. Non-compliant effluent should be discharged to the evaporation pond. Water quality analysis of groundwater in the receiving environment should be undertaken regularly.
- **Prevention of obstruction of water flow:** Impediments to natural water flow shall be avoided, or, if unavoidable, be allowed for in the design by means of appropriately sized and positioned drains, culverts etc.
- **Pollution control facility management (evaporation pond):** Leakage management system should be in place. Water quality analysis of perimeter boreholes around evaporation pond should be conducted regularly. Regular desludging of pond is to be undertaken. Sludge to be handled by waste contractor. A clean up protocol to be included in Environmental Management Plan.
- **Stormwater Management:** Potentially contaminated stormwater shall be kept separate from other drainage at the plant area. Potentially contaminated stormwater shall, if necessary, be tested and treated to remove contaminants before being released into the environment.

  Appropriate use of soak-ways, seepage fields and vegetation filters should be put in place to prevent contamination of water resources. Water quality analysis on water bodies in the receiving environment must be conducted regularly.

Mitigation measures proposed for the Decommissioning phase include:

- **Stormwater management** Construction of drainage control berms, sediment traps and control dams, and other means shall be used as necessary. It is recommended that all major earthworks be undertaken during the dry season to limit erosion and sedimentation.

  Protocols and measures in place to manage clean up and rehabilitate area must be adhered to limit soil contamination.

  Any stormwater that has been contaminated by oil, grease or other chemicals from site activity needs to be treated to the discharge standards

- **Maintain Govuro River system in natural state**: Limit footprint area as much as possible. Activities should be undertaken in dry season where possible. Limit disturbance to riverbed, banks and flow. Implement stormwater management controls and rehabilitate area to the desired level required.

Technology Options

A comparison of the surface water related aspects of the two proposed technology options are presented below, and an evaluation of the options indicate that:

- The OCGE option has a lower water supply requirement and produces lower quantities of the effluent;
- The CCGT option requires better water quality and thus requires ion exchange treatment step to produce demineralised water;
- The CCGT option also produces an additional effluent and waste stream *i.e*. HRSG blowdown and ion exchange waste.
- The OCGE option has a much smaller evaporation pond footprint; although of the effluent streams are of similar water quality.
- The OCGE option has a smaller potentially contaminated plant surface area thus resulting in smaller quantities of contaminated stormwater.

Aspect	CCGT Option	OCGE Option
Raw water supply	25.9 m^3/h	3.39 m^3/h
Potable water	0.41 m^3/h	0.64 m^3/h
Cooling Water	0.63 m^3/h	1.60 m^3/h
Utility Water	0.83 m^3/h	0.83 m^3/h
Demineralized Water	20.0 m^3/h	n/a
Ultrafiltration Reject	0.47 m^3/h	0.05m^3/h
Reverse Osmosis Reject	3.52 m^3/h	0.26m^3/h
HRSG Blowdown	1.5 m^3/h	n/a
Treated Sanitary (sewage) effluent	0.409 m^3/h	0.634 m^3/h
Treated effluent (oily water)	6.86 m^3/h	3.24 m^3/h

Aspect	CCGT Option	OCGE Option
Effluent to be irrigated	7.269 m^3/h	3.874 m^3/h
Evaporative losses	19.96 m^3/h	2.43 m^3/h
Spent/recovered oil (third party contractor)	0.54 m^3/h	0.22 m^3/h
Ion exchange waste stream (third party contractor	0.04 m^3/h	n/a
First Flush pump (capacity)	180 m^3	76.95 m^3
Stormwater/Firewater sump (capacity)	400 m^3	425 m^3
Plant area (clean stormwater)	109 100 m^2	110 000 m^2
Plant area (potentially contaminated water)	60 000 m^2	27 000 m^2
Evaporation Pond (capacity)	28 800 m^2 (356 days)	2450 m^3 (720 days)
Evaporation Pond (desludging)	Annually	Every 2 years

Table of Contents

1.0 INTRODUCTION 14

2.0 DESCRIPTION OF THE KEY PROJECT COMPONENTS 17

2.1 Ancillary Infrastructure 18

2.2 Water and electricity consumption 20

2.3 Temporary Beach Landing Site and Transportation Route Alternative 20

3.0 LEGISLATION 23

4.0 SURFACE WATER ASSESSMENT 24

4.1 Scope of Work 24

4.2 Study methodology 24

4.2.1 Desktop Assessment 24

4.2.2 Stormwater Management Review 24

4.2.3 Water Balance Review 24

4.2.4 Impact Assessment 25

4.2.5 Mitigation and Monitoring 25

5.0 BASELINE CONDITIONS 25

5.1 Regional Description and Local Catchment 25

5.2 Regional Climate 27

5.2.1 Temperature and Precipitation 27

5.2.2 Wind and Storms 27

5.2.3 Evaporation 28

5.3 Hydrology 28

5.4 Flood Modelling 29

5.5 Flow and Water quality 30

6.0 DESCRIPTION OF THE WATER CIRCUITS 31

6.1 Closed Circuit Gas Turbine (CCGT) Option 31

6.1.1 Raw Water 31

6.1.2 Water Treatment 31

6.1.3 Effluent and Wastewater 33

6.1.4 Evaporative Losses 33

6.2 Open Cycle Gas Engine (OCGE) Option 33
6.2.1 Raw Water 33
6.2.2 Water Treatment 35
6.2.3 Effluent and Wastewater 35
6.2.4 Evaporative losses 35
7.0 WATER BALANCE 35
7.1 Criteria to be met 35
7.1.1 Water Management 35
7.1.2 Waste/Effluent Management 36
7.1.3 Environmental Basis 37
7.2 Description of Surface Water Management 38
7.2.1 Water Source 38
7.2.2 Water Treatment 39
7.2.2.1 CCGT Option 39
7.2.2.2 OCGE Option 39
7.2.3 Effluent treatment and Storage Facilities 41
7.2.3.1 Sewage treatment 41
7.2.3.2 Oily water management system 41
7.2.3.3 Evaporation Pond 41
7.2.4 Water Balance Review 41
8.0 STORMWATER MANAGEMENT 43
8.1 Criteria to be met 43
8.2 Description of the Stormwater System 44
8.2.1 Uncontaminated Stormwater 46
8.2.1.1 Plant Area 46
8.2.1.2 Clean Stormwater/Firewater sump 46
8.2.2 Potentially Contaminated/Contaminated Stormwater 47
8.3 Evaluation of stormwater management plan 47
9.0 IMPACT ASSESSMENT 48
9.1 Assessment methodology and rating criteria 48
9.2 Identified impacts - Open Cycle Gas Engines/ Combined Cycle Gas Turbine 50
9.2.1 Construction phase impacts 50

9.2.1.1 Increased Erosion and Runoff Volumes 51
9.2.1.2 Sedimentation in the Govuro River 51
9.2.1.3 Altering of the river banks and bed through the upgrade of the Govuro bridge or Pipe bridge 51
9.2.1.4 Spillage of oils, fuel and chemicals polluting water resources 52
9.2.1.5 Construction camp – Wastewater 52
9.2.2 Operational phase impacts 52
9.2.2.1 Catchment Water Balance 53
9.2.2.2 Impact of Water Supply on River Baseflow 53
9.2.2.3 Irrigation of Effluents 54
9.2.2.4 Spillages from the Evaporation Pond 54
9.2.2.5 Desludging of the Evaporation Pond 54
9.2.2.6 Spills from the First Flush Pump 55
9.2.2.7 Discharge from the Clean Stormwater Sump 55
9.2.3 Decommissioning phase impacts 55
9.2.3.1 Soil Contamination 56
9.2.3.2 Spillage of oils, fuel and chemicals 56
9.2.3.3 Increased Erosion and Sedimentation 56
9.2.3.4 Disturbances to the Govuro River Bed and Banks 56
9.3 Environmental Action Plan – Gas engines/Gas Turbines 58
9.4 Monitoring Programme – Gas engines/Gas Turbines 61
10.0 CONCLUSIONS 64
11.0 REFERENCES 66

TABLES

Table 1: Effluent Standards 37
Table 2: Sanitary (Domestic) Treated Effluent Standards 38
Table 3: Water Quality Requirements for Irrigation 38
Table 4: Comparison of OCGE and CCGT options 42
Table 5: Scoring system for evaluating impacts 48
Table 6: Impact significance rating 49
Table 7: Types of impact 50
Table 8: Potential impacts– construction phase 50
Table 9: Potential impacts related to the operational phase 52
Table 10: Potential impacts related to the decommissioning phase 55

Table 11: Environmental Action Plan 58
Table 12: Monitoring programme 61

FIGURES

Figure 1: Project Location 16
Figure 2: Examples of gas to power plant sites (source: www.industcards.com and www.wartsila.com) 17
Figure 3: Conceptual layout of CTT plant site 18
Figure 4: Typical beach landing site with barge offloading heavy equipment (source: Comarco) 19
Figure 5: Example of large equipment being offloaded from a barge. Note the levels of the ramp, the barge and the jetty (source: SUBTECH) 19
Figure 6: Heavy haulage truck with 16-axle hydraulic trailer transporting a 360 ton generator (source: ALE) ..20
Figure 7: The three beach landing site options and route options at Inhassoro 21
Figure 8: The two main transportation route alternatives from the beach landing sites to the CTT site 22
Figure 9: Govuro River Catchment 26
Figure 10: Occurrences of tropical cyclones in Southern Mozambique from1970 to 2000 (INAM, 2006) 28
Figure 11: The 100 year flood lines for the Govuro River 29
Figure 12: The 100 year flood lines for the Temane Drainage Line 30
Figure 13: Water reticulation diagram of the CTT Plant: CCGT option 32
Figure 14: Water reticulation diagram of the CTT Plant: OCGE option 34
Figure 16: Stormwater System 45

APPENDICES

APPENDIX A
Potable Water Minimum Requirements

APPENDIX B
Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June - Appendix VI - Manual for the Classification and Interpretation of Laboratory Analyses of Soil and Water – for Effluent to be used for Irrigation

ACRONYMS

Acronym	Description
CCGT	Closed Circuit Gas Turbine
CPF	Central Processing Facility
CPI	Corrugated Plate Interceptor
CTRG	Central Térmica de Ressano Garcia
CTT	Central Térmica de Temane
EDM	Electricidade de Mozambique
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
IFC	International Finance Corporation
HRSG	Heat Recovery Steam Generator
MITADER	Ministério da Terra, Ambiente e Desenvolvimento Rural
OCGE	Open Cycle Gas Engine
POC	Potentially Oil Contaminated
PPZ	Partial Protection Zone
RO	Reverse Osmosis
SNE	Sasol New Energy Holdings (Pty) Ltd
UF	Ultrafiltration
WHO	World Health Organization

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 proposes to develop the CTT, which will be 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.

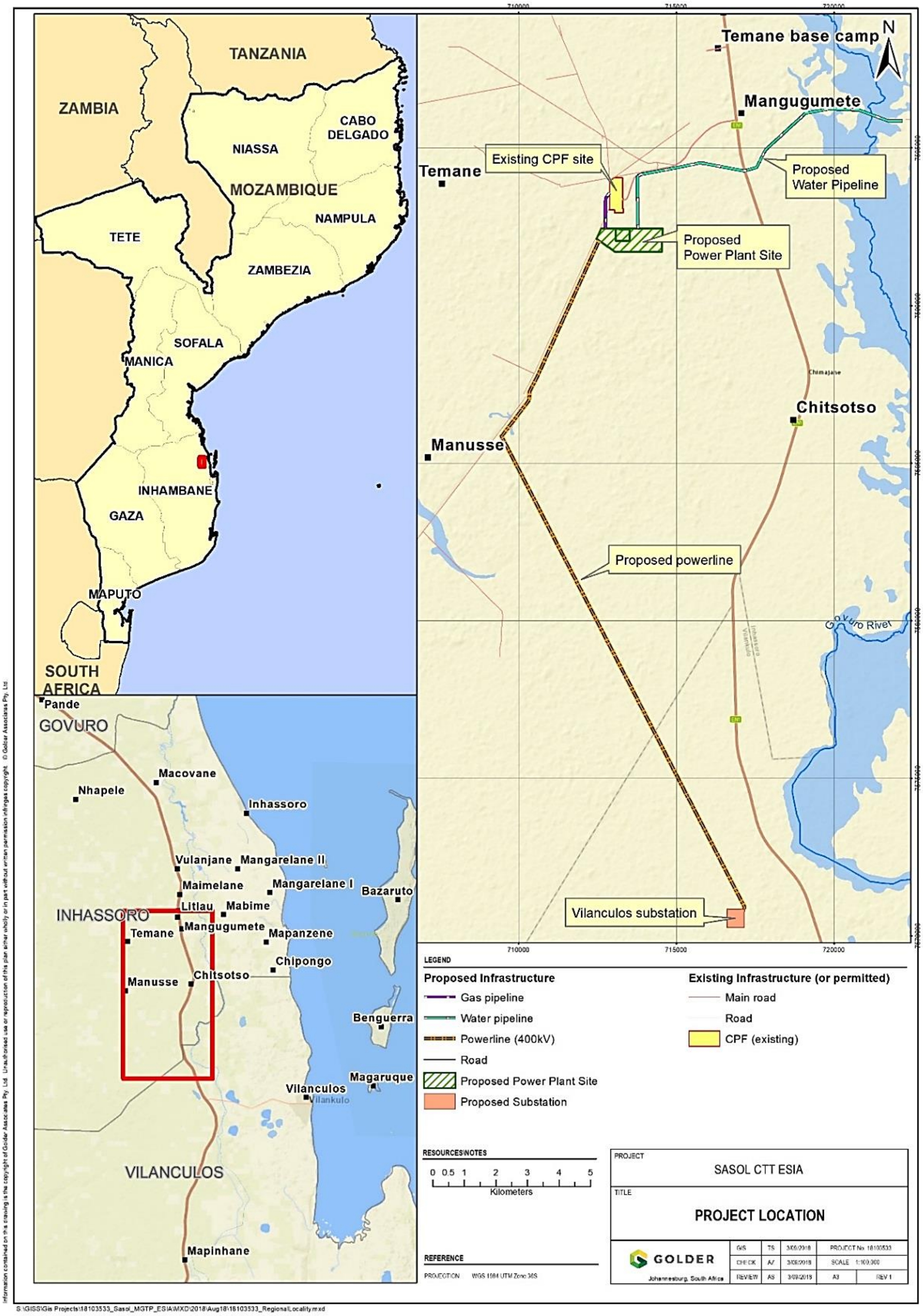

Figure 1: Project Location

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 approximately 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 town for the purposes of delivery of heavy and oversized 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.

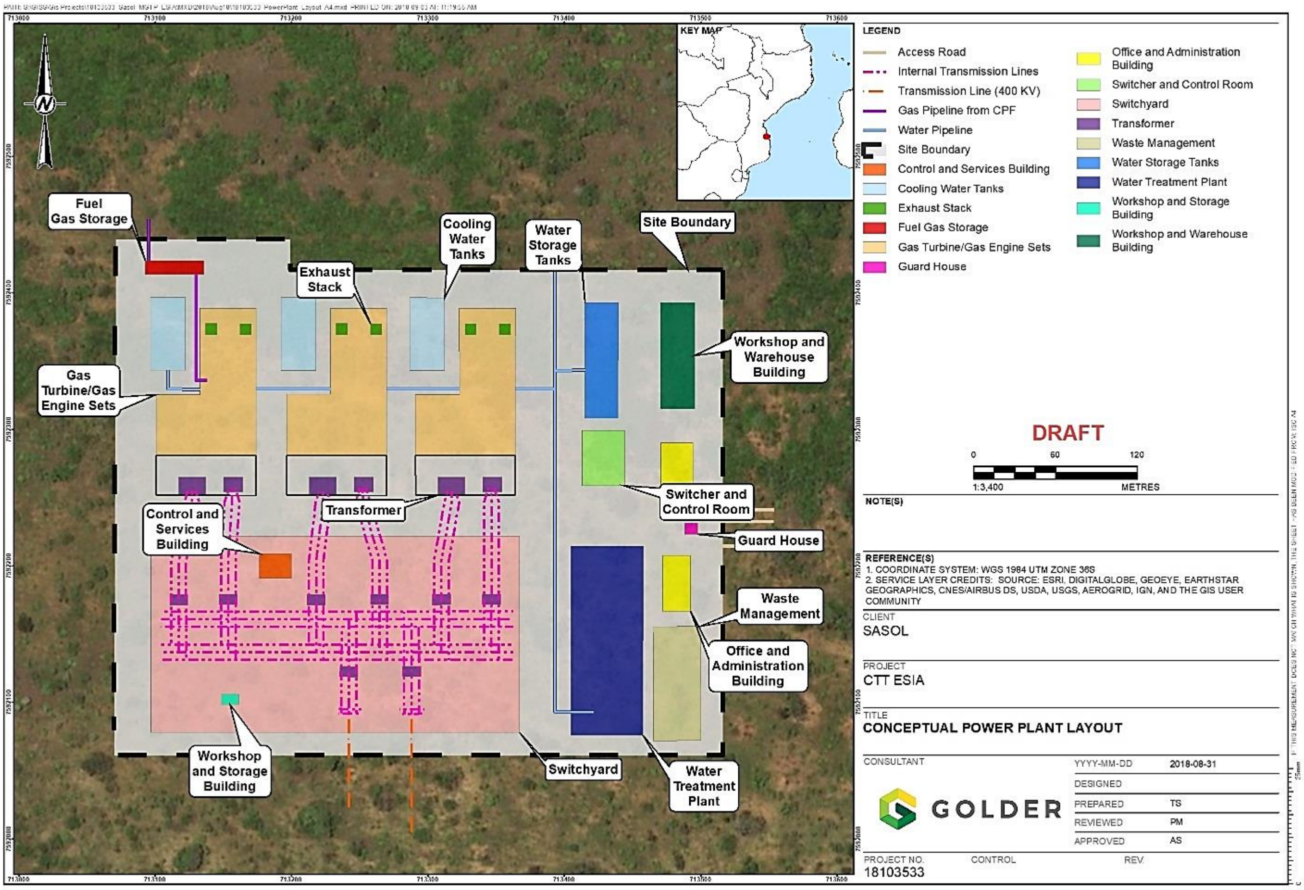

Figure 3: Conceptual layout of CTT plant site

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.

