4 Project Description

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4.1 Generalities

4.1.1 Overview

The Project comprises the construction and operation of a 206 MW HEPP on the Ruzizi River, downstream from the existing Ruzizi-I and -II hydroelectric schemes. The project includes a 7-km-long 220 kV transmission line. The river represents the border between Rwanda and DRC and project facilities and infrastructure will be installed on both the Rwanda and DRC riverbanks. A rockfill embankment dam, 51 m in height, will be constructed creating a small reservoir occupying 46 ha (30 ha in DRC and 16 ha in Rwanda) and inundating areas of agricultural land in both Rwanda and DRC. However, no dwellings or structures are impacted by the dam construction and reservoir impoundment.

Project components to be situated on the left bank (Rwanda) are as follows:

- Spillway.
- Bottom outlet.
- Two river diversion tunnels (used during construction, one of which is reused as the bottom outlet tunnel during operation).
- Power waterway components: water intake, 3.8 km headrace tunnel, penstock and an aboveground powerhouse.
- Permanent accommodation facilities.
- Access roads comprising completion of the existing road between Bugarama and existing bridge upstream of the powerhouse site, new road from the bridge to the dam site following the left bank of river.
- Temporary infrastructure for construction purposes including a borrow area, river diversion, worker accommodation facilities.

Project components to be situated on the right bank (DRC) are as follows:

- 220 kV switchyard (on the opposite side of the river to the powerhouse).
- 220 kV transmission line (7 km in length) from the 220 kV switchyard to the Kamanyola substation[1].
- 30 kV power line from the 220 kV switchyard to the dam site, following the dam access road in DRC.
- Permanent access roads and bridges comprising a dam access road following the right bank of the river from the outskirts of Kamanyola, and completion of the existing bridge upstream from the powerhouse site. The construction workers' accommodation camp adjacent to the 220 kV switchyard in DRC will continue to be used during operation as REL's DRC offices.
- Temporary infrastructure for construction purposes, including a bridge at the dam site, and storage areas near the river between the dam site and the 220 kV switchyard.

The Project has completed a Feasibility Study, and the detailed design and construction will be managed by an EPC Contractor in the next stage of the Project. Construction duration is estimated at 56 months, requiring an estimated workforce of 500-1,000 workers during the period of peak activities. On completion of the Project construction, the operation of the scheme will be handed over to an operating company that will be created or nominated at a later stage.

The Project will operate in a coordinated manner with the Ruzizi-I and -II hydroelectric schemes upstream which operate with periods of peak and off peak flows. The Project's peak flows (150 m^3/s) are identical to the peak flows from Ruzizi-I and -II.

[1] The Kamanyola substation is not part of the Project, it will be developed by *Energie des Grands Lacs* (EGL)

The Project's 220 kV Transmission Line will transport electrical power generated by the Project to the Kamanyola 220 kV substation, developed by EGL and which will be operated by SINELAC.

The Kamanyola substation will act as the dispatching centre and SINELAC will coordinate the equal sharing of the electrical power with Burundi, DRC and Rwanda. Five Transmission Lines will be connected to the Kamanyola substation; the Project's 220 kV Transmission Line, and four other 220 kV Transmission Lines; one for Rwanda, one for Burundi and two for DRC. The Kamanyola substation and the 5 transmission lines are considered to be "Associated Facilities" and are not included in the scope of this ESIA (see Chapter 1 Introduction - Section 1.6).

It should be noted that the Project does not include installation of power lines and supply of electricity to nearby villages. Nevertheless, the Project implement a Local Area Development Plan (LADP) as part of a benefit sharing strategy.

4.1.2 Project History

The Project history is summarised as follows:

- EGL carried out initial studies in 2007 and in the 2010s.
- A Feasibility Study (FS) and Front-End-Engineering Study (FEED) were prepared by Fichtner engineering company in 2010-11.
- After remaining dormant, the Project was re-launched via a Public-Private Partnership (PPP) with the company REL as the private partner in 2019.
- TRACTEBEL engineering company conducted further Feasibility Studies in 2020-22 for an alternative project design with the dam site moved to an alternative location to avoid an area exposed to landslide and to increase the reservoir volume and power production capacity.

Past ESIA studies conducted are as follows:

- An ESIA and a Resettlement Action Plan (RAP) based on Fichtner's technical studies and financed by the European Investment Bank (EIB) were prepared in 2012 by SOFRECO.
- SOFRECO updated the 2012 ESIA and RAP in 2021 for the original design and alternative dam location design. However, the 2021 ESIA (SOFRECO, 2021a) did not include a comprehensive social baseline update because of COVID travel restrictions and although two additional fish surveys were undertaken, the biodiversity baseline data from 2012 was not updated.

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4.1.3 Project Activities and Planning

The Project will be implemented on an Engineering Procurement and Construction (EPC) basis. A competitive tendering process will be undertaken to select the EPC Contractor. The EPC Contractor will then undertake the Project detailed design using information from the Feasibility Study and the outcomes of this ESIA. The EPC Contractor may also appoint sub-contractors for the provision of various items of the Project and different aspects of the construction works such as site clearing and civil construction. Following award of the EPC contract and the detailed design stage, it is anticipated that it will take around 56 months to complete the construction works.

REL has engaged Tractebel as Owner's Engineer, to assist in the EPC contractor appointment process, to advise REL on design features and monitor and report on the Project construction and commissioning.

The provisional Project schedule is provided in the Gantt Chart below. Site preparation works will start Q2 2026, and reservoir filling is anticipated in Q2 2030. Power production is planned to commence at the end Q4 2030.

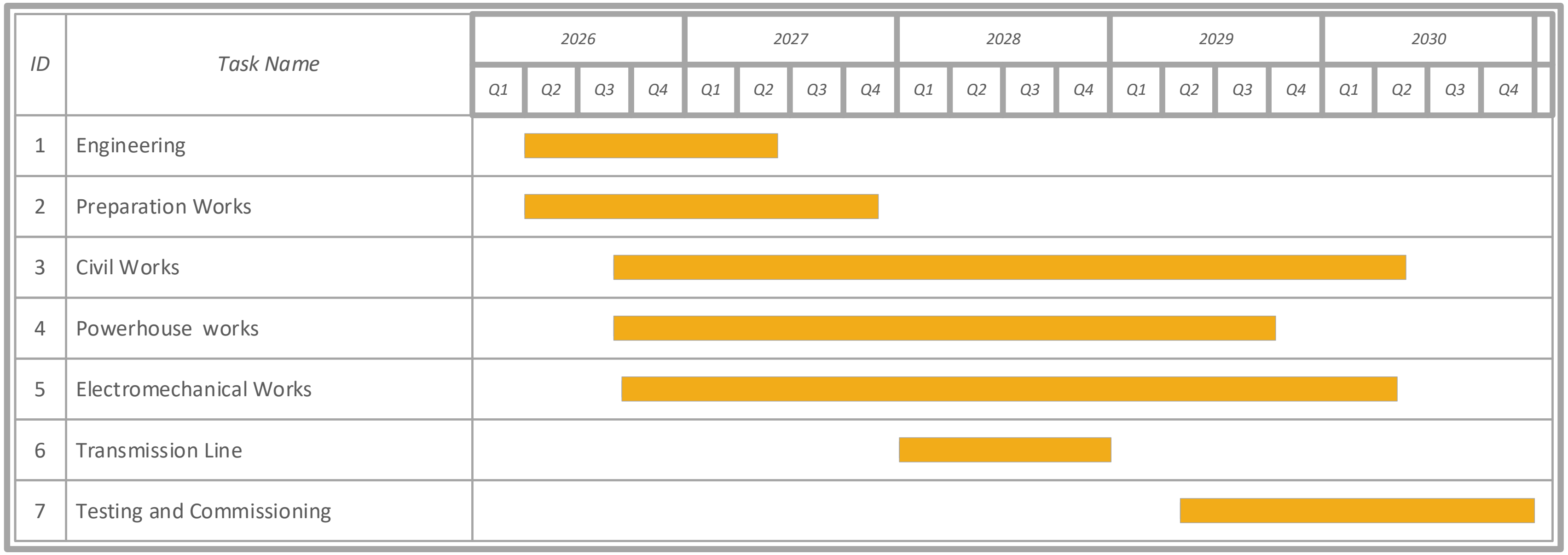

Figure 4-1 Provisional Project Implementation Schedule

4.1.4 Project Location, Access and Setting

4.1.4.1 Project Location

The Project site is located on the border between DRC and Rwanda. It is located on the Ruzizi River, between Lake Kivu and Lake Tanganyika (see Figure 4-2).

- Project components situated in Rwanda are located in the Rusizi district of the Western Province. The dam and reservoir are located in the Nzahaha Sector, and the powerhouse is in the Bugarama Sector.
- Project components situated in DRC are located in the Walungu territory of the South Kivu Province. The dam and reservoir components are located in the Karhongo groupement (administrative seat at Nyangezi) and the 220 kV transmission line, 220 kV switchyard and dam access road are located in the Kamanyola groupement (administrative seat at Kamanyola).

4.1.4.2 Access

The Project site can be accessed from Kigali (Rwanda) by travelling to Kamembe by air (30-minute flight) or road (6-hour drive). Then by road to Bugarama (1-hour). The powerhouse site can be accessed by road from Bugarama (15 minutes). At the current time the dam access road has not been constructed and is undertaken on foot (2-hour walk) from a partially completed road bridge near the powerhouse. Alternatively, the dam and reservoir can be accessed on foot from the village of Murya, Rwanda (situated on the reservoir rim), a 90-minute walk down a steep path.

The Project components in the vicinity of Kamanyola DRC can be accessed by road from Bukavu, the capital South Kivu Province (3 to 4-hour drive) along the RN5 road, which is unpaved and in poor condition. Alternatively, they can be accessed from Rwanda by crossing the border at Bugarama.

4.1.4.3 Environmental and Social Setting

A Upstream Setting

The Project's dam site is situated 31 km downstream from the Lake Kivu outflow. The lake is situated at an altitude of 1,462 m asl and occupies an area of 2,412 km^2. The DRC cities of Goma and Bukavu are situated on the shores of the lake, each have more than one million inhabitants with high levels of poverty and lack of collective sanitation infrastructure and little solid waste collection. Consequently, there is bacteriological and chemical contamination of the lake due to inadequately treated, poorly treated or untreated domestic and industrial wastewater.

The Ruzizi-I and -II hydropower schemes are situated upstream from the Project's dam site, situated 3 km and 19 km from the Lake Kivu outflow respectively and Ruzizi-III is situated 12 km downstream from Ruzizi-II (and 16 km downstream from Ruzizi-I). Ruzizi-I and -II started operation in 1959 and 1989 respectively and both operate with hydropeaking with peak flows of 150 m^3/s, as will the Project. The hydropeaking has resulted in significant degrading of the aquatic biodiversity of the river.

The Ruzizi River valley upstream from Ruzizi-II is characterised by a dense and extensive urban development on the right bank and significant quantities of domestic solid waste accumulates in the Ruzizi-I and -II reservoirs, carried by runoff from the urban areas. The floating solid waste that accumulates in the reservoir is removed from the reservoir by the Operator of the Ruzizi-II hydropower scheme and the waste is transported to a municipal disposal site and some is burnt within the Ruzizi-II grounds. However, some floating waste (plastic bottles, plastic bags, etc) is not trapped by the reservoir and is carried downstream by the Ruzizi River waters.

There has been extensive deforestation of the banks resulting in slope instability and soil erosion. Consequently, the storage capacity of the Ruzizi-I and -II reservoirs have been significantly

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reduced because of accumulation of sediments. The KfW is funding a programme to rehabilitate the Ruzizi-I and -II hydropower schemes which includes reservoir dredging to remove the accumulated sediment and improve the live storage capacity of the Ruzizi -I and -II reservoirs. If sufficient sediment is removed it should enable sediment flushing for these reservoirs to be performed in the future.

If the Ruzizi-I and -II reservoir dredging is ineffective, it can be expected that the available storage volume in Ruzizi-I and -II will further decrease in the coming years because of continued accumulation of sediment. The reduced storage volume will result in shorter time intervals with peak flows and longer intervals with off peak flow from Ruzizi-I and -II (i.e. tending towards a run-of-river mode of operation). However, because of overall quantity of water released downstream during the Ruzizi-III reservoir filling time interval will be unchanged, no consequences on the Project power production capacity are expected.

Downstream from the Ruzizi-I the valley becomes a steep-sided gorge with land use dominated by agriculture. There are only small areas of natural habitat on craggy slopes that that are too steep to be cultivated and along the edge of the river. Between Ruzizi-II and -III dam sites there are a total of 22 areas (on both sides of the river) where slopes are subject to landslides which contribute to the sediment load in the Ruzizi River.

A description of the studies to identify and assess the slope instability and landslide hazards is provided in Chapter 7 - Environmental Baseline, Section 7.2.3. Information on the soil, slope stability and erosion control is provided in Vol. IV – ESMP, section 3.8.