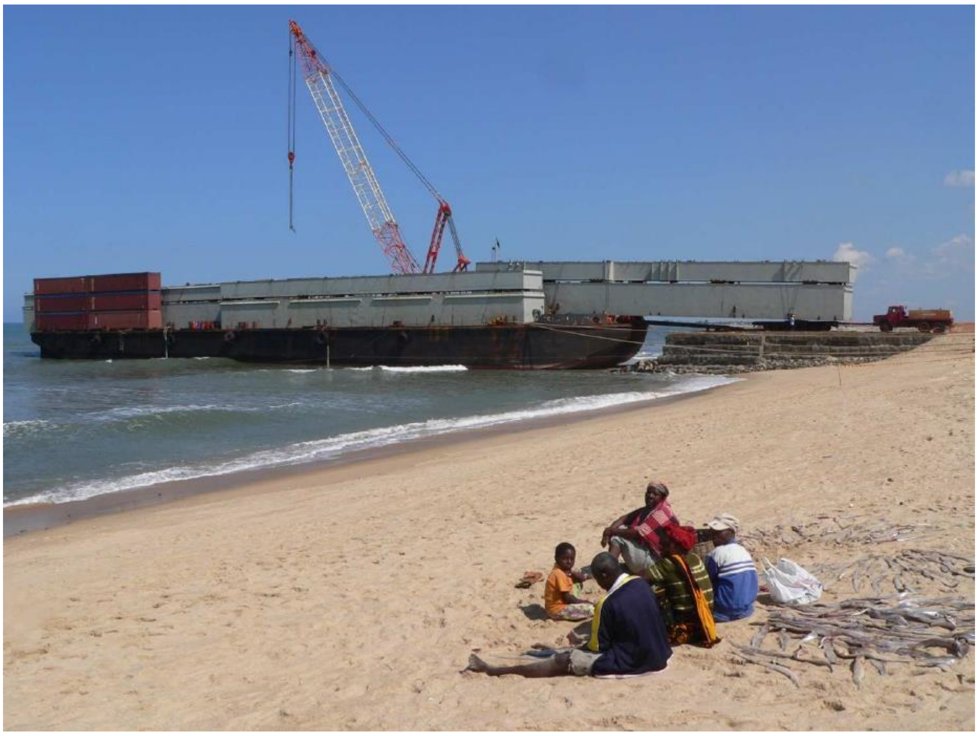

Figure 4: Typical beach landing site with barge offloading heavy equipment (source: Comarco)

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 (assuming the use of one of the identified anchor sites) 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 Grovuro 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

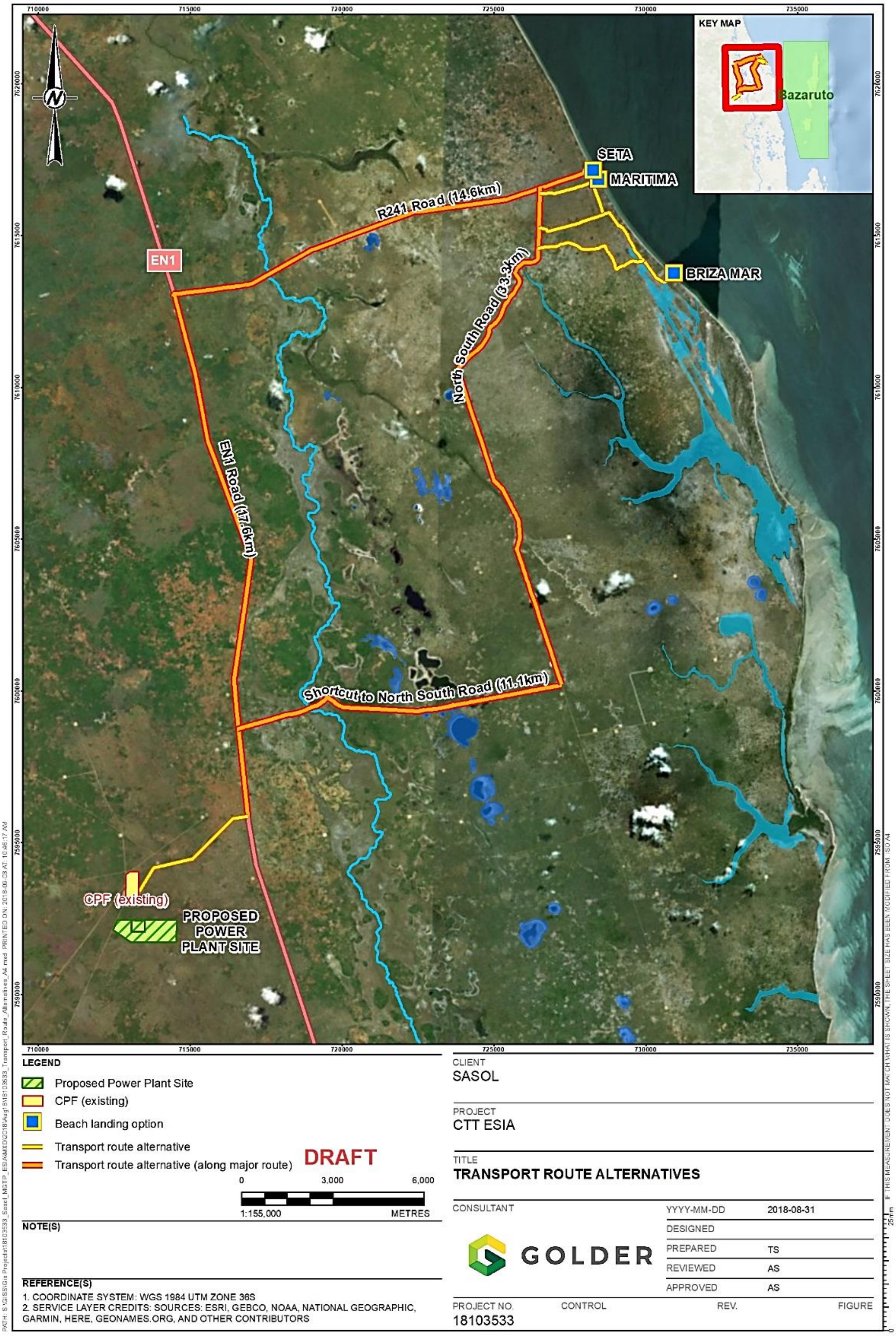

Figure 8: The two main transportation route alternatives from the beach landing sites to the CTT site

3.0 LEGISLATION

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 Surface Water Impact Assessment undertaken to support the ESIA. This study is undertaken in terms of the following relevant legislation as well as the World Bank Group operational policies and general environmental health and safety guidelines. In particular the World Bank Performance Standards (OP 4.03), have been considered and incorporated throughout this assessment.

- Mozambican Legislation:
  - Ministerial Diploma No. 180/2004, dated September 15 – Quality of Water for Human Consumption;
  - Regulation on Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June – Appendix III – Standards of Emission of Liquid Effluents by Industry
  - Regulation on Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June – Appendix IV – Standards of Emission of Domestic Liquid Effluents
  - Regulation on Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June – Appendix VI – Manual for Classification and Interpretation of Laboratory Analyses of Soil and Water
  - Regulation on Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June – Article 12 – Water Quality Parameters for Use of Water
- World Health Organisation:
  - Guidelines for Drinking Water Quality, Fourth Edition, 2011
  - Guidelines for the safe use of waste water, excreta and greywater – Volume 2: Waste water in Agriculture (2006)
- International Finance Corporation:
  - General Environmental, Health and Safety Guidelines for Sanitary Effluent (30 April, 2007)
  - General Environmental, Health and Safety Guidelines for Thermal Power Plants (19 December 2008)
  - Water Effluent Requirements for Irrigation Purposes
  - Performance Standards on Environmental and Social Sustainability. January 2012.

4.0 SURFACE WATER ASSESSMENT

4.1 Scope of Work

The CTT project scope includes the establishment of a gas to power facility at Temane which will produce electricity using natural gas as feedstock. The plant will generate approximately 400-450MW that will be totally exported to the Mozambican National Power Grid. The two technologies being considered include:

- Gas Turbines in Combined Cycle (CCGT)
- Gas Engines Open Cycle (OCGE).

The baseline scope of the surface water impact assessment includes a review of water and effluent management and related infrastructure in terms of two different technology options that are currently being considered for the power generation component. As a greenfield site, the surface water conditions are assessed according to the technical and environmental basis of design in order to determine the suitability of the design of water infrastructure, the possible impacts to the receiving environment and to inform the water management required for the project operation.

The surface water assessment addresses the following, for the two technology options:

- Description of the surface water baseline conditions;
- Review of the water balance for the facility to assess water storage availability and supply;
- Review of the stormwater management system against the design criteria;
- Assessment of surface water impacts during the construction, operational and decommissioning phases; and
- Recommended mitigation and monitoring measures.

4.2 Study methodology

4.2.1 Desktop Assessment

The baseline study undertaken in 2014 and the 2018 update provided the majority of the surface water resources and climate baseline information, while the CTT project Configuration Study undertaken in 2014 provided the technical study information that informed the impact assessment.

4.2.2 Stormwater Management Review

The proposed stormwater system for the plant was derived from the CTT project Configuration Study (2014) and reviewed against design criteria for both power generation components, *viz*. gas turbines and gas engines.

4.2.3 Water Balance Review

Based on the technical and environmental design basis provided by the CTT project Configuration Study (2014), this review of the water balance for the gas turbines and gas engines technologies included:

- Compilation of a water balance schematic of the water system based on the proposed reticulation system, stormwater routing and the inputs and outputs from the plant water circuit;
- Assessment of the envisaged operational scenario to:
  - Understand the reticulation and balance; and
  - Determine spill frequencies and discharges from the various impoundments/circuits.

4.2.4 Impact Assessment

An impact is essentially any change (positive or negative) to a resource or receptor brought about by the presence of the project component or by the execution of a project related activity.

The purpose of impact assessment is to identify and evaluate the likely significance of the potential impacts on identified receptors and natural resources according to defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise, reduce or compensate for any potential adverse environmental effects and to report the significance of the residual impacts that remain following mitigation.

The evaluation of baseline data gathered during desktop and field studies provides information for the process of evaluating and describing how the project could affect the surface water environment. Assessment of impacts on the surface water environment is undertaken using an Impact Assessment Matrix in terms of the requirements, which provides a quantitative indication of the severity of an impact prior to and following mitigation. The approach adopted for assessing the significance and rating of impacts identified for the proposed CTT project is detailed in Section 9.1.

4.2.5 Mitigation and Monitoring

Based on consideration of the findings of the impact assessment with regards to the potential of future surface water impacts, mitigation actions and monitoring are proposed.

5.0 BASELINE CONDITIONS

This section describes the current (pre-project) surface water conditions in the study area, also referred to as the “baseline”. It is important to describe and understand the baseline before making an evaluation of the potential impacts of the proposed project on the surface water environment.

5.1 Regional Description and Local Catchment

The proposed CTT plant site is situated in the Inhambane Province, within the Govuro River catchment. The site includes the Temane gas field and CPF. The site is 20 km from the coast and at an elevation of approximately 30 mamsl. The surrounding topography is relatively flat and dips gently towards the Govuro River which is approximately 8 km to the east of the proposed project site.

The Govuro River meanders for a distance of approximately 200 km from its origin in the lake land near the town of Pomene at the point (Ponta de Barra Falsa), to its mouth at Bartholomew Diaz Point, 130 km north of Vilanculos. The river flows in a predominantly northerly direction, parallel to the coastline and due to its proximity to the coast, most of its catchment is located on its western bank, with only a very narrow strip of catchment between the river and the ridges towards the east.

The Govuro River flows along the project area from South (Pambarra) to North to Macovane (South of Nova Mambone) in the Inhassoro District. The Govuro is considered to be one of the most important rivers in the northern part of the province, as north of Mapinhane, the river is considered to be a perennial river. This river has few tributaries and the most important of these are Sili, Nhavuo and Manhale.

The Govuro River catchment is covered with coastal dunes in the eastern area and in the western area by sand layers. The catchment is confined to the coastal plain and is associated with dune and limestone aquifers. The basin drains into mangrove swamps in the Govuro River estuary. Parallel to the Govuro River is a north-south oriented chain of small coastal barrier lakes. Patches of seasonal and permanent wetlands are also found in the eastern margin of Govuro. The average slope of the Govuro River is approximately 0.2%.

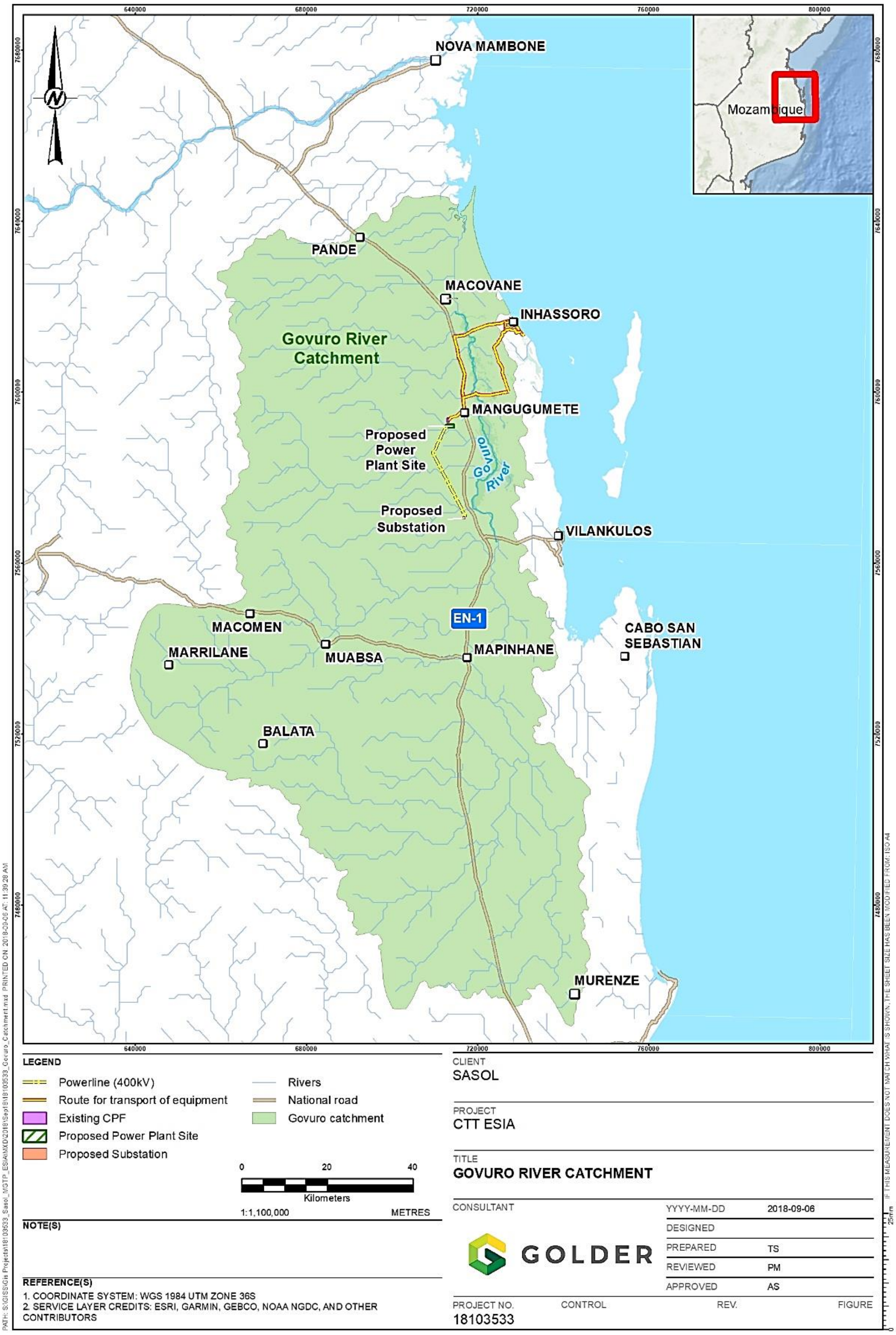

Figure 9: Govuro River Catchment

A wide variety of aquatic and wetland habitats are present in the eastern Govuro area. These areas are considered sensitive habitats. In this area several seasonal streams occur in the rainy season, which feed the coastal lakes and the wetlands. These are used by local communities for consumption and agriculture. Inhabitants in the area primarily use surface water for domestic purposes. The water resource is abundant in summer, however becomes constrained in winter. Due to the seasonality of the surface water resources, groundwater is the main source of water in the project area. Water quality of the Govuro River is considered to be good as it is currently unaffected by significant abstraction or effluent discharge (Coffey, 2014).

5.2 Regional Climate

The CTT Project site area falls within a sub-tropical climate. The climate in this region is moderately humid with annual rainfall dominated by two climate systems namely the Indian Ocean Subtropical Anticyclone System and the East African Monsoonal system. The rainy season is in summer (October to March), with winds and frequent thunderstorms. The summers are warm, often with high humidity. The winters are mild and dry. Rainfall is more abundant along the coast.

5.2.1 Temperature and Precipitation

Minimum temperatures in the area average between 14.2 ºC in winter and 23.5 ºC in summer, and the average maximum temperatures range from 25.2 ºC in winter to 30.9 ºC in summer. The mean annual temperature of 24 ºC and the relative humidity is fairly constant ranging from a low of 70% during October to a high of 80% in January.

The catchment rainfall has seasonal variability during the year with an average annual precipitation in the order of 800mm (inland) to 1000 mm (in the coastal area). The wet season lasts from November to April, *i.e*. the warmer months, with 71% of annual rainfall occurring during these months. Annual and monthly rainfall varies from month to month and year to year, strongly influenced by the variation in wind and sea surface temperatures. Annual average rainfall at the CTT project site is 851mm, with the maximum recorded in a 24 hour period being 370mm (Sasol, 2014). Due to cyclones in this part of the country, extreme annual rainfall has been up to 1,130 mm (recorded in 2014), nearly 48% higher than the annual average.

The average annual precipitation recorded at the Temane weather station (the CTT site) between 2010 and 2018 is 848mm, with a mean annual temperature of 24.27ºC.

5.2.2 Wind and Storms

The project area is influenced by the Indian Ocean Anti-cyclonic Zone. In the Vilanculos and Inhassoro region, winds are predominantly from the southern to eastern quadrants and strengthen in the afternoon. Between January and August, winds are predominantly from the south while the predominant wind direction between September and December is from the east. Average wind velocity is 2.88 m/s.

During January/February the northern and central part of Mozambique is typically subject to cyclonal weather. The cyclones generate strong storms and heavy rainfall followed by strong winds, with speeds of up to a 100 km/h or more (Golder, 2018). The area in Temane is prone to cyclone activities (4 to 5 per year) (Figure 10. During the period from 1975 to 2008, the region was hit by several cyclones and tropical storms of different magnitude. The cyclone season in this region extends from December to March, peaking in December and January, and typically resulting in seasonal flooding.

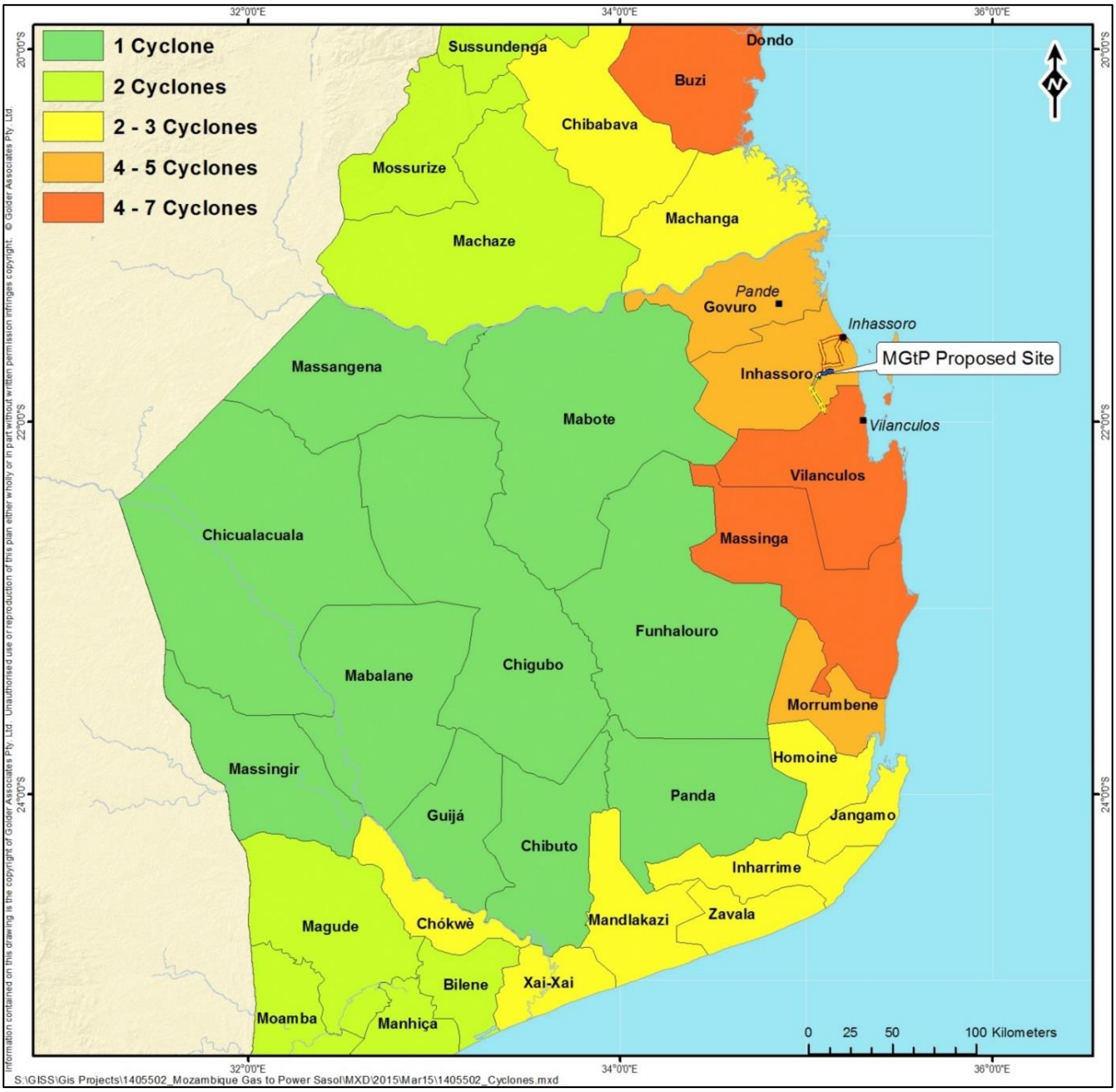

Figure 10: Occurrences of tropical cyclones in Southern Mozambique from1970 to 2000 (INAM, 2006)

5.2.3 Evaporation

Potential evaporation as a climatic parameter is not available for Mozambique. A study undertaken by the National Institute of Agronomic Investment in Maputo, Mozambique to determine spatial distribution of climatic parameters in order to understand climatic zones for crop production, calculated the evapotranspiration in Inhambane using the Penman Monteith equation to be 1300mm/annum (Reddy, 1984).

5.3 Hydrology

The Govuro River has a catchment of 11 169 km^2 of which almost all locates to the west of the river, with only short drainage channels flowing from the east. Most of the catchment to the west of the river is governed by rifting, *i.e*. the southern limits of the Great African Rift Valley, and these low-lying rifts disturb the normal surface run-off towards the Govuro River by intercepting and attenuating the surface run-off. For this reason, most of these drainage channels are ephemeral and only flow during extreme rainfall conditions. The bulk of the catchment of the Govuro River being comprised of Bushveld vegetation.

The catchment is fairly rounded and storm events with comparatively short times of concentration will produce the maximum flood peaks. This however, is only true for large storms, *i.e*. storms having return periods of 50- to 100-years. Due to the ephemeral nature of most of the streams in its western catchment, smaller storms will be attenuated, and/or the water would simply be absorbed by the soil and geological formations covering this catchment (Coffey, 2014).

The Govuro catchment area encompasses two distinct drainage areas. The eastern drainage area is located east of the Govuro River. This area will typically drain towards the immediate coastal line south of Inhassoro. The drainage and surface flows of the western drainage area (includes the CTT site area) primarily located west of the EN-1 national road will be slow and drain typically towards the Govuro River.

5.4 Flood Modelling

Flood modelling was done on the Govuro River and the Temane Drainage Line during the feasibility phase (Coffey, 2014). A series of storms with return periods of 100 years were modelled. In the case of the Govuro River, a 14-hour storm (*i.e*., a storm with a time of concentration of 14 hours) produced the highest peak flow. The discharge was 3 262 m^3/s for the 100-year recurrence interval. For the Temane drainage line a 4-hour storm produced the highest discharge *i.e.* 322.4 m^3/s for the 100-year flood line. The effect of the oceans and its tides on the flood line elevations of the Govuro River was also assessed.

The floodline determination study found that the 100-year flood in the Govuro River will not reach the proposed CTT site, and the floodwaters will not come closer than ~5km to the site, and thus will not impact on the CTT Project infrastructure. There will be a vertical elevation difference between the 100-year flood line and the ground level at the entrance gate of the Temane CPF of ~12.0m. This elevation difference should be sufficient to also ensure that even if a 100-year flood occurs together with an onshore ocean surge or a very high ocean tide (which has a probability of occurring every 19 years), the proposed site will still be higher than the 100-year flood lines of the Govuro River (Coffey, 2014). The 100-year flood lines are shown in Figure 11 and Figure 12.

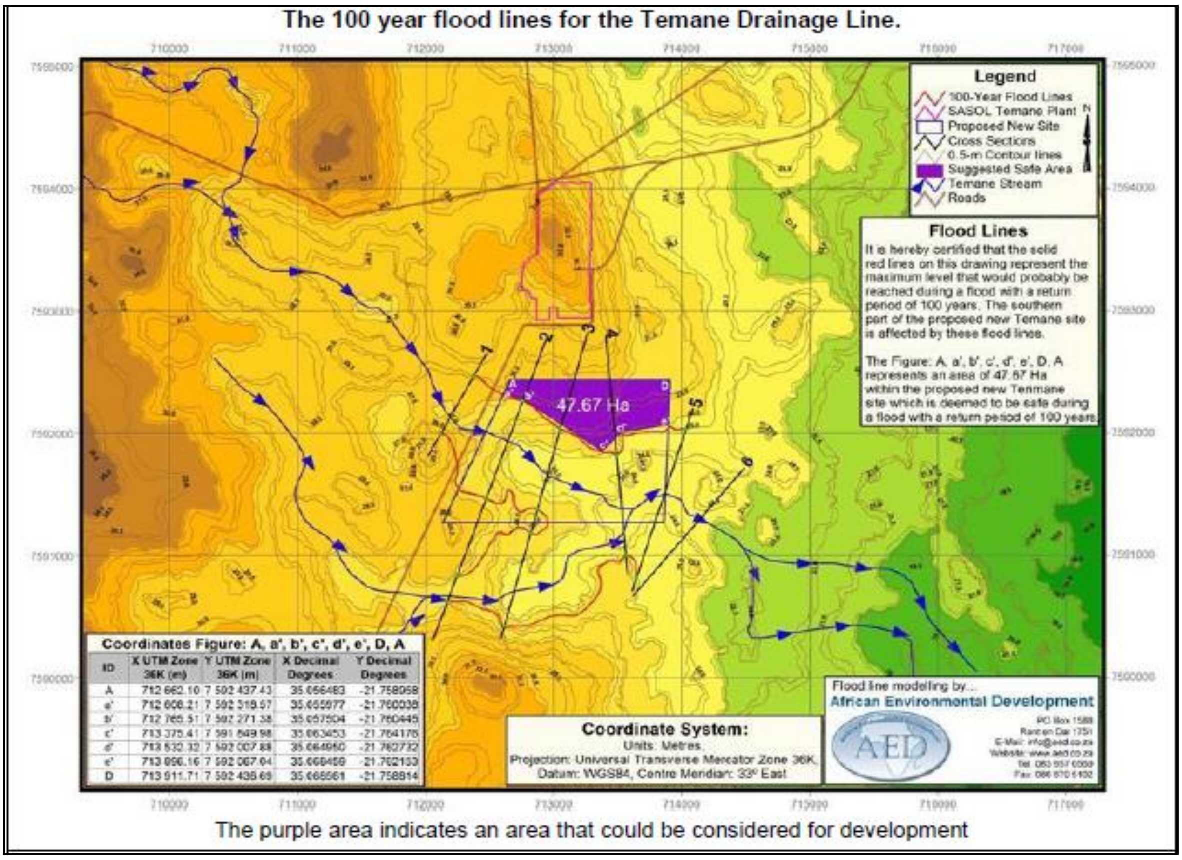

Figure 11: The 100 year flood lines for the Govuro River

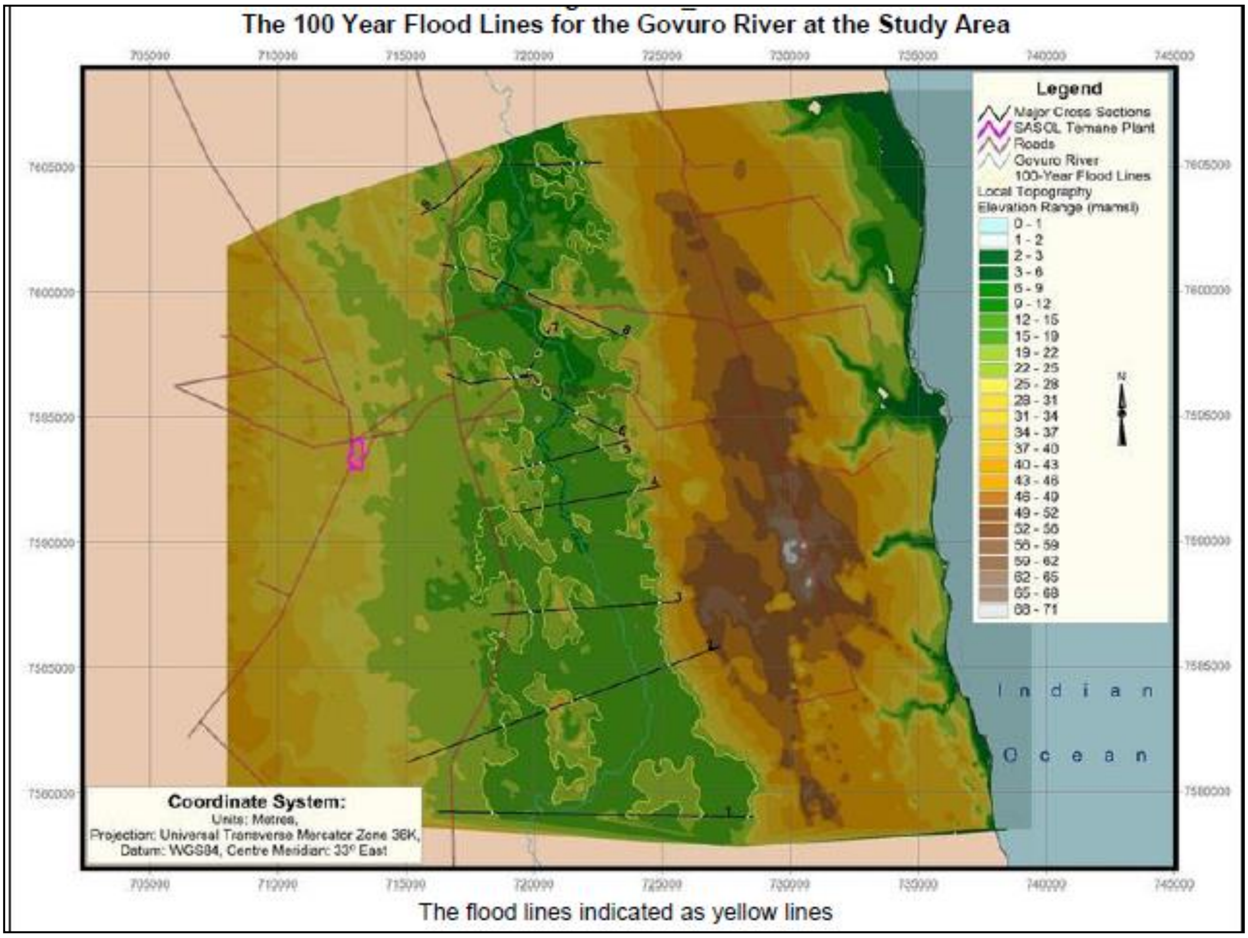

Figure 12: The 100 year flood lines for the Temane Drainage Line

5.5 Flow and Water quality

Based on recordings at a flow station close to its source, the average annual flow of the Govuro River is 121 Mm^3/yr. Hydrometric station data shows that water levels can vary between 0.5m to 3m in a year. The maximum registered daily average flow was 26 m^3/s (AED, 2014).