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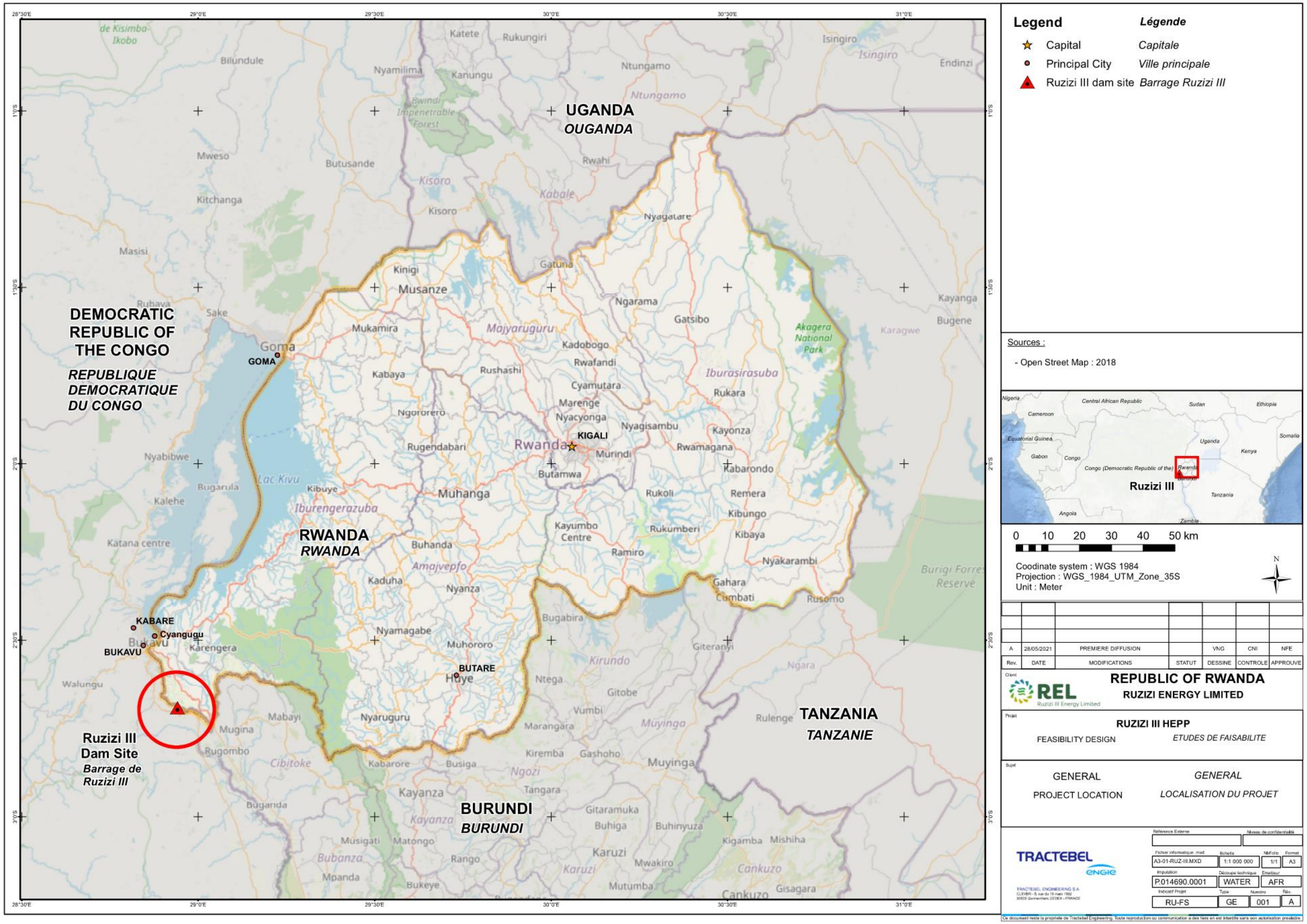

Figure 4-2 Project Location

B Dam and Reservoir Area Setting

The dam and reservoir are situated in a deep, steep sided valley. The river is at an elevation of c.1,000 m asl and the reservoir rim at an altitude of c. 1,500 m. At the current time there are no roads to the site of the proposed dam and reservoir and access is undertaken on foot from the reservoir rim or following the river from the partially completed road bridge upstream from Bugarama. There are no dwellings or structures in the valley in or near the footprint of the proposed dam and reservoir. The major types of land cover in the valley are agricultural land, areas comprising a mosaic of agricultural land/modified natural habitat, steep rocky outcrops and riverine habitat at the edge of the riverbanks. All land that can be cultivated is being cultivated – even very steep land – and the only land that is not cultivated is that which is too steep and rocky.

C Powerhouse Area Setting

The site for the powerhouse is situated 5.5 km downstream from the dam where the valley sides are less steep and the valley bottom wider. The powerhouse site can be accessed by road on the left bank following the river from Bugarama, Rwanda. The predominant land use in the powerhouse area is agriculture, and there are almost no areas of natural vegetation.

D 220 kV Switchyard and 220 kV Transmission Line Area Setting

The site of the 220 kV switchyard in DRC is situated close to a village and land around the village is predominantly agricultural land. The 220 kV Transmission Line that transports electricity from the Project switchyard to Kamanyola substation crosses land that is also predominantly used for agriculture with almost no area of natural vegetation. The line crosses the Bugarama-Kamanyola road.

E Downstream Setting

The Ruzizi River downstream from the Project flow to Bugarama, Rwanda and then crosses the Ruzizi plain and flows into Lake Tanganyika some 131 km further downstream. Land use in the plain is predominantly cattle grazing and agriculture and there are several large irrigation projects planned – which divert water from the Ruzizi's tributaries. The Ruzizi delta area at the outflow into Lake Tanganyika is a RAMSAR site.

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4.2 Permanent Project Components

4.2.1 Overview and Layout

The Project components described in the following subsections comprise:

- Reservoir
- Rockfill embankment dam
- Spillway
- Bottom Outlet
- Ecological flow release – minihydro power plant
- Power waterway (including water intake, headrace tunnel, surge shaft, penstock and powerhouse)
- Roads
- Permanent camps

The layout is illustrated in the drawing below.

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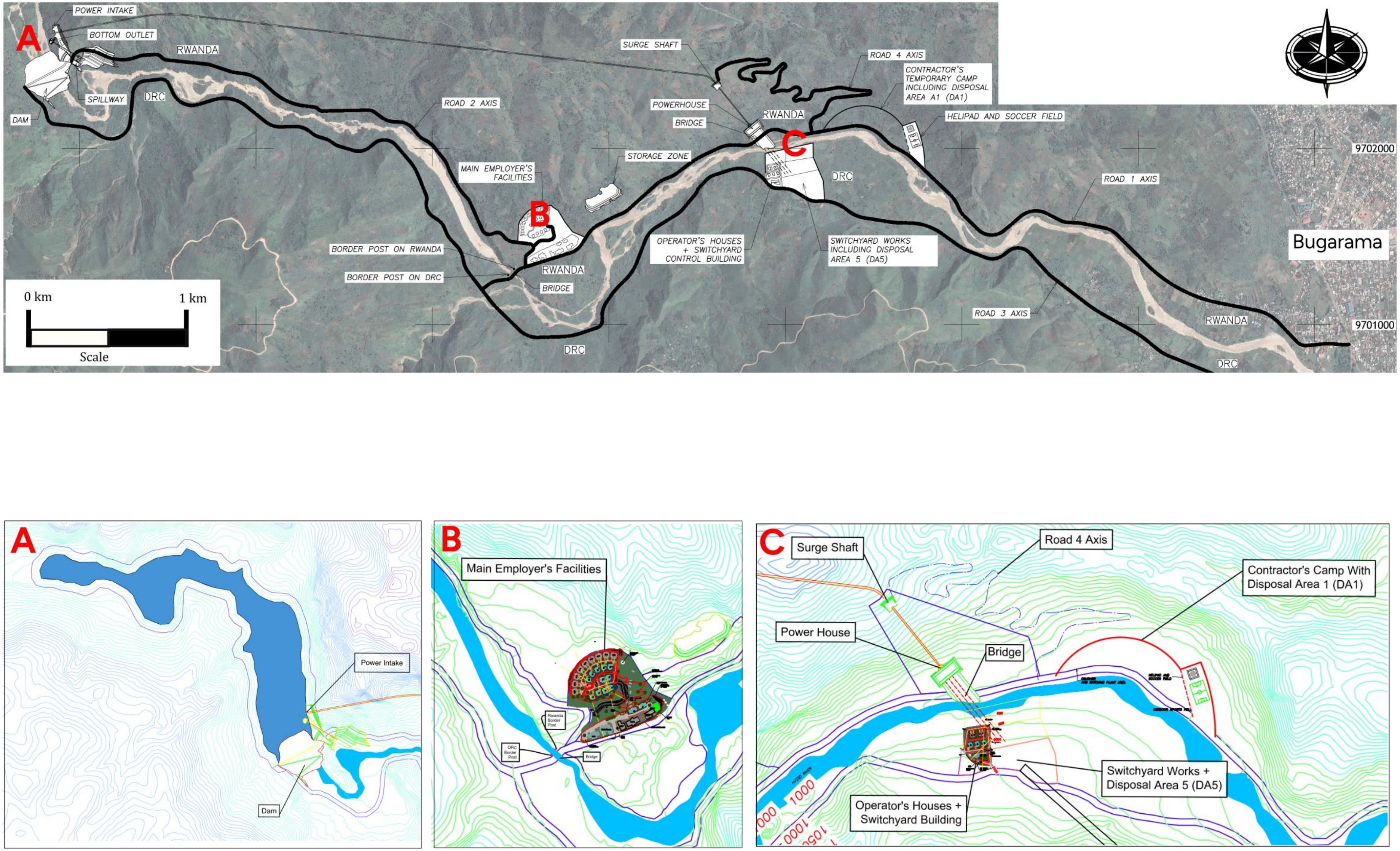