In terms of the surface water baseline study (2014 and 2018 update), the analysis of the data of the present state of the water in the Govuro River reflects that quality of the water is good. Compliance was assessed against WHO, IFC and Mozambican standards as well as South African water quality guidelines. The water quality is indicative of a fairly natural state with relatively low concentrations of most water quality parameters assessed.

Most inorganic parameters are within guideline limits, the trace metals present are compliant with Mozambican effluent/discharge standards and the pH of the water is within the acceptable guidelines and can be described as slightly basic. The nutrient (nitrate and ortho-phosphate) concentrations in the river are low. The Govuro River water is typical of hard water (>300mg/l). However, salinity levels are elevated and increase along the river towards the lower reaches. While the source of raw water for the CTT plant will be groundwater, increasing salinity and total hardness of the Govuro River would be factors for consideration should it be considered as a supplementary water source.

6.0 DESCRIPTION OF THE WATER CIRCUITS

With an understanding of the baseline biophysical environment, it is also necessary to understand the water system at the proposed CTT project site, in order to determine what the impacts would be. The section describes the water circuit of the proposed CTT project, for the two technology options.

The water reticulation for the CTT plant for the CCGT option is shown in Figure 13 and for the OCGE option is shown in Figure 14. The reticulations for the two options are described below:

6.1 Closed Circuit Gas Turbine (CCGT) Option

Natural gas fed through from the CPF is heated and sent to each gas turbine. The gas turbine burners shall be of dry cooling type operating with or without steam or water to control emissions. Exhaust flue gases from the gas turbine will be cooled through the Heat Recovery Steam Generators (HRSG) which will recover heat from the exhaust of the gas turbine. The heat recovery steam generators will use hot make up demineralised water to generate steam that will be converted to electrical power via the gas turbine and generator.

The water quality is controlled by the injection of suitable chemicals and by blowing down a small quantity of boiler water. Cooling water blow down will report to a waste water treatment facility.

6.1.1 Raw Water

The raw water treatment system provides the following qualities of water:

- Filtered water;
- Potable water;
- Utility water;
- Demineralised water;
- Fire Fighting.

Raw water quantity required is 25.9 m^3/h.

6.1.2 Water Treatment

With the exception of utility water (0.83 m^3/h) raw water will require treatment for use as follows:

- Potable water: 0.41 m^3/h;
- Top up for closed loop cooling systems: 0.63 m^3/h; and
- Demineralised water for boiler feed water: 20 m^3/h.

CCGT: Option 1 (Gas Turbines)

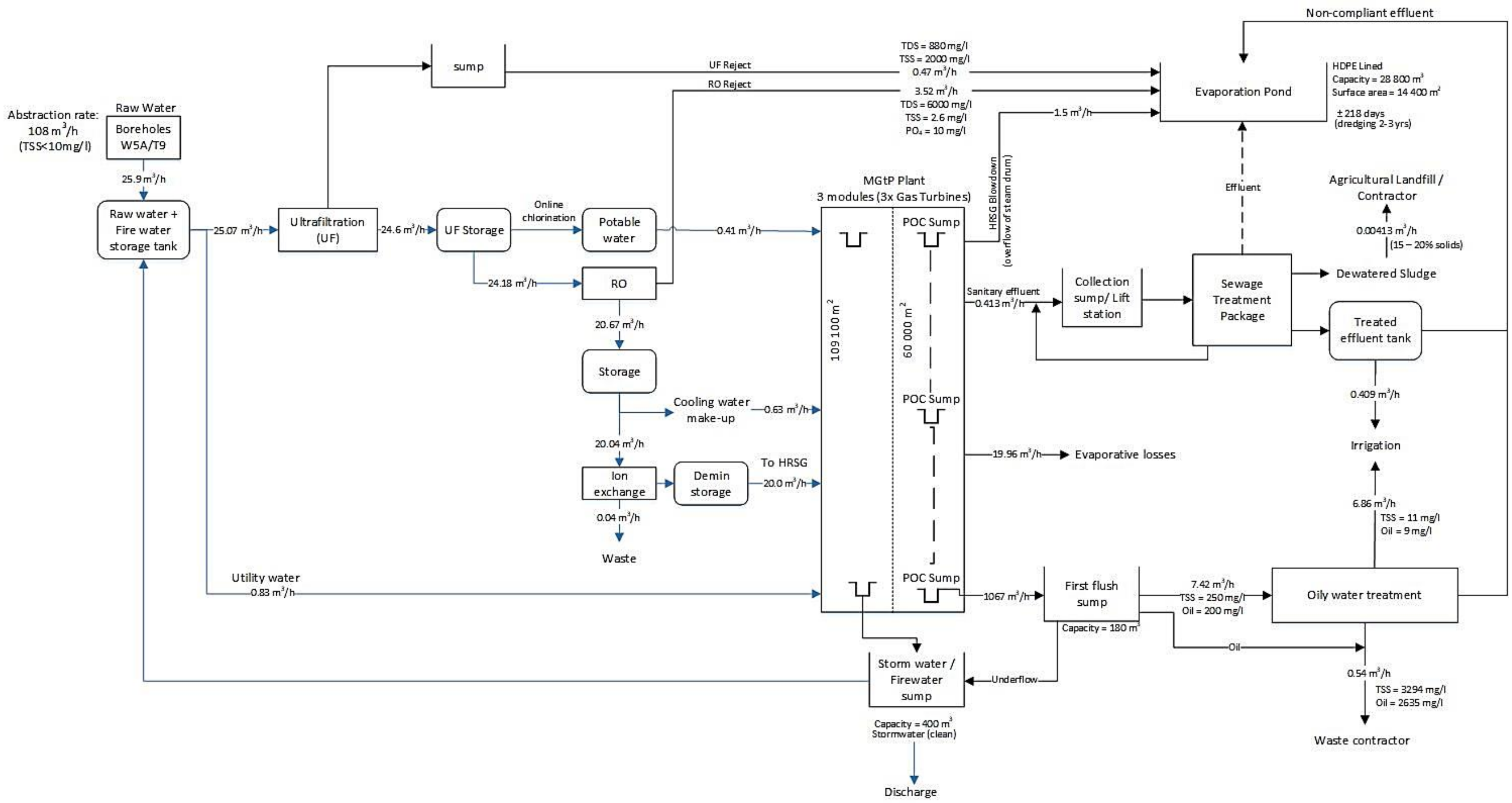

Figure 13: Water reticulation diagram of the CTT Plant: CCGT option

Treatment processes will include:

- Potable water – ultrafiltration and chlorination;
- Cooling water – ultrafiltration and reverse osmosis (permeate of 44 mg/l TDS); and
- Demineralized water – ion exchange.

6.1.3 Effluent and Wastewater

The following types of liquid effluent are produced by the CTT plant:

- Ultrafiltration (0.47 m^3/h) and RO reject (3.52m^3/h);
- HRSG boiler blow down (1.5m^3/h);
- Ion exchange regenerate (0.04m^3/h);
- Sewage effluent (0.413 m^3/h);
- Oily water from rain water, fire water or wash down at potentially oil contaminated areas (6.86 m^3/h); and
- Spent Oil (0.54 m^3/h).

The ultrafiltration and RO reject and HRSG blowdown will report to an evaporation pond on the plant site. The ion exchange waste stream, spent oil and recovered oil from the oily water will be handled by a third party waste contractor. The oily water will be treated and the effluent irrigated or disposed of in the evaporation pond. The sewage will be treated through a sewage treatment package plant.

6.1.4 Evaporative Losses

The evaporative losses for the CCGT option is estimated to be 19.96 m^3/h.

6.2 Open Cycle Gas Engine (OCGE) Option

The process for the gas engine configuration requires that the natural gas from fed through from the CPF is heated and sent to each gas engine. The gas engines are equipped with water and oil radiator coolers. Lubrication oil is used to primarily lubricate, but also to cool the engines. The engine options does not include a heat recovery system. Water quality is not as critical as with the gas turbines therefore the demineralization unit is not required. Since the heat recovery steam generators and steam turbine is not required, water quantities are much lower than for gas turbines. The main water use in the process is for gas engine cooling.

6.2.1 Raw Water

The raw water treatment system provides the following qualities of water:

- Filtered water;
- Potable water;
- Utility water;
- Fire Fighting; and

Raw water quantity required is 3.39 m^3/h.

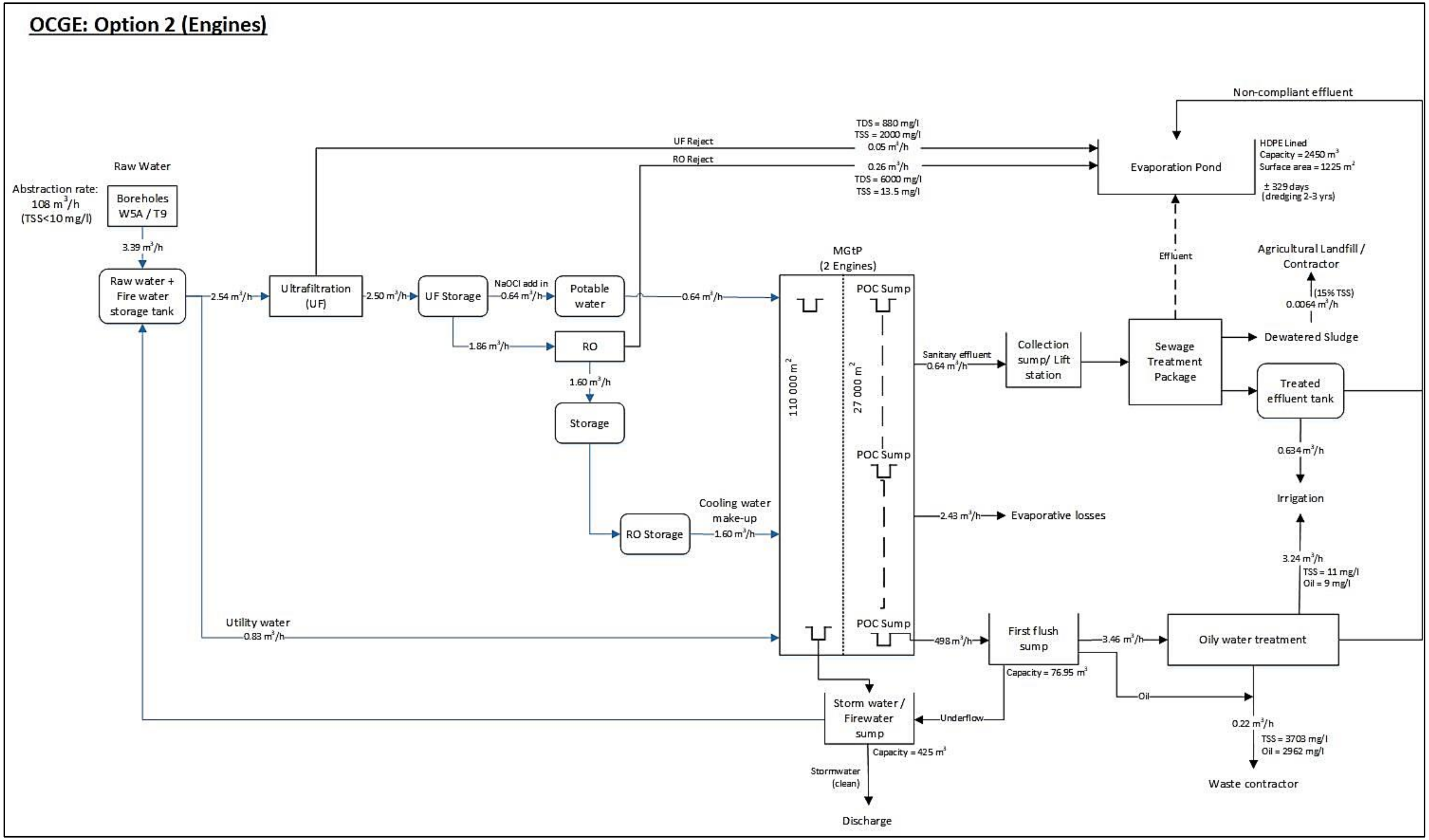

Figure 14: Water reticulation diagram of the CTT Plant: OCGE option

6.2.2 Water Treatment

With the exception of utility water (0.83 m^3/h) raw water will require treatment for use as follows:

- Potable water: 0.64 m^3/h;
- Top up for closed loop cooling systems: 1.60 m^3/h; and
- Utility water: 0.83 m^3/h.

Treatment processes will include:

- Potable water – ultrafiltration and chlorination; and
- Cooling water – ultrafiltration and reverse osmosis (permeate of 44 mg/l TDS).

6.2.3 Effluent and Wastewater

The following types of liquid effluent are produced by the CTT plant:

- Ultrafiltration (0.05 m^3/h) and RO reject (brine) (0.26m^3/h);
- Sewage effluent (0.64 m^3/h);
- Oily water from rain water, fire water or wash down at potentially oil contaminated areas (3.24 m^3/h); and
- Spent Oil (0.22 m^3/h).

The ultrafiltration and RO reject (brine) will report to an evaporation pond on the plant site. The spent oil and recovered oil from the oily water will be handled by a third party waste contractor. The oily water will be treated and the effluent irrigated or disposed of in the evaporation pond. The sewage will be treated through a sewage treatment package plant.

6.2.4 Evaporative losses

The evaporative losses for the OCGE option is estimated at 2.43 m^3/h.

7.0 WATER BALANCE

The CTT Phase 0 (Setup) and Phase 1 Configuration Study (2014) has provided the Design Basis and Philosophies and the Environmental Design Basis for the project. The general philosophy is that the facility will be self-sufficient in so far as utility supply and effluent treatment is concerned.

Of specific relevance to the surface water assessment, the water (utilities) process system and the waste/effluent management of the CTT project are applicable.

7.1 Criteria to be met

7.1.1 Water Management

- Raw bulk water supply will be sourced from boreholes and treated accordingly – required for cooling water, demineralised water and potable water
- Rainwater will be harvested and used during the rainy season (off-set to borehole supply).
- Stormwater will be captured and stored in a raw water tank and reused and recycled as far as possible. Borehole pumping will cease during periods when raw water source/fire water is supplemented by stormwater.
- Cooling of gas engines/gas turbines require treated and filtered water of stringent water quality.

- Fire water system to meet required provisions relating to design, operation, maintenance, pumping, storage and installations.
- Potable water to be made available via the raw water treatment plant to meet required human consumption specifications.
- Service water available once weekly to wash down floors to be drawn off prior to fire water tank.
- Demineralised water will be used for the cooling in the gas and steam turbine.
- Water cooling will be used as an alternate when air cooling is not possible.

7.1.2 Waste/Effluent Management

- Oily water:
  - Intermittent system, resulting from cleaning of gas engines/turbines
  - All areas of possible oil leakage must be bunded.
  - An oily water separator will be used to treat the contaminated 'stormwater'/service water stream to reduce volume of oil to be cleaned/recycled.
  - Oil that cannot be recycled will be collected in an oil tank for removal by a waste contractor.
- Treated Effluent:
  - The water phase of the oily water separation should adhere to the effluent quality standards as defined by the environmental design basis.
  - Option for the treated effluent to be used for irrigation (on site watering) subject to approval of the ESIA by the Mozambican government.
- Used oil (organic effluent) will have to be stored in a dedicated tank and removed by a waste contractor
- Stormwater:
  - Rainwater from the roofs of the plant buildings will be captured and fed into the raw water tank.
  - Uncontaminated stormwater will run off into the environment.
  - Contaminated stormwater must be contained, treated and analysed before release.
  - Volumes greater the $20m^3$ will need to be treated via the oily water system.
- Domestic Sewage:
  - to be pumped to a sewage treatment facility
  - treated domestic sewage effluent to conform to the environmental design basis criteria with the option to be used for site irrigation or discharge to the evaporation pond pending the approval of the ESIA by the Mozambican government.
  - Sludge to be stabilized with the option to be used for agricultural application subject to approval from the Mozambican government
- Spent Demineralized Regenerate Rinse water, Regenerate Chemicals and Ultrafiltration Reject:
  - Evaporation Pond will be used to store ultrafiltration reject, spent rinse and chemical water.

- Dredging out of pond every 2 to 3 years pending building up of sludge and salts is required that would need to be disposed of by a waste contractor.

7.1.3 Environmental Basis

The following standards are applicable to water and effluent management and will dictate the design standards of the various utilities.

- Potable Water Minimum Requirements (see APPENDIX A): The strictest between the WHO Drinking Water Quality Annex 3 – Table A3.3 requirements and the drinking water requirements from the Mozambique Ministerial Diploma No 180/2004
- Organic Effluent (Used Oil): The waste contractor must be certified to adhere to Mozambican legislation in terms of treatment and disposal.
- Treated Effluent (Organic Wastewater) – Effluent Quality Standards (Table 1): Strictest between the Mozambican Regulation on Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June – Appendix III – Standards of Emission of Liquid Effluents by Industry and the IFC General Environmental, Health and Safety Guidelines for Thermal Power Plants (19 December 2008).

Table 1: Effluent Standards

Components	Units	Guidelines for direct discharges
pH		6 - 9
Temperature increase	ºC above ambient temperature of receiving water	<= 3*
Oil, grease and fats	mg/l	10
Total Suspended Solids (TSS)	mg/l	50
Chlorine (Cl)	mg/l	0.2
Arsenic (As)	mg/l	0.5
Cadmium (Cd)	mg/l	0.1
Chromium (VI)	mg/l	0.5
Copper (Cu)	mg/l	0.5
Iron (Fe)	mg/l	1
Lead (Pb)	mg/l	0.5
Mercury (Hg)	mg/l	0.005
Zinc (Zn)	mg/l	1
Heavy metals (total)	mg/l	Note*

* Site specific requirements to be established by the Environmental License (EL).

- Domestic Sewage Effluent: Sanitary Effluent Standards (Table 2) Strictest between the Mozambican Regulation on Environmental Quality Standards and Effluent Emission - Decree No. 18/2004 of 2 June –

Appendix IV – Standards of Emission of Domestic Liquid Effluents and the IFC General Environmental, Health and Safety Guidelines for Sanitary Effluent (30 April 2007).

Table 2: Sanitary (Domestic) Treated Effluent Standards

Component	Units	Standards
pH		6 - 9
Temperature increase	ºC above ambient temperature of receiving water	35
Bio-chemical Oxygen Demand (BOD)	mg/l	30
Chemical Oxygen Demand (COD)	mg/l O_2	125
Oil and grease	mg/l	10
Total Suspended Solids (TSS)	mg/l	50
Total Nitrogen (total)	mg/l	10
Total Phosphorus (P) (total)	mg/l	10 (3 - in sensitive zones)
Coliform bacteria (total)	MPN/100ml	400
Colour, odour		1:20 dilution (Presence : Absence)

- Inorganic Wastewater: Discharges from the evaporation pond must meet the effluent quality standards (Table 1).
- Irrigation: Requirements applicable to the irrigation of water (Table 3) - Mozambican Regulation on Environmental Quality Standards and Effluent Emission - Decree No. 18/2004 of 2 June – Article 12 – Water Quality Parameters for Use of Water. Additional recommended intervals and water classification as per Appendix VI of Decree No. 18/2004 - Manual for the Classification and Interpretation of Laboratory Analyses of Soil and Water also apply for effluent to be used for irrigation (see APPENDIX B).

Table 3: Water Quality Requirements for Irrigation

Component	Units	Standards
Total Dissolved Solids	mg/l	<500
Bacteria	per 100ml	<= 100000 (total)

7.2 Description of Surface Water Management

Based on the water reticulation of the CCGT and OCGE technology systems described above, the management of the surface water for the CTT project will be undertaken as follows.

7.2.1 Water Source

Raw water will be supplied from aquifers in the area and treated accordingly. Two boreholes of differing water quality and abstraction rates are currently being considered as the source of raw water to the CTT site, T9 and W5A (Figure 15). Borehole T9 in an alluvial aquifer, delivers good quality water similar to the quality of the Govuro River, but is located about 12 km from the site on the east bank of the Govuro River (total dissolved salts of 140 mg/l). Borehole W5A in the same vicinity of the CPF, approximately 2 km from the proposed CTT site, delivers water from the karst aquifer. However the water is very hard and water quality has elevated concentrations of the macro ions with high total dissolved salts and electrical conductivity (880 mg/l and 156 mS/m respectively) (Coffey, 2014). Borehole W5A has a sustainable abstraction rate of 20 l/s and borehole T9 a sustainable abstraction rate of 6.2 l/s.

Raw water sourced from borehole W5A is of poorer quality and would result in increased volumes of brine, but is close to the CTT plant requiring less piping and pumping costs. Raw water from borehole T9 is of much better quality resulting in less brine, but increased costs to pump and pipe to the plant site.

The selected borehole (water source) will be used to supply either of the two technology options. Raw water is pumped directly to the combined Raw Water / Fire Water reservoir tank. Due to the low suspended solids content (<10 mg/l) the raw water does not require filtration.

The CCGT option requires a water supply of 25.9m^3/h and the OCGE option has a requirement of 3.39 m^3/h. Clean stormwater harvested will be used to offset borehole water supply.

7.2.2 Water Treatment

7.2.2.1 CCGT Option

From the raw water tank (25.9 m^3/h) water is pumped to the ultrafiltration unit as a pre-treatment step for the reverse osmosis (RO) unit. During ultrafiltration suspended solids and bacteria are filtered out. The permeate from the ultrafiltration serves as the feed (0.41m^3/h) to a chlorination step to produce potable water and it also feeds (24.18 m^3/h) the RO unit. The ultrafiltration backwash is collected in a sump and pumped to the evaporation pond (0.47m^3/h)

The RO is a 2 stage RO unit. It reduces the TDS content by 90% to 95% per stage and results in a permeate with approximately 4 mg/l TDS. The permeate (20.04m^3/h) from the RO unit is pumped to the ion exchange unit. Brine reject (3.52 m^3/h) from the RO unit is pumped to the evaporation pond.

A mixed bed polishing ion exchange is the last step in the process for the CCGT option. The required boiler feed water quality (demineralised water) is produced for use in the heat recovery steam generators (HRSG) (20.0 m^3/h) in the plant, with a waste stream of 0.04m^3/h being generated.

7.2.2.2 OCGE Option

From the raw water raw water tank (3.39 m^3/h) water is pumped to the ultrafiltration unit as a pre-treatment step for the reverse osmosis (RO) unit. During ultrafiltration suspended solids and bacteria are filtered out. The permeate from the ultrafiltration serves as the feed (0.64 m^3/h) to a chlorination step to produce potable water and it also feeds (1.60 m^3/h) the RO unit. The ultrafiltration backwash is collected in a sump and pumped to the evaporation pond (0.05m^3/h)

The RO is a single stage RO unit. It reduces the TDS content by 90% and results in a permeate with approximately 44 mg/l TDS. This meets the requirement for water to be used in the closed circuit cooling loop. Brine reject (0.26 m^3/h) from the RO unit is pumped to the evaporation pond.

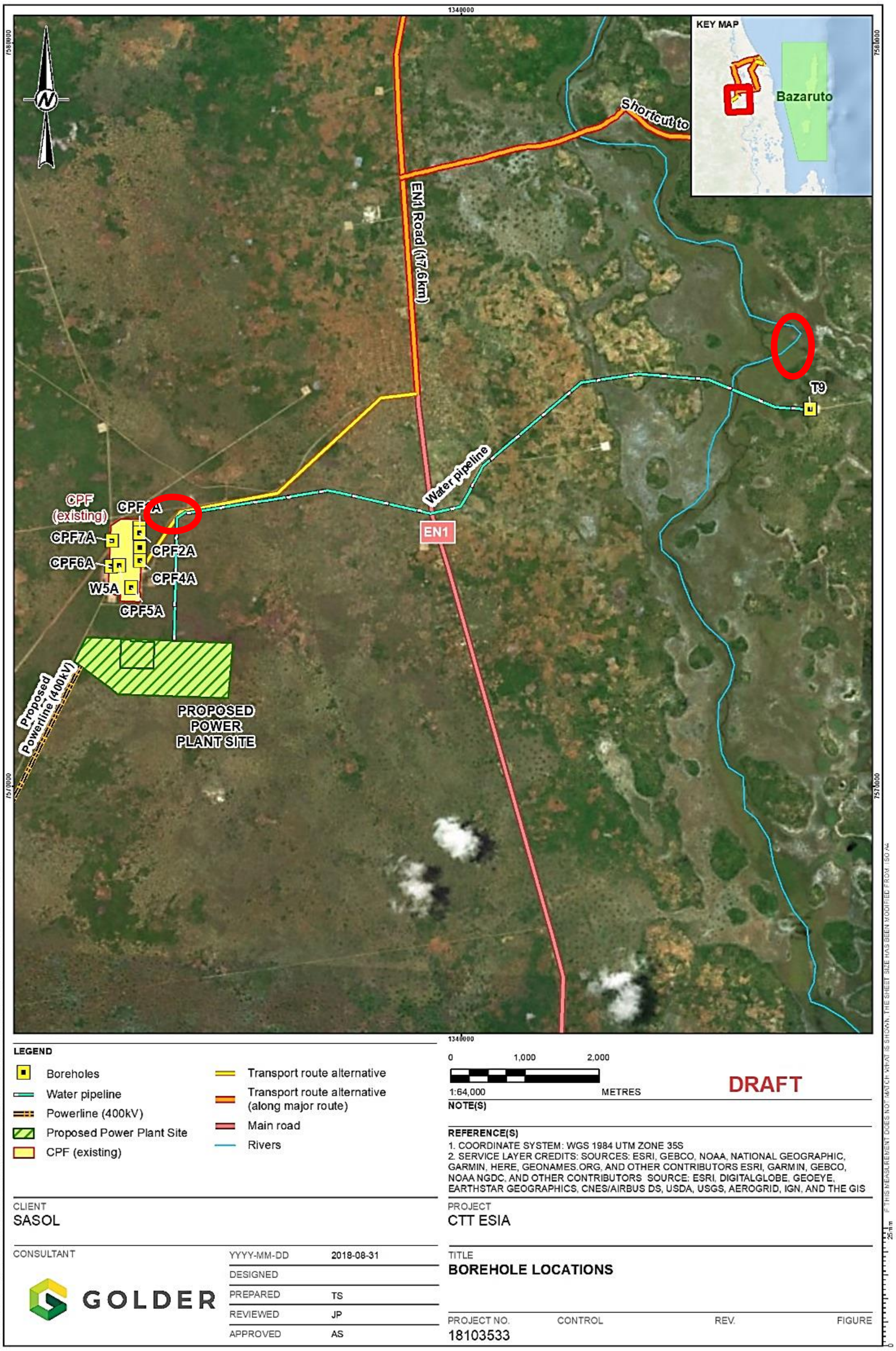

Figure 15: Location of the boreholes W5A and T9 – options for the source of raw water

7.2.3 Effluent treatment and Storage Facilities

7.2.3.1 Sewage treatment

Domestic sewers will be provided from discharge sources at the buildings on site. Sewers will gravitate to a below ground collection sump and pumped to the sewage treatment system (package plant) (0.413 m^3/h for the CCGT option and 0.64 m^3/h for the OCGE option).

Treatment will typically involve activated sludge and some degree of thickening and dewatering of the sludge. The treated effluent may be used for service water on the site or used for irrigation (0.409 m^3/h for the CCGT option and 0.634 m^3/h for the OCGE option). The treated water quality will be required to meet the specification for irrigation. Should the required specifications not be met, the effluent will report to the evaporation pond. The sludge will be collected by a waste contractor or may be used for agriculture, pending further approvals.

7.2.3.2 Oily water management system

The oily water management system includes the first flush sump, corrugated oil plate interceptor, the recovered oil tank, the oil separator, DAF unit and treated oily effluent tank.

The water collected in the first flush sump (7.42 m^3/h for the CCGT option and 3.46 m^3/h for the OCGE option) is sent to a corrugated plate interceptor (CPI) that separates the oil and sludge from the water. Collected oil and sludge is sent to the recovered oil tank for removal by a waste contractor (0.54 m^3/h for the CCGT option and 0.22 m^3/h for the OCGE option).

The de-oiled water from the CPI is sent to a flotation unit where any remaining suspended oil is separated (7.08 m^3/h for the CCGT option and 3.30 m^3/h for the OCGE option). Collected oil from the oil separator is also sent to the recovered oil tank for removal by a waste contractor. The oily effluent is then treated and if in compliance with the water effluent standards and is of good enough quality may be used for irrigation (6.86 m^3/h for the CCGT option and 3.24 m^3/h for the OCGE option). Alternatively the treated oily effluent reports to the evaporation pond.

7.2.3.3 Evaporation Pond

The evaporation pond will serve as an effluent storage facility on the CCT project site for management of wastewater (UF, RO reject and HRSG blowdown) and non-compliant treated effluent (sewage and oily water) that cannot be irrigated.

- CCGT Option

An evaporation pond with a capacity of 28 800m^3 and surface area of 14 400m^2 will be constructed. The pond is lined with an HDPE liner and will receive ultrafiltration reject (0.47m^3/h), brine reject (3.52m^3/h), HRSG blowdown (1.5m^3/h) and treated oily effluent that cannot be irrigated due to non-compliance with water quality irrigation standards. Based on a daily evaporation rate of 51 m^3/day, the evaporation pond will be required to be desludged annually.

- OCGE Option

An evaporation pond with a capacity of 2 450 m^3 and surface area of 1225m^2 will be constructed. The pond is lined with an HDPE liner and will receive ultrafiltration reject (0.05m^3/h), brine reject (0.26m^3/h) and treated oily effluent that cannot be irrigated due to non-compliance with water quality irrigation standards. Based on a daily evaporation rate of 4.1m^3/day, the evaporation pond will be required to be desludged every 2 years.

7.2.4 Water Balance Review

An analysis of the water balance at the CTT project site was undertaken based on the understanding of the baseline conditions, water reticulation and management system and basis of design requirements. The analysis highlighted that the key aspect of surface water management on site is the evaporation pond.

The followed can be concluded from the analysis:

- the water balance reflects that the facility has adequate water storage availability and water supply based on the proposed design criteria and operational scenarios for both technology options.
- the evaporation ponds (for both technology options), based on the design inflow rates of the various waste streams and the evaporation rate for the area, have approximately 356 days of capacity available for the CCGT option and 720 days available for the OCGE option. However certain factors are still unconfirmed at this stage that may influence the storage capacity:
  - evaporation rates based on monitored data;
  - the volume of non-compliant treated effluent (sewage and or oily water) that may report to the evaporation pond;
  - the frequency of desludging pending build-up of sludge and salts; and
  - the water qualities of the waste streams which may influence the sludge deposition rates.

  These factors will be important considerations in the management of the evaporation pond.
- Treated sewage effluent and oily water that will be used for onsite irrigation of vegetation requires regular monitoring to ensure that compliance to discharge water quality standards. Salinity standard of 500 mg/l must be complied with.
- Based on the distance of 8km to the Govuro River from the plant site, it is not likely that any potential spillages, discharges or irrigated effluent would report to the surface water resource. However monitoring of groundwater in the site area would be necessary to determine any influence on water quality.