Dam-Reservoir, power intake and spillway

Employer's Facilities

Powerhouse and switchyard

Figure 4-3 Project Layout

4.2.2 Reservoir

The dam (described in section 4.2.3) will create a relatively small reservoir extending upstream from the dam structure and inundating areas in Rwanda and DRC as shown the figure below. The land cover in the inundated area is predominantly agricultural land with some small areas of natural habitat. No dwellings or structures are expected to be flooded.

The key characteristics of the reservoir are presented in the table below.

Table 4-1 Key Reservoir Characteristics

Data	Unit	Value
Full supply level (FSL)	m asl	1,145.0
Maximum water level	m asl	1,149.4
Minimum operating level	m asl	1,133
Total storage at FSL	Mm^3	7.7
Active storage at FSL	Mm^3	5.1
Dead volume	Mm^3	1.0
Reservoir area at FSL	ha	46
Reservoir area at minimum operating level	ha	20
Reservoir area at maximum operating level	ha	53
Length of reservoir	km	2.3 km

The reservoir surface area and capacity curves are presented in the figure below. The maximum water level is defined as the water level in the reservoir when a 10,000-year return period (the design flood) occurs in the Ruzizi River.

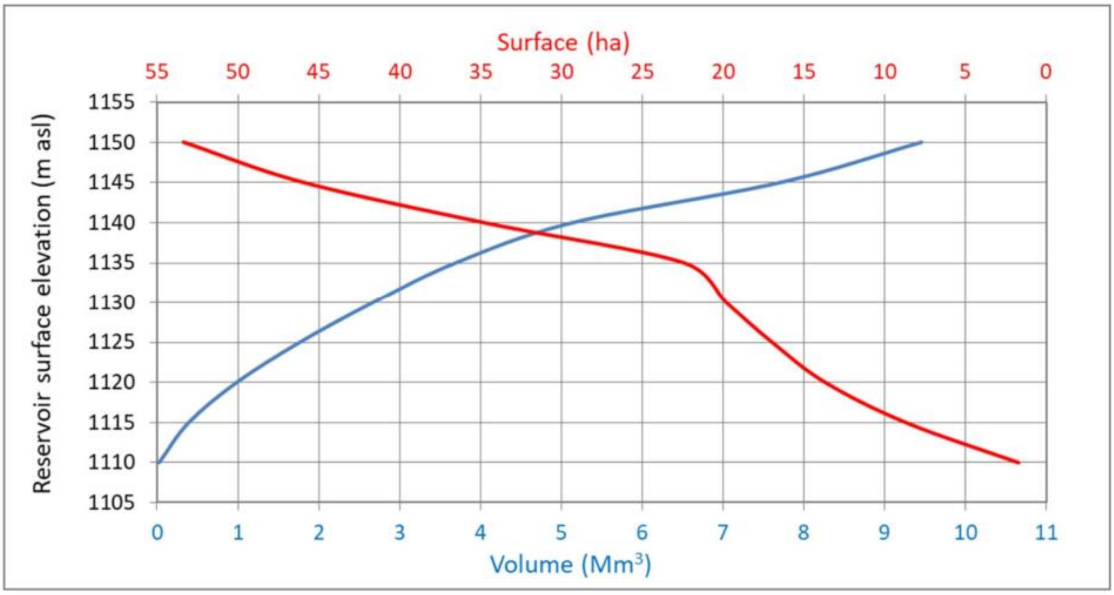

Figure 4-4 Reservoir Surface Area and Capacity Curves

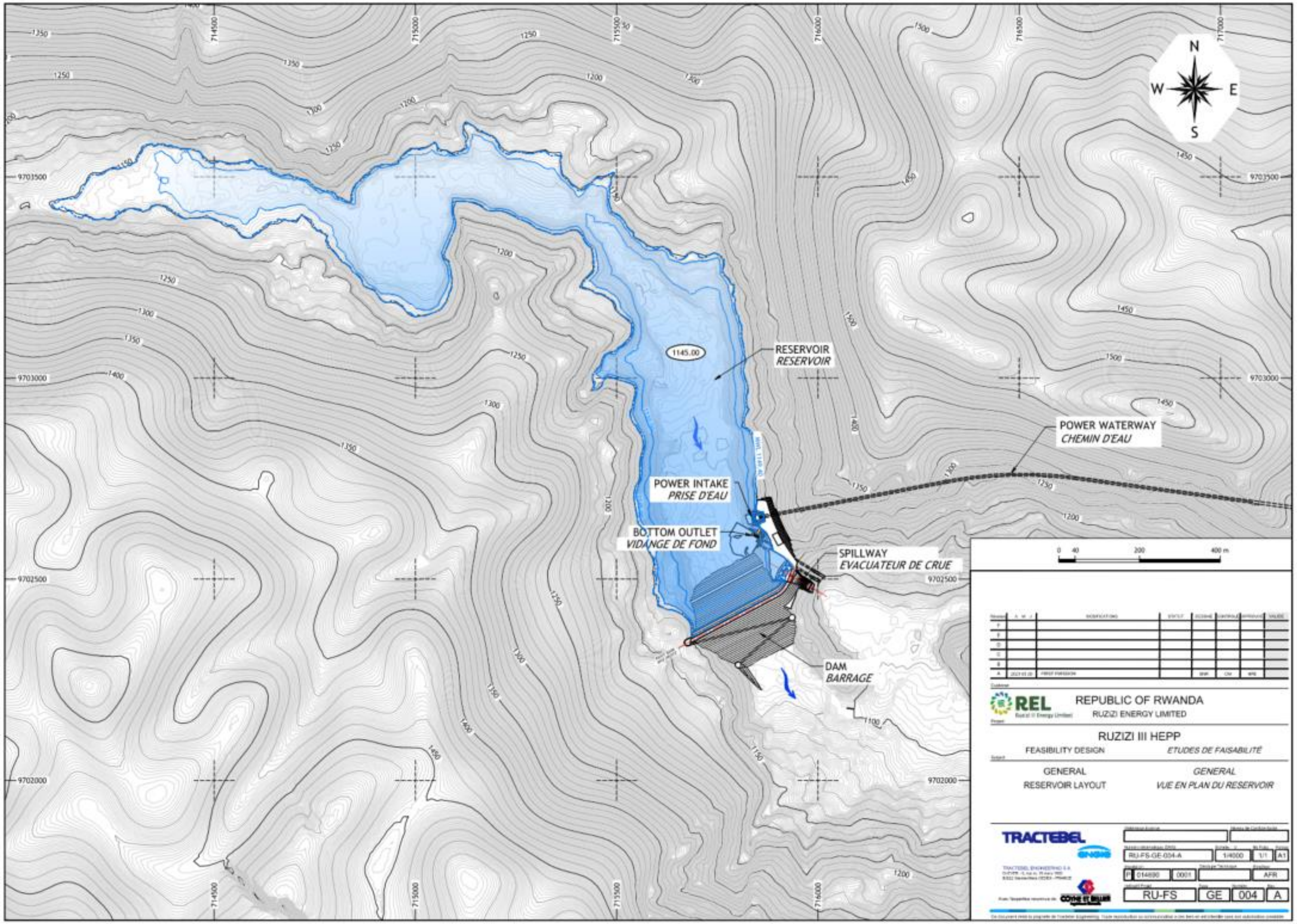

Figure 4-5 Reservoir Layout

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4.2.3 Rockfill Embankment Dam