A comparison of the surface water related aspects of the two proposed technology options are presented in Table 4 below, and an evaluation of the options indicate that:

- The OCGE option has a lower water supply requirement and produces lower quantities of the effluent;
- The CCGT option requires better water quality and thus requires ion exchange treatment step to produce demineralised water;
- The CCGT option also produces an additional effluent and waste stream *i.e*. HRSG blowdown and ion exchange waste.
- The OCGE option has a much smaller evaporation pond footprint; although of the effluent streams are of similar water quality.
- The OCGE option has a smaller potentially contaminated plant surface area thus resulting in smaller quantities of contaminated stormwater.

Table 4: Comparison of OCGE and CCGT options

Aspect	CCGT Option	OCGE Option
Raw water supply	25.9 m^3/h	3.39 m^3/h
Potable water	0.41 m^3/h	0.64 m^3/h
Cooling Water	0.63 m^3/h	1.60 m^3/h
Utility Water	0.83 m^3/h	0.83 m^3/h

Aspect	CCGT Option	OCGE Option
Demineralized Water	20.0 m^3/h	n/a
Ultrafiltration Reject	0.47 m^3/h	0.05m^3/h
Reverse Osmosis Reject	3.52 m^3/h	0.26m^3/h
HRSG Blowdown	1.5 m^3/h	n/a
Treated Sanitary (sewage) effluent	0.409 m^3/h	0.634 m^3/h
Treated effluent (oily water)	6.86 m^3/h	3.24 m^3/h
Effluent to be irrigated	7.269 m^3/h	3.874 m^3/h
Evaporative losses	19.96 m^3/h	2.43 m^3/h
Spent/recovered oil (third party contractor)	0.54 m^3/h	0.22 m^3/h
Ion exchange waste stream (third party contractor	0.04 m^3/h	n/a
First Flush pump (capacity)	180 m^3	76.95 m^3
Stormwater/Firewater sump (capacity)	400 m^3	425 m^3
Plant area (clean stormwater)	109 100 m^2	110 000 m^2
Plant area (potentially contaminated water)	60 000 m^2	27 000 m^2
Evaporation Pond (capacity)	28 800 m^2 (356 days)	2450 m^3 (720 days)
Evaporation Pond (desludging)	Annually	Every 2 years

8.0 STORMWATER MANAGEMENT

Management of stormwater is the other key area of surface water management on the CTT project site. The proposed stormwater system is described in this section.

8.1 Criteria to be met

In terms of the Environmental Design Basis requirements for the project (CTT Phase 0 (Setup) and Phase 1 Configuration Study (2014) the following must be met:

- Stormwater shall be separated from process (organic and inorganic) and sanitary wastewater streams;
- Plant drainage and storm water systems shall be designed to avoid contamination of clean storm water. Stormwater collection areas must slope away from dedicated chemical sewers, storage areas etc. to a central plant collection point for re-use;

- Areas that are classified as contaminated or potentially contaminated areas are to be identified and bunded. The area must slope away from the general plant area to a central plant collection and containment point. This will be connected to an oily water sewer system;
- All discharge points shall be equipped with a shut-off mechanism;
- The oily storm water system must be designed to contain the 1 in 100 year storm event; or the buffer capacity (reservoir size) of the possible contaminated storm water sewer must be based on a risk analysis of different release scenarios;
- The storm water system of the site must be able to handle all fire protection water, in case of an emergency. There should be sufficient capacity to store the water and not discharge into the environment before conducting chemical analysis;
- Oil traps must be included in the design of the storm water sewer. Oil recovered from oil traps must be recycled or disposed of through a certified waste contractor.
- Storm water must be analysed and depending on the quality, sent to a water treatment facility or could be discharged to environment if complies with the effluent standards.

8.2 Description of the Stormwater System

Key issues associated with management of stormwater include separation of uncontaminated and contaminated water, minimizing run-off, avoiding exposed ground surfaces, avoiding sedimentation of drainage systems and minimizing exposure of polluted stormwater areas to surrounding environment.

The three key areas for the management of stormwater at the CTT site are the plant area internal reticulation, the potentially contaminated/contaminated water management system (which includes the first flush sump) and the stormwater/firewater sump. The principle adopted is to prevent clean runoff from entering polluted areas and containing the runoff from polluted areas into an oily water management system. The stormwater system is indicated in Figure 16.

Stormwater areas within the CTT plant include source areas of uncontaminated (clean); potentially contaminated and contaminated water.

- Uncontaminated areas include:
  - Perimeter roads;
  - Unpaved areas (gravel);
  - Open areas outside the battery limit; and
  - Administrative buildings, warehouse, shelters where there is no potential contamination.

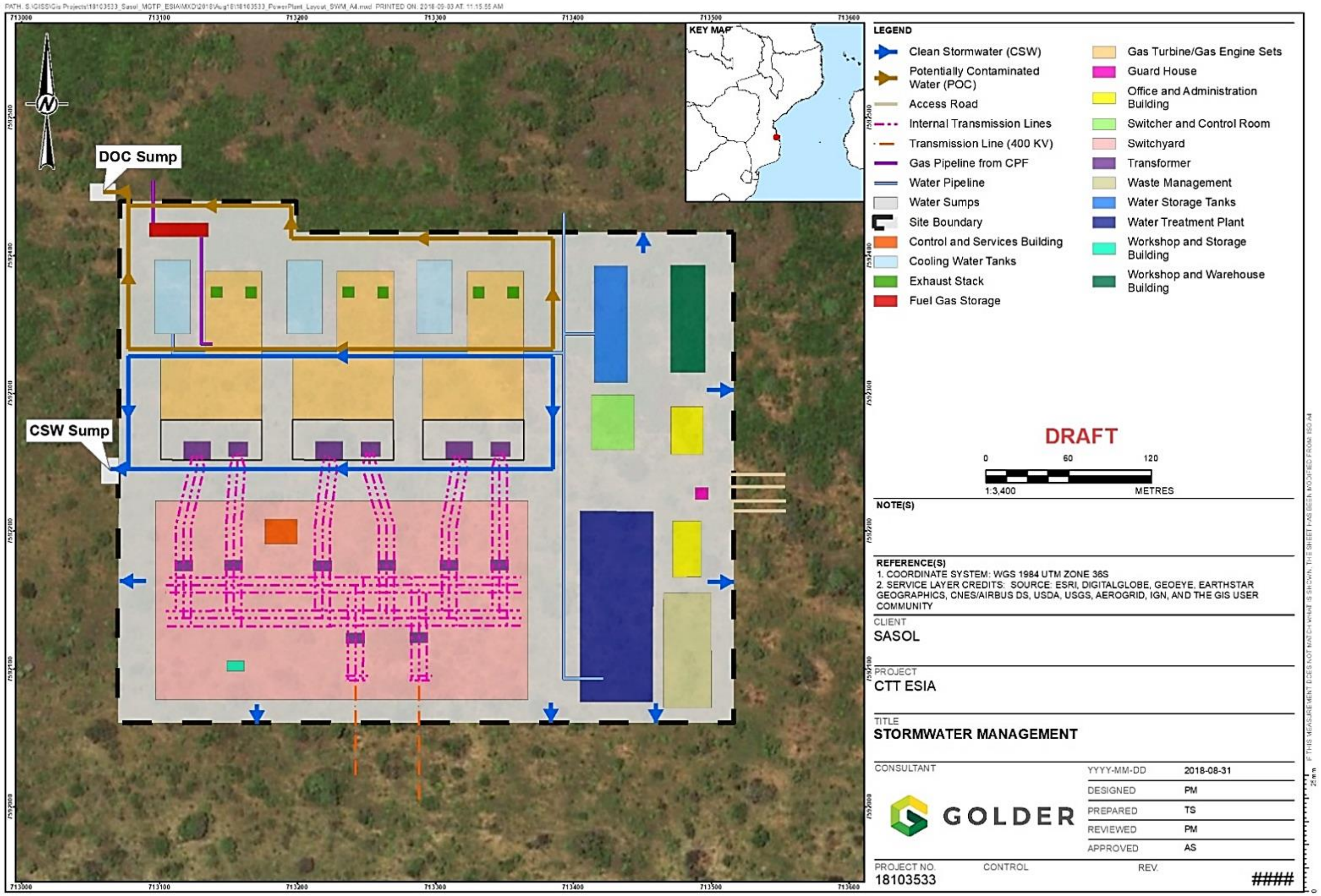

Figure 16: Stormwater System

- Potentially Contaminated areas include:
  - Maintenance wash down from paved areas;
  - Tank bund areas;
  - Process areas that could be contaminated by leaks and spills;
  - Firewater run-off from process areas; and
  - Large roofed areas in contaminated areas.
- Contaminated Areas include:
  - Oil storage areas;
  - Loading areas;
  - Sampling points;
  - Chemical storage areas; and
  - Pump bases; paved areas where hydrocarbon/chemical materials are continuously handled.

8.2.1 Uncontaminated Stormwater

Runoff from perimeter roads, paved areas, open areas outside battery limits and administration building roofs will be collected in concrete lined, open drain channels and concrete stormwater pipes which will discharge towards the natural water course.

8.2.1.1 Plant Area

The stormwater runoff within the plant will be diverted around the plant by an uncontaminated and a potentially contaminated channel sized to convey the 10 minutes of 100mm/hour peak rain event.

The oil/chemical storage areas within the plant area will be bunded to collect spills, wash water, fire water and local runoff. The water collected in the bunded plants areas (approximate area of 60 000m^2 for the CCGT and 27 000m^2 for the OCGE) will be transferred via the potentially oil contaminated (POC) sumps to the first flush sump.

There are 3 potentially oil contaminated (POC) sumps in the CCTG plant and 2 POCs in the OCGE plant. There is one sump per train. Each train's main transformer is also housed in its own bunded area. The rainwater collected in the transformer bunded area is released from time to time to the POC.

In the case of a large oil spill in the bunded area the oil is contained in the bund and transferred manually into drums. This would be classified as an abnormal event / accident.

The clean runoff from the remainder of the plant site (an approximate area of 109 100m^2 for the CCGT and 110 600m^2 for the OCGE) will report to the stormwater/firewater sump.

8.2.1.2 Clean Stormwater/Firewater sump

The stormwater/firewater sump collects uncontaminated stormwater from the plant area and underflow from the first flush sump, from where it will be pumped to the raw water tank for use in the plant or as firewater makeup.

The sizing is based on the clean storm water sump serving as water source for replenishing the fire water reserve after a fire event. The capacity of the stormwater/firewater sump is sized at 400m^3 which is to capture 10minutes of a 100mm/hour peak rain event.

Should the raw water storage tank be at full capacity, the water from the clean stormwater/firewater sump will be discharged to the surrounding environment on the basis that the water quality discharge specifications are met.

8.2.2 Potentially Contaminated/Contaminated Stormwater

Potentially contaminated and oily stormwater water will be managed via the first flush sump and oily water management system.

Oil spillage and contaminated rainwater originating from the potentially oil contaminated areas within the plant in the oily water sumps (3 within the CCGT and 2 within the OCGE) is collected and directed to the first flush sump. The first flush sump holds the first 10 minutes of water of the 100mm/hour peak rain event. Thereafter it overflows to the clean stormwater sump. A skimmer weir prevents oil on the surface from flowing to the clean stormwater sump.

The contaminated stormwater collected in the first flush sump is sent to a corrugated plate interceptor (CPI) that separates the oil and sludge from the water. Collected oil and sludge is sent to the recovered oil tank for removal by a waste contractor.

The de-oiled water from the CPI is sent to a flotation unit where any remaining suspended oil is separated. Collected oil from the oil separator is also sent to the recovered oil tank for removal by a waste contractor. The oily effluent is then treated and if in compliance with the water effluent standards and is of good enough quality may be used for irrigation. Alternatively the treated oily effluent reports to the evaporation pond.

The sizing basis of the first flush sump is 10 minutes of design basis rainfall of 100 mm/hour or largest fire suppression water flow from potentially oil contaminated area.

The governing case is the rainfall case. The oily effluent treatment is designed on the basis of processing the contents of the first flush sump over a 24 hour period.

8.3 Evaluation of stormwater management plan

The proposed conceptual stormwater system at the CTT project site was reviewed to determine as to whether it is able to meet the design objectives. Hydraulic and geotechnical work are still required to attain the development of specifications to achieve a detailed design.

The following can be concluded from the analysis of the assessment of the compliance of the stormwater management system against design criteria:

- the clean stormwater/firewater sump and first flush sumps have adequate storage capacity based on the proposed design criteria for the runoff from 10minutes of a 100mm/hour rainfall event for both technology options.
- The clean stormwater/firewater sump will however discharge into the surrounding environment during wet season and rainfall events should the raw water reservoir have no capacity to accept the excess water.
- the stormwater management system is able to cater for the runoff from a 10minutes of 100mm/hour rainfall event. However the design does not cater for runoff from a 24hr storm event or continuous rainfall over a 2 to 3 day period. The stormwater/firewater sump will discharge in such events. Water quality discharge standards may not be compliant in such cases should clean stormwater be contaminated with oily water.
- Any stormwater water discharges will drain into the surrounding natural vegetation in the vicinity of the plant area. Regular monitoring would be required to confirm compliance to the water quality standards prescribed.

9.0 IMPACT ASSESSMENT

9.1 Assessment methodology and rating criteria

The impact assessment process compares the intensity of the impact with the sensitivity of the receiving environment. This method relies on a detailed description of both the impact and the environmental or social component that is the receptor. 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 5 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 5.

Table 5: 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 6.

Table 6: 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 7 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 7: 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.

9.2 Identified impacts - Open Cycle Gas Engines/ Combined Cycle Gas Turbine

The impacts that have been identified for the CTT project are applicable to the both OCGE and CCGT technologies. These are described in the sections below during the lifespan of the project.

9.2.1 Construction phase impacts

The potential impacts of the project during the construction phase are listed and ranked in Table 8 and described in the sub-sections below. The rating presented in are based on pre-mitigation and post mitigation interventions.

Table 8: Potential impacts– construction phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Increased erosion and runoff volumes	8	2	2	4	**48**	4	2	2	3	**21**
Sedimentation in the Govuro River	8	2	3	4	**52**	4	2	3	3	**21**
Altering the river banks and bed through the upgrade of the Govuro bridge	10	3	3	5	**80**	8	3	3	4	**56**
Spillage of oils, fuel and chemicals	8	2	3	4	**52**	4	2	2	2	**16**

polluting water resources										
Construction camp - Sewage wastewater	8	2	2	4	**48**	8	2	2	2	**24**

9.2.1.1 Increased Erosion and Runoff Volumes

The removal of vegetation and topsoil, as well as the compaction of surfaces during construction, will result in increased flood peaks, runoff and erosion from the project site. The topography site area is relatively flat with the Govuro River 8km away. The surface water quickly ponds and seeps into the ground, hence surface water impacts will be confined to the site area and are considered local.

This has been scored with a moderate significance. The impact is largely site specific, and if the sediment control mitigation is put in place then the impact is ranked as low.

Mitigation measures

Mitigation measures should include the construction of stormwater collection channels conveying site runoff to sediment control dams and vegetation filters. The dams will allow the sediment to settle prior to discharge of runoff to the environment. The stormwater management berm system must be constructed on the perimeter of the development area. Mitigations measures will reduce the impact to low.

9.2.1.2 Sedimentation in the Govuro River

The more probable areas of sedimentation risk are where infrastructure work is done on the existing pipeline to transfer raw water from borehole T9 on the eastern bank of the Govuro River, should this borehole be selected as the water source; and on the upgrades to the Govuro River bridge to accommodate the transportation route for the site equipment. Steeper gradients in this area will make the area prone to erosion and the construction work may result in disturbance to banks and main river channel. These construction activities will increase the sediment load in the runoff reporting to the water course.

The movement of vehicles in the Govuro River floodplain during the construction phase are likely to cause a short term mobilisation of sediment and increased dust levels.

The impacts of sedimentation are likely to be short term and local with moderate significance.

Mitigation measures

Mitigation measures should include installation of drainage control berms or stormwater channels to limit erosion and sedimentation. The construction footprint should be maintained as small as possible. If work in these sections is scheduled for the dry season, the impacts can be significantly reduced.

Implementing mitigation measures will reduce the impact to a moderate significance.

9.2.1.3 Altering of the river banks and bed through the upgrade of the Govuro bridge or Pipe bridge

The transportation route from the beach landing to CTT project site will follow one of two routes that will cross the Govuro River; *i.e* the via the R241 over the Govuro River bridge; or the southern crossing, a new bridge to replace Kelly's bridge. The upgrade of the Govuro River Bridge and that for the replacement Kelly's bridge will require major construction. Both upgrades will alter the river banks and the river bed, with the southern crossing route (short to CPF) being more significant. There is the potential for erosion downstream of the upgrade, backwater upstream of the construction work and erosion at the bridge structures. This could lead to negative impacts in the Govuro River. The impact would have a moderate to higher significance.

Mitigation measures

The protocols to be applied to the bridge upgrade should be developed and documented in the Environmental Management Plan (EMP). The mitigation measures include installation of drainage control berms to limit erosion and sedimentation and rehabilitation of the watercourse once the construction is completed to the extent required, depending on the transport route option selected.

Implementing mitigation measures will reduce the impact to a moderate significance.

9.2.1.4 Spillage of oils, fuel and chemicals polluting water resources

During the construction phase, the spillage of oils, fuel and chemicals can result in the pollution of water resources if due care is not taken. The impact is rated with a moderate significance.

Mitigation measures

The protocols that should be applied during the construction phase should be developed and documented in the EMP. The protocols should address the following:

- Storage of new and used oils in bunded areas;
- No co-handling of reactive liquids or solids;
- Creation and monitoring of an inventory of chemicals held on site;
- Storage of hazardous or toxic substances securely and controlled use thereof;
- Availability and accessibility of HAZOP sheets of all chemicals;

If the recommended construction protocols are followed, then impact during construction will be reduced to low significance.

9.2.1.5 Construction camp – Wastewater

The sanitary wastewater (sewage) generated at the construction camp will need to treated and disposed of in a responsible manner. Sewage effluent would either need to be treated on site or managed by a third party. Failure to do so could result in pollution impacts to water resources and potential health impacts to workers on site.

This impact is would have a moderate significance.

Mitigation measures

Wastewater treated and discharged on site must comply with the sanitary effluent standards (see Table 2) and maybe used on site as service water or irrigated. This would reduce the impact to low.

9.2.2 Operational phase impacts

The potential impacts during the operational phase identified for the surface water environment are presented in Table 9 and described in the sub-sections below. The rating presented in are based on pre-mitigation and post mitigation interventions.

Table 9: Potential impacts related to the operational phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Catchment Water Balance	4	4	2	4	**40**	2	4	2	2	**16**

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Severity	Duration	Geographic Extent	Probability	Significance	Severity	Duration	Geographic Extent	Probability	Significance
Water supply impact on River baseflow	8	4	3	3	**45**	6	4	3	2	**26**
Irrigation of effluents	10	4	2	4	**64**	6	4	2	2	**28**
Spills from the evaporation pond	10	4	2	5	**80**	8	4	2	4	**56**
Desludging	8	4	2	4	**56**	6	4	2	2	**24**
Spills from the first flush pump	8	3	2	4	**52**	8	3	2	2	**26**
Discharge from the clean stormwater sump	6	3	2	3	**33**	4	3	2	2	**18**

9.2.2.1 Catchment Water Balance

The infrastructure development in the area and project footprint will marginally reduce the surface water runoff volume reporting to the local streams. However, this could have a potential impact on the groundwater recharge of the karst aquifer in the local catchment.

The impact was ranked with a low significance.

Mitigation measures

The clean stormwater and stormwater that is potentially contaminated on the site plant areas, will be collected by the stormwater channels and channelled to the clean stormwater sump and first flush sump, before the water can be released to the environment. The potentially contaminated stormwater that is treated via the oily water system, will be irrigated to the surrounding environment. Water released to the environment should be comply with the treated effluent standards specified. This will allow for a minimal impact on the natural runoff volumes and recharge, without contaminating the surface water.

With mitigation, the impact will be reduced to almost negligible.

9.2.2.2 Impact of Water Supply on River Baseflow

The two possible water sources of raw water supply to the CTT are the karst aquifer (borehole W5A) or alluvial aquifer (boreholeT9). Both aquifers are able to provide sustainable yields. Abstraction of water from the sand aquifer at T9 in the Govuro River floodplain will reduce base flows river, since the surface water flow and the sand aquifer are directly connected. The abstraction from the karst aquifer at W5A could impact the groundwater levels and availability in local area, and influence potential contribution to the baseflow of the Govuro River.

However, the model simulations of the two aquifers suggest that there will be minimal drawdown at rate of 12m^3/hr. The maximum drawdown at borehole T9, after 20 years of continuous pumping is 1.90m, approximately 7% of the available drawdown, while for borehole W5A the maximum drawdown, after 20 years of continuous pumping is 2.42m, approximately 3% of the available drawdown. The effect of the additional abstraction from the groundwater resources on the contribution to the Govuro River baseflow is therefore likely to be minimal.

The preferred technology option will also determine the extent of water demand on the aquifer systems. The CCGT option has a higher water requirement.

This potential impact has been scored with a low significance, however regular monitoring of the boreholes in the catchment area is required to assess any cumulative impact.

Mitigation measures

Comply with the recommendations of the Geohydrology Impact Assessment, with regard to the monitoring of water levels in the water supply boreholes.

9.2.2.3 Irrigation of Effluents

The sanitary effluent and treated oily water effluent streams are to be irrigated to the surrounding environment. There is a potential to pollute the local aquifer systems should non-compliant effluent be irrigated, and best practices not be followed in terms of application rates.

As there is expected to be minimal surface flow of the irrigated water, with almost all of the water draining to underground, the perimeter boreholes should be regularly monitored to assess any potential contamination.

The impact is considered to be of moderate significance.

Mitigation measures

The oily water effluent and sewage effluent streams must comply with required discharge water quality standards for treated effluent as stipulated in terms of the Mozambican and IFC standards. Continuous monitoring of the effluent streams is required prior to irrigation to determine compliance to discharge standards. Non-compliant effluent should be discharged to the evaporation pond. Best practices should be applied in terms of application rates.

With mitigation, the impact will be reduced to a low significance.

9.2.2.4 Spillages from the Evaporation Pond

The evaporation pond will serve as the local pollution control dam at the CTT plant site. The pond will handle onsite wastewater streams including the ultrafiltration reject, brine, cooling water blow down, as well as non-compliant sewage and treated oily water effluents streams from the CTT plant. The water qualities of these streams will include very high salts, total suspended solids, oils as well as other contaminants. Liner failure and leakages and inadequate capacity of the evaporation pond to handle higher than anticipated waste stream volumes could potentially result in spillages to the surrounding environment. Spills from the evaporation could cause local ground water pollution.

The impact is considered to be of high significance.

Mitigation measures

Measures for containment of spills and warning systems for leaks must be included in the design of the evaporation pond. The protocols that should be applied in the event of a spill in the operational phase should be developed and documented in the EMP. A clean-up plan should be prepared and carried out in this event.

Mitigation measures will result in the impact being ranked as a moderate significance.

9.2.2.5 Desludging of the Evaporation Pond

Based on the capacities of the evaporation ponds and evaporation rates desludging will be required annually for the OCGE option and biennially for the CCGT option. Improper management of the sludge could result in potential pollution of surface water runoff and of groundwater resources in the local catchment.

This has been scored as a moderate significance.

Mitigation measures

The protocols that should be applied for sludge management and handling during the operational phase should be developed and documented in the EMP.

The mitigation measures will reduce the impact to a low significance.

9.2.2.6 Spills from the First Flush Pump

The first flush pump collects potentially contaminated stormwater from the plant area. The inability of the first flush sump capacity to handle a longer period rainfall event could result in potentially contaminated water spilling to the surrounding environment. The oily water could pollute the surface water run-off and the local aquifer system.

The impact is considered to be of moderate significance.

Mitigation measures

Measures for pollution prevention around the first flush sump should be put in place. Control measures such as artificial wetland areas and vegetation areas to serve as filters may be implemented. The protocols and measures to be applied for management of potential spillage should be documented in the EMP. With mitigation, the impact will be reduced to low significance.

9.2.2.7 Discharge from the Clean Stormwater Sump

The clean stormwater sump collects clean stormwater from the plant area and the underflow from the first flush sump. This water is to be used either as raw water or firewater or released to the environment. Water released to the environment should be analysed regularly to determine discharge quality. An extreme or longer period rainfall event could result in the clean stormwater sump receiving a mixture of clean and potentially contaminated stormwater from the first flush sump. In such a situation, potentially contaminated water could be released into the environment, which may result in pollution of the surface water and groundwater.

The impact is considered to be of low significance.

Mitigation measures

Control measures such as artificial wetland areas and vegetation areas to serve as filters may be implemented. With mitigation, the impact will be reduced to negligible.

9.2.3 Decommissioning phase impacts

The potential impacts during the operational phase identified for the surface water environment are presented in Table 10 and described in the sub-sections below. The rating presented in are based on pre-mitigation and post mitigation interventions.

Table 10: Potential impacts related to the decommissioning phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Magnitude	Duration	Geographic Extent	Probability	Significance	Magnitude	Duration	Geographic Extent	Probability	Significance
Soil contamination	8	2	2	4	**48**	8	2	2	2	**24**
Spillage of oils, fuel and chemicals	8	2	2	4	**48**	6	2	2	2	**20**

Increased Erosion and Sedimentation	8	2	2	4	**48**	6	2	2	2	**20**
Disturbances to the Govuro River bed and banks	10	2	2	4	**56**	8	2	2	3	**36**

9.2.3.1 Soil Contamination

The decommissioning of plant infrastructure, specifically the oil storage tanks, evaporation pond, sewage treatment plant and oily water treatment system could result in soil contamination in the vicinity of these facilities. Contaminated soil has the potential to cause pollution of the surface water and groundwater.

This impact has been rated as a moderate significance.

Mitigation measures

The protocols that limit potential pollution from the effluent facilities should be applied during the decommissioning phase should be developed and documented in the EMP.

The mitigation measures will reduce the impact to a low significance.

9.2.3.2 Spillage of oils, fuel and chemicals

During the decommissioning phase, the spillage of oils, fuel and chemicals can result in the pollution of water resources if due care is not taken. The impact is rated with a moderate significance.

Mitigation measures

The protocols that should be applied during the decommissioning phase should be developed and documented in the EMP.

The mitigation measures will reduce the impact to a low significance.

9.2.3.3 Increased Erosion and Sedimentation

The decommissioning of infrastructure will result in exposed areas, surface disturbances and removal of vegetation and topsoil. This will result in increased runoff and erosion, and some sedimentation from the site. Due to the relatively flat topography of the catchment area, the surface water impacts will be confined to the site area and are considered to be local.

This has been scored with a moderate significance.

Mitigation measures

Mitigation measures should include installation of drainage control berms or stormwater channels to limit erosion and sedimentation. The decommissioning footprint should be maintained as small as possible. If work in these sections is scheduled for the dry season, the impacts can be significantly reduced.

9.2.3.4 Disturbances to the Govuro River Bed and Banks

The decommissioning of the water supply pipeline across the Govuro River from borehole T9, could result in disturbances to the bed and banks of the river, as well as potential for sedimentation. This could impact negatively on the habitat, biota, water quality and flows of Govuro River. The decommissioning must be managed to limit footprint and reduce the disturbances to the river bed and banks.

The impact is considered as a moderate significance.

Mitigation Measures

The protocols to be applied to the water supply pipeline decommissioning should be developed and documented in the EMP. The mitigation measures include installation of drainage control berms to limit sedimentation, a reduced footprint area and rehabilitation of the affected area to restore normal river functioning.

The mitigation measures will reduce the impact to a low significance.

9.3 Environmental Action Plan – Gas engines/Gas Turbines

Mitigation measures proposed for the CTT project are presented in Table 11, and are applicable to either the CCGT or OCGE option.

Table 11: Environmental Action Plan

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
Construction Phase				
Sewage effluent management	Pollution of surface and groundwater resources	Workers camp – sewage plant	Any discharge from sewage works should meet the IFC Environmental and the Mozambican standards for treated sanitary effluent.	CTT contractor
Stormwater management	Sedimentation Erosion and increased runoff	Development area of CTT plant and transportation route	Implementation of a stormwater management system around the development area. Construction of stormwater collection channels, drainage control berms, sediment traps and control dams, and other means shall be used as necessary. Recommend that all major earthworks be undertaken during the dry season.	All contractors
	Chemical pollution of surface and groundwater resources	Spillages of chemicals and oils	Potentially contaminated stormwater shall be kept separate from other drainage at construction sites. Potentially contaminated stormwater shall, if necessary, be tested and treated to remove contaminants before being released into the environment.	CTT contractor
Maintenance of the integrity of the Govuro River system	Alteration of the river bed and banks, impact on water quality and river flow	Construction activities within the Govuro River	Necessary management actions and interventions to limit vegetation removal, disturbance of habitats and ecosystems and changes to water quality and flow. Footprint area is kept as small as possible.	CTT contractor

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
			Water quality and flow upstream and downstream of the construction area shall be monitored to assess changes. Upgrade the pipeline across the Govuro River only in the dry season. River system shall be restored by appropriate rehabilitation measures.	
Operational Phase				
Prevention of obstruction of surface water runoff	Reduction in surface water runoff to catchment area	Project footprint area	Impediments to natural water flow shall be avoided, or, if unavoidable, be allowed for in the design by means of appropriately sized and positioned drains, culverts etc. Clean stormwater and potentially contaminated water that is adequately treated to discharge quality must be released to the environment.	CTT contractor
Environmental flow requirements to be maintained	Reduction in baseflow of Govuro River	Abstraction at borehole T9 to meet plant water requirements	Flow monitoring programme in place to monitor changes to river baseflow. Compliance with the environmental flow requirements for the Govuro River. Alternate water supply must be available, should restriction be placed on abstraction from the floodplain.	CTT contractor
Prevention of pollution by effluent management	Pollution of surface and groundwater resources	Sewage treatment plant, treated oily effluent plant	Effluent streams must comply with the Mozambican and IFC discharge water quality standards for treated effluents. Continuous analysis of quality of the effluent streams prior to irrigation to determine compliance to discharge standards. Non-compliant	CTT contractor

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
			effluent should be discharged to the evaporation pond. Adopt best practices in terms of application rates. Water quality analysis of groundwater in the receiving environment.	
Stormwater management	Pollution of surface and groundwater resources	Spillages from First flush sump and Clean stormwater sump	Potentially contaminated stormwater shall be kept separate from other drainage at the plant area. Potentially contaminated stormwater shall, if necessary, be tested and treated to remove contaminants before being released into the environment.	CTT contractor
			Appropriate use of soak-ways, seepage fields and vegetation filters should be put in place to prevent contamination of water resources. Water quality analysis on water bodies in the receiving environment.	
Pollution control facility management (evaporation pond)	Pollution of surface and groundwater resources	Spillages and leakages from evaporation pond	Leakage management system in place. Water quality analysis of perimeter boreholes around evaporation pond. Regular desludging of pond is to be undertaken (dependant in evaporation rates). Sludge to be handled by waste contractor. Clean up protocol in place.	CTT contractor
Decommissioning Phase				
Stormwater management	Erosion and increased sediment	Plant footprint area	Implementation of a stormwater management system around the development area. Construction of drainage control berms, sediment traps and control dams, and other	All contractors

Aspect	Potential Impact	Impact Source	Detailed Actions	Responsibility
			means shall be used as necessary. Recommend that all major earthworks be undertaken during the dry season	
	Soil contamination (and of water resources)	Effluent treatment systems and evaporation pond.	Adhere to protocols and measures in place to manage clean up and rehabilitate area.	CTT contractor
	Chemical pollution of surface and groundwater resources	Spillages of chemicals and oils during decommissioning.	Potentially contaminated stormwater shall be kept separate from other drainage at construction sites. Potentially contaminated stormwater shall, if necessary, be tested and treated to remove contaminants before being released into the environment.	All contractors
Maintain Govuro River system in natural state	Disturbance of river system	Decommissioning of water supply pipeline	Limit footprint area as much as possible. Activities should be undertaken in dry season where possible. Limit disturbance to river bed, banks and flow. Implement stormwater management controls Rehabilitate area to desired state.	CTT contractor

9.4 Monitoring Programme – Gas engines/Gas Turbines

A monitoring programme proposed for the CTT project are presented in and is applicable to either the CCGT option or the OCGE option.