The Project plans for a central core rockfill dam. This type of dam is considered to be the most appropriate type of dam structure because of the geological conditions, the high seismic activity in the area and the availability of construction materials. The key characteristics are presented in the table below.

Table 4-2 Key Dam Characteristics

Data	Unit	Value
Design flood (10,000-year return period flood)	m^3/s	985
Check flood (100,000-year return period flood / Probable Maximum Flood (PMF))	m^3/s	1,420
Dam type	-	Rockfill
Crest elevation	m asl	1,150.5
Dam height at axis	m	51.5
Crest length	m	287.6

The upstream embankment of the dam will integrate the upstream cofferdam (used for protecting the works during construction – see Section 4.3.7). The upstream slope, above the cofferdam, will be protected against erosion with rip rap, and the downstream slope will be protected with coarse rockfill.

Lateritic material extracted from the excavations of the other Project components (river diversion tunnels, headrace tunnel and spillway) will be used for the rockfill. Relatively mild embankment slopes are foreseen so that material of moderate performance can be used and to reduce the amount of material disposed of at spoil disposal sites.

Foundation treatment will be used to control water seepage. This will comprise grouting below the abutments and construction of a 50-m-deep plastic/concrete cut-off wall in the riverbed below the dam structure.

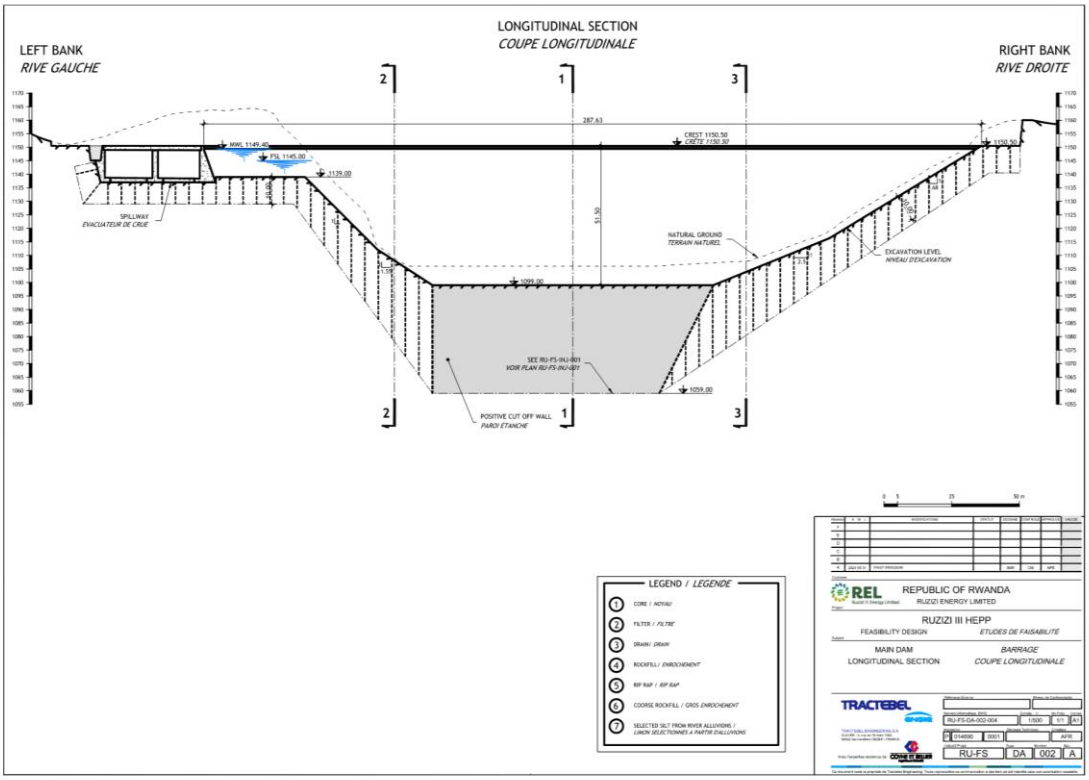

Figure 4-6 Dam Design Drawings: Longitudinal Section

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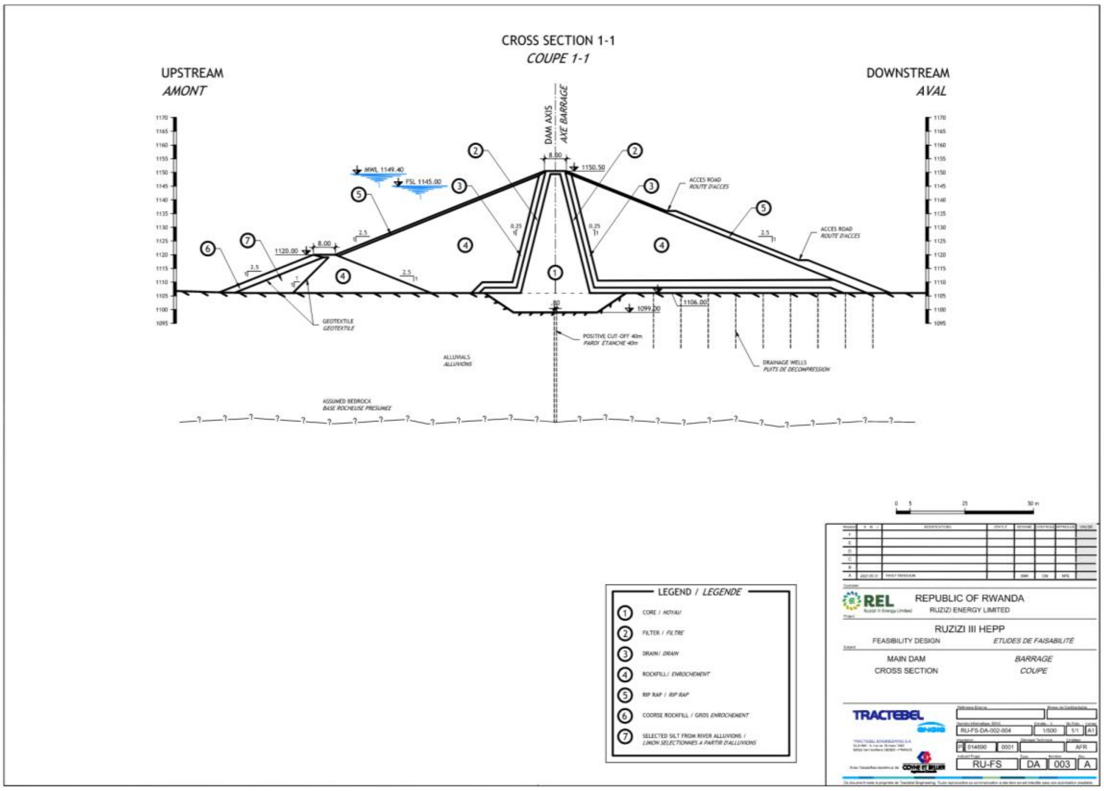