Table 12: Monitoring programme

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
Construction Phase				
To assess compliance of discharge quality of sewage effluent	Monitoring of any discharge from sewage works should meet the	Construction worker's camp – sewage plant	Monthly	

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
	IFC Environmental and the Mozambican standards for treated sanitary effluent. Non-compliant effluent should be discharged to a pollution control dam.			
To assess compliance of potentially contaminated or contaminated stormwater to discharge standards	Monitor the stormwater runoff from site activities. If necessary, the stormwater should be tested and treated to remove contaminants before being released into the environment. IFC Environmental and the Mozambican standards for treated effluent must be complied with.	At stormwater discharge points around the plant area.	Continuously	
To assess water quality and flow impacts in the Govuro river	Monitoring of water quality and flow in the Govuro River to assess the impact of construction activities.	Upstream and downstream of the bridge upgrade construction site on the Govuro River.	Weekly	
Operational Phase				
To assess compliance of the treated effluent to discharge standards	Monitoring of treated effluent to determine compliance to the effluent standards as stipulated in terms of the Mozambican and	Sewage treatment plant discharge point, oily water management system	Continuously	

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
	IFC standards for discharge and irrigation. Non-compliant effluent should be discharged to an evaporation pond.			
To assess compliance of the stormwater discharge quality	Monitor the stormwater runoff from site activities. Stormwater should be tested and treated to remove contaminants before being released into the environment. IFC Environmental and the Mozambican standards for treated effluent must be complied with.	At stormwater discharge points around the plant area.	At all times	
To assess the impact of water supply, if any, on the local groundwater	Comply with the recommendations of the Specialist Study, Geohydrology Impact Assessment, with regard to the monitoring of water levels in the water supply boreholes.	At perimeter boreholes and at T9.	Monthly	
To assess the impact of spillages/leakage from the evaporation pond on the receiving environment	Water quality analysis of the boreholes in the vicinity of the evaporation pond to determine	Perimeter of the evaporation pond.	Monthly	

Objective	Detailed Actions	Monitoring Location	Frequency	Responsibility
	existence of pollution impacts. Implement remedial actions if impacts are noted.			
Decommissioning Phase				
To assess compliance of the stormwater discharge quality	Monitor the stormwater runoff from site activities. Stormwater should be tested and treated to remove contaminants before being released into the environment. IFC Environmental and the Mozambican standards for treated effluent must be complied with.	At stormwater discharge points around the plant area.	At all times	
To assess impact to the Govuro River	Water quality monitoring of the Govuro River for inorganic and organic parameters, and flow monitoring in river reach of the water supply pipeline.	Upstream and downstream of the new bridge (replacement to Kelly's bridge)	Weekly	

10.0 CONCLUSIONS

The following conclusions can be drawn from the outcome of the impact assessment of the CTT Project on the surface water environment, for both the OCGT and OCGE options, *viz*.

- Alteration of the bed and banks of the Govuro River during the construction phase and the spillages and/or liner failure from the evaporation pond during the operational phase are impacts rated as high significance. However both are reduced to a moderate significance with implementation of mitigation measures, and necessary protocols in place, but if not adequately addressed the impacts can be severe.

- Stormwater management can be considered the most ‘important impact’ that requires intervention during all three phases of the project. It has moderate significance for each of the phases, but is reduced to low with the necessary mitigation. The stormwater management across all phases requires separation of clean stormwater from potentially contaminated stormwater, as well construction of the necessary stormwater channels, drainage structures, collection systems and diversion berms to limit impacts. These are easily achievable to mitigate impacts. Management of the impacts also requires that potentially contaminated stormwater be treated, if necessary, prior to release to the environment.
- Impacts related to potential pollution and effluent management, *i.e.* sewage and treated oily water are also of importance in terms of the receiving surface water environment, and are both rated as moderate significance pre-mitigation. Effluent quality should comply with the Mozambican and IFC effluent quality discharge standard. Irrigation of the effluents is linked to effluent management, and must comply with the discharge standards. Achievement of compliance reduces the impacts to a low significance.
- The impacts of low significance include the catchment water balance, impact of the water supply on baseflow and spillages from the clean stormwater sump.

With the implementation on the stormwater management plan, monitoring programme and recommendations to comply with the EMP, the impacts to the surface water environment are low to moderate with no fatal flaw being identified for the CTT project.

SPECIALIST RECOMMENDATION

Based on the evaluation and assessment undertaken of the two proposed technologies, the OCGE would be the recommended option from a surface water perspective. The only differentiating factor between the two technologies from a water management point of view is that the OCGE option has a lower water requirement (3.39 m^3/h compared to 25.9 m^3/h) and thus generates smaller volumes of effluent. The OCGE option does not require demineralised water and as it does not use heat steam recovery generators, no blowdown is generated.

The OCGE is a more water efficient process with a smaller impact footprint.

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APPENDIX A

Potable Water Minimum Requirements

Potable Water Minimum Requirements: The strictest between the WHO Drinking Water Quality Annex 3 – Table A3.3 requirements and the drinking water requirements from the Mozambique Ministerial Diploma No 180/2004

Potable Water Quality Standards

Component	Maximum Level in mg/l or as indicated
Acrylamide	0.5 (Note a)
Alachlor	0.02 (Note a)
Aldicarb (Applies to aldicarb sulfoxide and aldicarb sulfone)	0.1
Aldrin and dieldrin (For combined aldrin plus dieldrin)	0.03 µg/l
Ammonia	1.5
Antimony	0.005
Arsenic	0.01
Atrazine and its chloro-striazine metabolites	0.1
Barium	0.7
Benzene	0.01 (Note a)
Benzo[*a*]pyrene	0.7 µg/l (Note a)
Boro	0.3
Boron	2.4
Bromate	0.01 (Note a)
Bromodichloromethane	0.06 (Note a)
Bromoform	0.1
Cadmium	0.003
Calcium	50
Carbofuran	0.007
Carbon tetrachloride	0.004
Chlorates	0.7
Chlordane	0.2 µg/l
Chlorine	5 (Note b)

Component	Maximum Level in mg/l or as indicated
Chlorite	0.7
Chloroform	0.3
Chlorotoluron	0.03
Chlorpyrifos	0.03
Total Chromium	0.05
Colour	15 TCU (Total colour unit)
Conductivity	50-2000 µohm/cm
Copper	1
Cyanazine	0.6 µg/l
Cyanide	0.07
2,4 – Dichlorophenoxy acetic acid (Applies to free acid)	0.03
2,4 – Dichlorophenoxy butyric acid	0.09
Dichlorodiphenylchloroethane (DDT and metabolites)	0.001
Dibromoacetonitrile	0.07
Dibromochloromethane	0.1
1,2-Dibromo-3-chloropropane	0.001 (Note a)
1,2-Dibromoethane	0.4 µg/l (Note a)
Dichloroacetate	0.05 (Note a)
Dichloroacetonitrile	0.02
1,2-Dichlorobenzene	1
1,4-Dichlorobenzene	0.3
1,2-Dichloroethane	0.03 (Note a)
1,2-Dichloroethene	0.05
Dichloromethane	0.02
1,2-Dichloropropane	0.04
1,3-Dichloropropene	0.02 (Note a)
Dichlorprop	0.1

Component	Maximum Level in mg/l or as indicated
Di(2-ethylhexyl) phthalate	0.008
Dimethoate	0.006
1,4-Dioxane	0.05 (Note a)
Edetic acid (Applies to free acid)	0.6
Endrin	0.6 µg/l
Epichlorohydrin	0.4 µg/l
Ethylbenzene	0.3
Faecal Coliforms	0-10 NMP*/100 ml Nº of Colonies/ 100 ml
Fenoprop	0.009
Ferro Total	0.3
Fluorides	1.5
Hexachlorobutadiene	0.0006
Hydroxyatrazine (Atrazine metabolite)	0.2
Isoproturon	0.009
Lead	0.01
Lindane	0.002
Magnesium	50
Manganese	0.1
4-(2-methyl-4-chlorophenoxy)acetic acid (MCPA)	0.002
Mecoprop	0.1
Mercury	0.001
Methoxychlor	0.02
Metolachlor	0.01
Microcystin-LR (For total microcystin-LR (free plus cell-bound))	0.001
Molinate	0.006

Component	Maximum Level in mg/l or as indicated
Molybdenum	0.07
Monochloramine	3
Monochloroacetate	0.02
Nickel	0.7
Niguel	0.02
Nitrates ((as NO^{3-}) Short-term exposure)	50
Nitrilotriacetic acid	0.2
Nitrites ((as NO^{2-}) Short-term exposure)	3
N-Nitrosodimethylamine	0.1 µg/l
Organic Matter	2.5
Pendimethalin	0.02
Pentachlorophenol	0.009 (Note a)
pH	6.5 – 8.5
Phosphor	0.1
Selenium	0.01
Simazine	0.0023
Smell	Odourless
Sodium	200
Sodium Dichloroisocyanurate	50 (As dichloroisocyanurate)
	40 (As cyanuric acid)
Styrene	0.02
Sulphates	250
5,4,2-T	0.009
Taste	Tasteless
Terbuthylazine	0.007
Tetrachloroethene	0.04

Component	Maximum Level in mg/l or as indicated
Toluene	0.7
Total Coliforms	NMP (Most probable number)/ 100 ml No. of Colonies/ 100 ml
Total dissolved solids	1000
Total Hardness	500
Total Pesticides	0.0005
Total Suspended Solids	1000
Trichloroacetate	0.2
Trichloroethene	0.02
2,4,6-Trichlorophenol	0.2 (Note a)
2,4,5-Trichlorophenoxyacetic acid	0.009
Trifluralin	0.02
Trihalomethanes	The sum of the ratio of the concentration of each to its respective guideline values should not exceed 1
Turbidity	5 NTU (Nephelometric turbidity unit)
Uranium (Only chemical aspects of uranium addressed)	0.03
Vibrio cholerae	Absent per 1000 ml
Vinyl Chloride	0.3 µg/l (Note a)
Xylenes	0.5
Zinc	3

Note a - For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking water associated with an upper-bound excess lifetime cancer risk of 10^{-5} (one additional case of cancer per 100 000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years). Concentrations associated with upper-bound estimated excess lifetime cancer risks of 10^{-4} and 10^{-6} can be calculated by multiplying and dividing, respectively, the guideline value by 10.

Note b - For effective disinfection, there should be a residual concentration of free chlorine of ≥ 0.5 mg/l after at least 30 min contact time at pH < 8.0. A chlorine residual should be maintained throughout the distribution system. At the point of delivery, the minimum residual concentration of free chlorine should be 0.2 mg/l.

APPENDIX B

Environmental Quality Standards and Effluent Emission - Decree 18/2004 of 2 June - Appendix VI - Manual for the Classification and Interpretation of Laboratory Analyses of Soil and Water – for Effluent to be used for Irrigation

Electrical Conductivity of Water

Electrical Conductivity in mS/cm				
Min	**Max**	**Classification**	**Qualification**	**Interpretation**
0.1	0.25	Very low	Non-salty	Without restrictions for irrigation
0.26	0.75	Low	Little salty	Little risk for irrigation with moderate leaching
0.76	2.25	Intermediate	Salty	Risk for irrigation: use the water on soils moderately to poorly permeable and sowings with intermediate to good tolerance to salinity: leaching is necessary
2.26	4	High	Highly salty	High risks for irrigation: use water on well permeable soils and sowings tolerant to salinity, “necessary special leaching conditions”
4.01	6	Very High	Extremely salty	Undesired irrigation: only on soils highly permeable and sowings highly tolerant to salinity
>6.00		Extremely high	Excessive salty	Water not suitable for irrigation, only in very special conditions

Maximum Electrical Conductivity of Irrigation Water (mS / cm) in the Light of the Texture

EC paste (soil)	Soil texture				
mS / cm	**Sand**	**Frank-sandy**	**Frank**	**Frank-clayey**	**Clay**
< 4.0	2.5	1.6	0.8	0.8	0.4
4.1 – 10.0	6.5	4	2	2	1
> 10.0	10	6	3	3	1.6

pH and Cations and Anions Content of Irrigation Water

Ion	Symbol, unit	Degree of restriction		
		None	**Moderate**	**Severe**
Calcium	Ca^{2+}, meq / l	Normal interval 0 – 20		
Magnesium	Mg^{2+}, meq / l	Normal interval 0 – 5		

Ion	Symbol, unit	Degree of restriction		
		None	**Moderate**	**Severe**
Sodium and Chloride	Na+ and Cl-, meq / l	Sprinkler		
		< 3	< 3	
Chloride	Cl-	Gravity irrigation		
		< 4.0	4.1 – 10.0	> 10
Carbonate	CO3 2-, meq / l	Normal interval 0.0 – 0.1		
Bicarbonate	HCO3-, meq / l	Sprinkler		
		< 1.5	1.5 – 8.5	> 8.5
Sulphate	SO4 2-, meq / l	Normal interval 0 – 20		
Nitrate	N-NH3-, mg / l	< 5	5 -30	> 30
Ammonia	N-NH4+, mg / l	< 5	5 - 30	> 30
Phosphate	P-PO4 3-, mg / l	Normal interval 0 – 2		
Potassium	K=, mg / l	Normal interval 0 – 2		
Boron	B, mg / l	< 0.7	0.8 – 3.0	> 3.0
pH		Normal interval 6.5 – 8.4		

Soluble Salts (g/litres)

Min	Max	Classification	Qualification	Interpretation
0.0	0.2	Low	Little salty	Useful for irrigation
0.3	0.5	Intermediate	Moderately salty	Useful for irrigation with moderate leaching, sowings with a moderate tolerance to salinity
0.6	1. 5	High	Very salty	Restrictions for soils poorly drained, sowings shall be tolerant to salinity
> 1.5		Very high	Extremely salty	Not suitable for irrigation in ordinary conditions. Soils shall be permeable, adequate drainage, excessive irrigation, with considerable leaching and sowings highly tolerant to salinity

Min	Max	Classification	Qualification	Interpretation
> 6.00		Extremely high	Excessively salty	Water not suitable for irrigation, only in very special conditions.

Sodium-Adsorption Ratio (SAR) of Irrigation Water

Min	Max	Classification	Qualification	Interpretation
0	10	Low	Good	Suitable for irrigation, without restrictions
11	18	Intermediate	Moderate	Problematic in soils with fine texture, with low leaching speed, except if the soil has plaster. Water may be used in soil with coarse texture or well permeable organic soils
19	26	High	Bad	Problematic in most of the soils. Possible irrigation of soils containing plaster.
> 26		Very high	Very bad	Generally not suitable for irrigation

Total of Dissolved Solids, mg / litre

Min	Max	Classification	Qualification	Interpretation
0	450	Low	Optimum	Without restrictions for irrigation
451	2000	Intermediate	Moderate	Moderate restrictions for irrigation
> 2000		High	Bad	Severe restrictions for irrigation

IFC water effluent requirements for irrigation purposes

Parameter	Unit	Degree of restriction		
		None	**Slight to Moderate**	**Severe**
Salinity – Electrical conductivity EC_w at 25 C	dS/m	< 0.7	0.7 – 3.0	> 3.0
TDS	mg/l	<450	450 – 2000	>2000
TSS	mg/l	<50	50 – 100	>100

Parameter	Unit	Degree of restriction		
		None	**Slight to Moderate**	**Severe**
SAR (Sodium adsorption Ratio) (0-3)	meq/l	> 0.7 EC_w	0.7–0.2 EC_w	< 0.2 EC_w
SAR (3–6)	meq/l	> 1.2 EC_w	1.2-0.3 EC_w	< 0.3 EC_w
SAR (6-12)	meq/l	> 1.9 EC_w	1.9-0.5 EC_w	< 0.5 EC_w
SAR (12-20)	meq/l	> 2.9 EC_w	2.9-1.3 EC_w	< 1.3 EC_w
SAR (12-20)	meq/l	> 5.0 EC_w	5.0-2.9 EC_w	< 2.9 EC_w
Sodium (Na^+) – sprinkler irrigation	meq/l	< 3	> 3	
Sodium (Na^+) – surface irrigation	meq/l	< 3	3-9	> 9
Chloride (Cl^-) – sprinkler irrigation	meq/l	< 3	> 3	
Chloride (Cl^-) – surface irrigation	meq/l	< 4	4-10	> 10
Chlorine (Cl_2) – Total residual	mg/l	< 1	1-5	> 5
Bicarbonate (HCO_3^-)	mg/l	< 90	90-500	> 500
Boron (B)	mg/l	< 0.7	0.7-3.0	>3.0
Hydrogen sulphide (H_2S)	mg/l	< 0.5	0.5-2.0	> 2.0
Iron (Fe) – Drip irrigation	mg/l	< 0.1	0.1-1.5	> 1.5
Manganese (Mn) – Drip irrigation	mg/l	< 0.1	0.1-1.5	> 1.5
Total nitrogen (TN)	mg/l	< 5	5-30	> 30
pH	mg/l	Normal range 6.5 - 8		

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