Figure 4-7 Dam Design Drawings: Cross Section 1-1

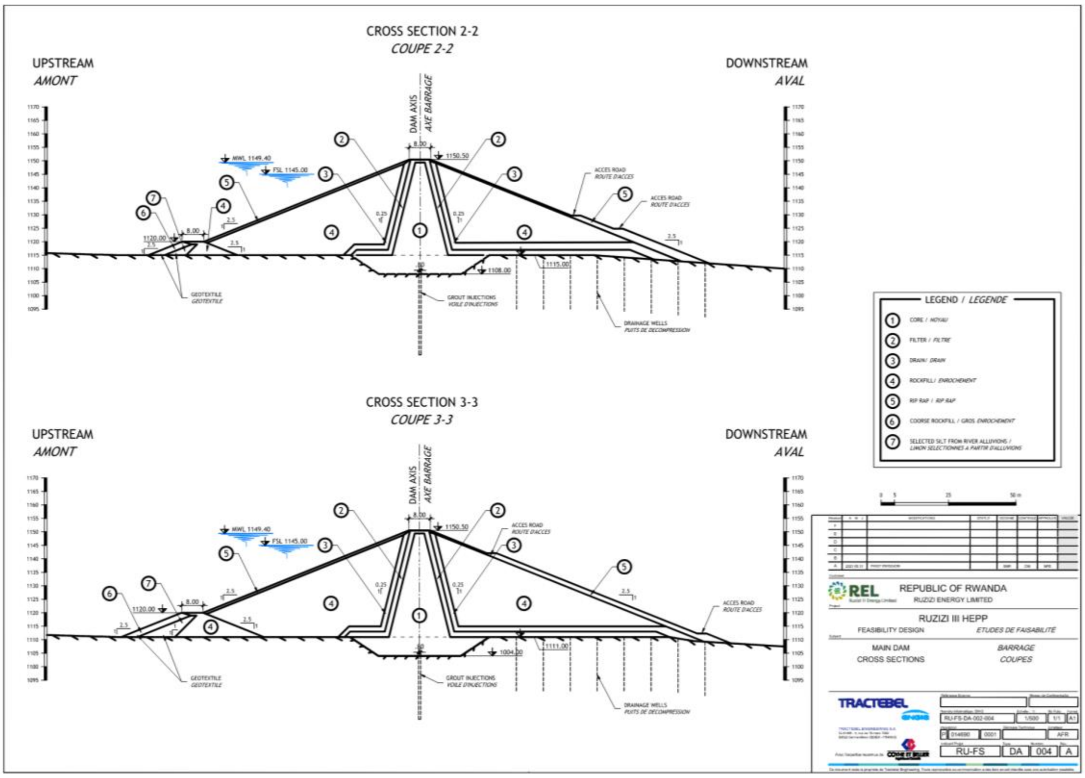

Figure 4-8 Dam Design Drawings: Cross Sections 2-2 and 3-3

4.2.4 Spillway

The spillway is a safety feature of the dam. When the flow of the Ruzizi River is greater than the turbining capacity of the powerhouse, the excess flow is diverted safely to the reach of the Ruzizi River immediately downstream from the dam via the spillway. This prevents uncontrolled overtopping of the dam structure which can damage the dam.

A labyrinth weir type spillway will be a located on the Rwandan abutment of the dam. A labyrinth weir spillway comprises a weir wall constructed in a zigzag manner in order to increase the effective length of the weir crest with respect to the channel width. The increase in effective length raises the discharge capacity of the weir. The spillway comprises three main subcomponents, the approach channel, the labyrinth weir and the chute channel.

The spillway is designed for the Project's Design Flood (985 m^3/s, 10,000-year return period) and checked for the PMF (1,420 m^3/s, 100,000-year return period).

The spillway layout and position on dam are illustrate in the drawings provided in Figure 4-10.

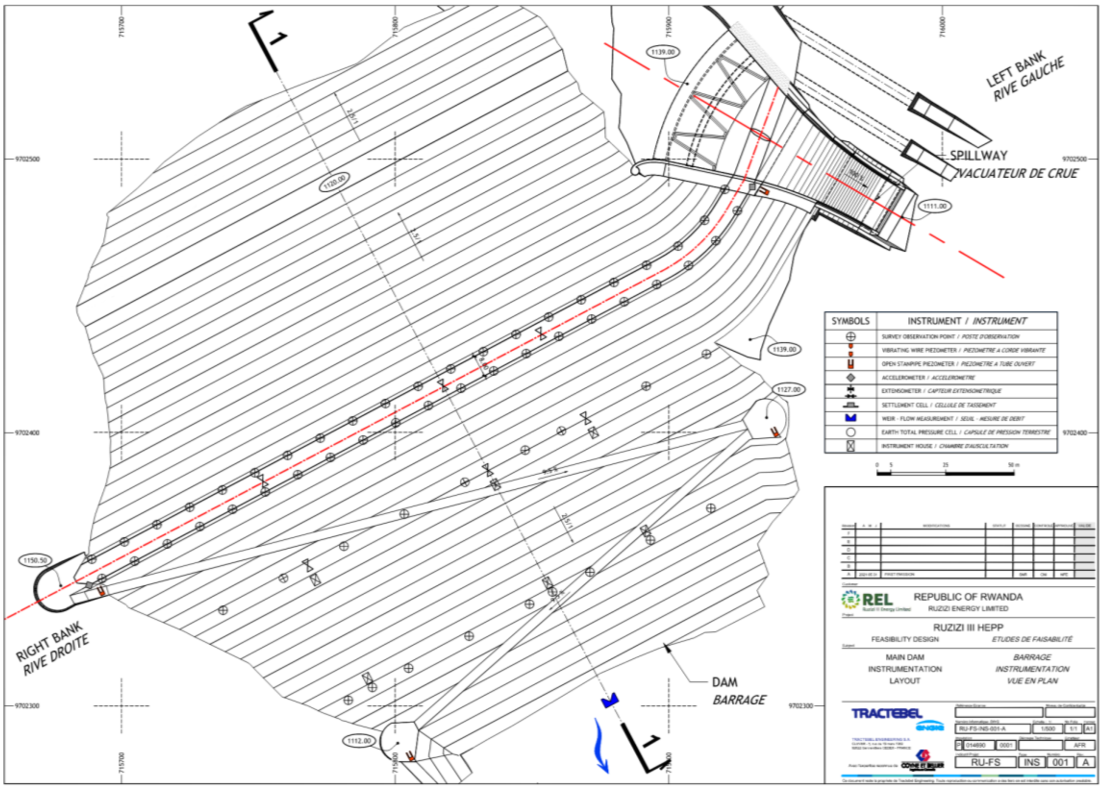

Figure 4-9 Spillway and Dam layout Drawing

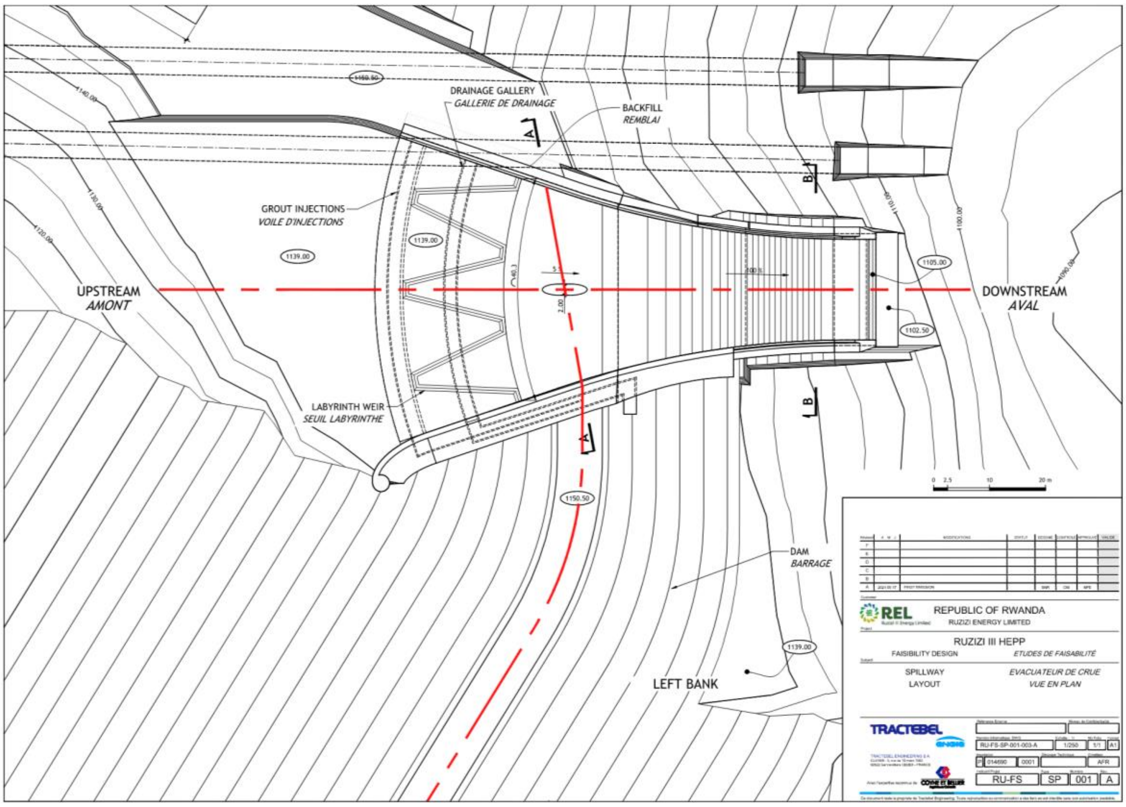

Figure 4-10 Spillway Design Drawing

4.2.5 Bottom Outlet

The bottom outlet is a safety feature of the dam. It allows the reservoir water level to be drown down if the need arises, such as for maintenance or inspection of the dam structure. It is comprised of a radial gate (service gate) and a guard gate and is operated from a tower above the gates. The gates are opened using a hydraulic jack and close by gravity.

The bottom outlet and control tower are situated at the upstream portal of the left bank diversion tunnel. A bridge links the tower to the left bank of the river. Downstream from the bottom outlet, released water is conveyed as free surface flow in one of the diversion tunnels (from construction) that is reused. The tunnel is 180 m in length and has diameter of 4.8 m and discharges the water into the Ruzizi River downstream from the dam via a short chute.

The capacity of the bottom outlet is 200 m^3/s at FSL and 160 m^3/s at minimum operating level. The reservoir water level can be lowered from FSL to the minimum operating level in less than an hour and can be lowered to below the power intake within 3 hours.

The position of the bottom outlet in relation to the dam, spillway and power intake is illustrated in the drawing provided in Figure 4-11. The cross-sectional drawing is provided in Figure 4-12.

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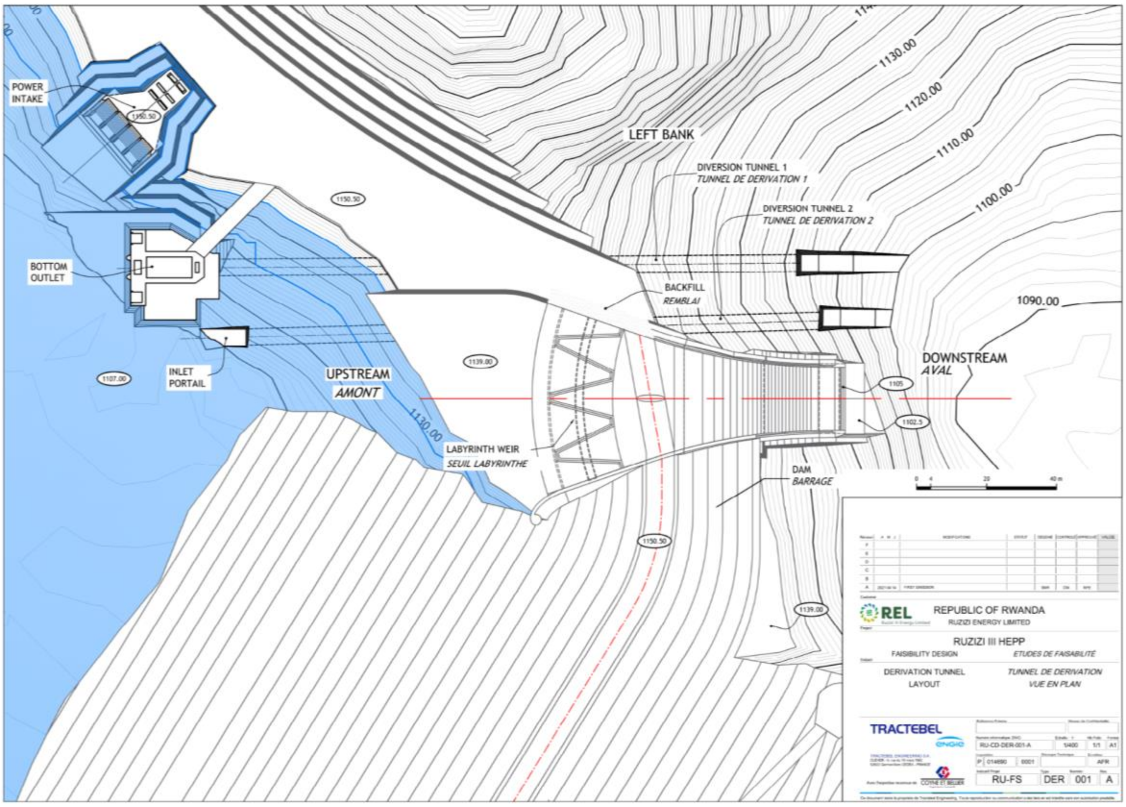

Figure 4-11 Deviation Tunnel Layout (showing Bottom Outlet, Water Intake and Spillway)

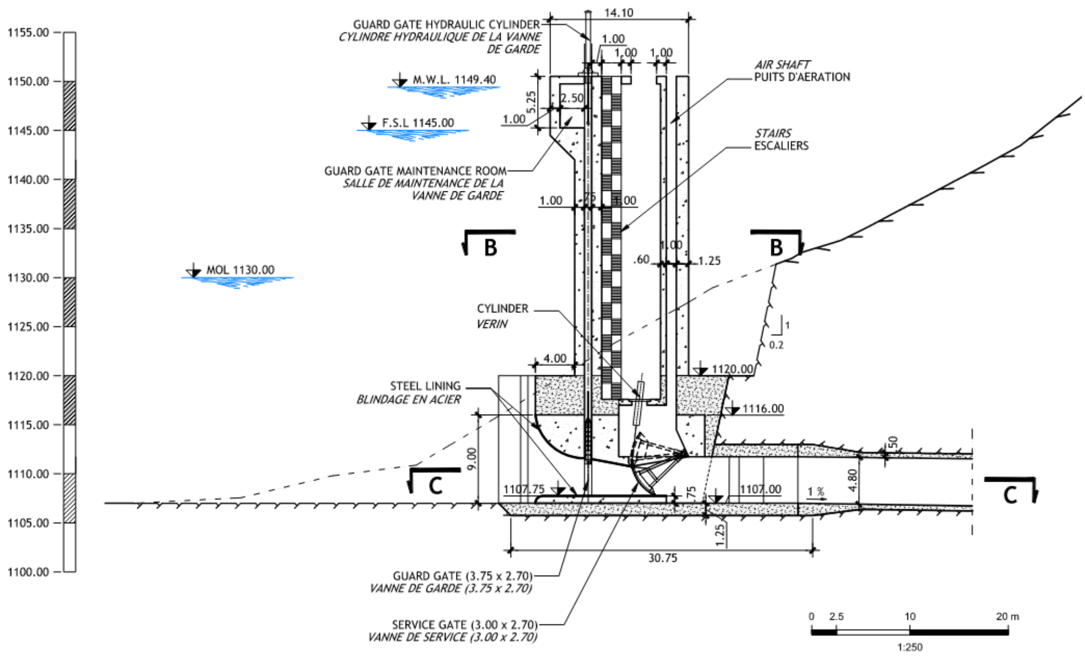

Figure 4-12 Bottom Outlet Cross Section

4.2.6 Ecological Flow Release – Minihydro

The ecological flow has been set by the Feasibility Study (Tracebel, 2021) at 10 m³/s (9% of average annual flow of the Ruzizi River). The ecological flow is turbined by a minihydro power generation group (2.9 MW capacity) situated in the Bottom Outlet tower before being discharged into the Ruzizi River via the bottom outlet tunnel. Group consists of a horizontal axis Francis turbine. The cross-sectional drawing is provided in the figure below.

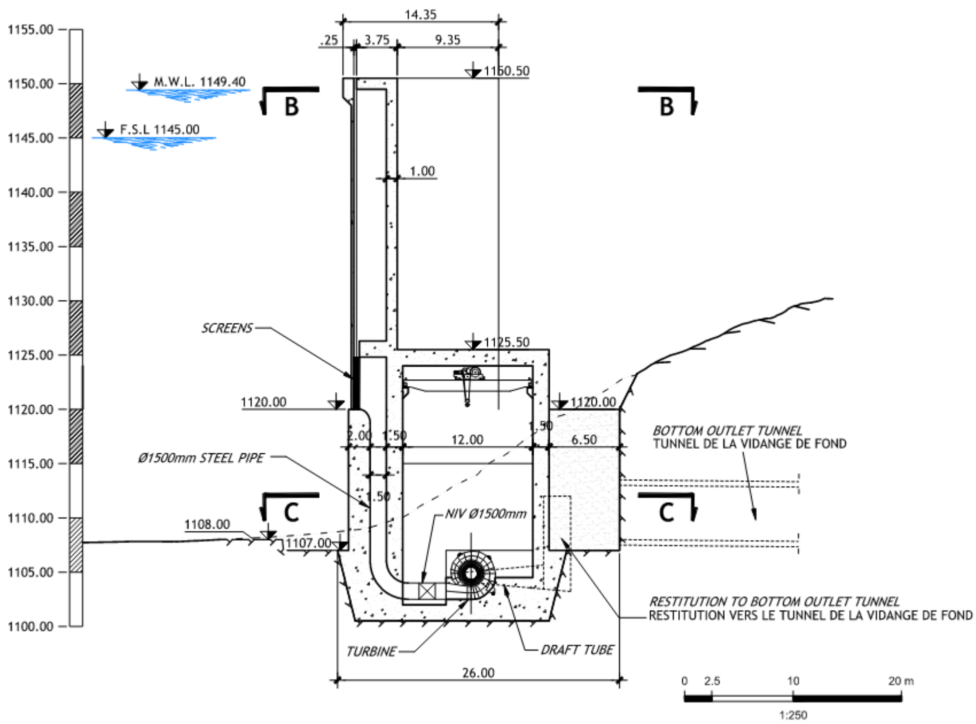

Figure 4-13 Minihydro Cross Section

4.2.7 Power Waterway

The components of the power waterway comprise the following:

- Water intake: The intake is located on the Rwanda side of the reservoir near the dam. The location of the water intake is illustrated in Figure 4-11. The intake comprises 2 main sluices each divided into 2 narrower sluices.
- Concrete-lined headrace tunnel: The tunnel conveys the water from the water intake to the penstock. The Layout and profile are provided in Figure 4-14.
- Surge shaft. The purpose of the surge shaft is to absorb transient surges in flow conditions in the waterway associated with powerhouse operation. The surge shaft is situated at the end of the headrace tunnel and comprises a vertical shaft from the tunnel to the ground surface. The layout and profile are provided in Figure 4-14 and Figure 4-15.
- Steel-lined tunnel and penstock. The steel-lined tunnel and penstock is situated downstream of the surge shaft. The layout and profile are provided in Figure 4-14 and Figure 4-15.
- Aboveground powerhouse: The powerhouse is situated in the left bank of the Ruzizi River at a location 5.5 km downstream from the dam, and where there is a relatively large bank and set back from the steep slopes above. The exact location, footprint and building dimensions of the powerhouse will be determined by the EPC Contractor.

- Tailrace channel: A short but wide tailrace will convey discharges from the powerhouse to the Ruzizi River.

The general layout of the power waterway components is provided in Figure 4-3 and key characteristics are provided in the table below.

Table 4-3 Key Characteristics of the Power Waterway Components

Data	Unit	Value
Water intake		
Platform elevation	m asl	1,1150.5
Number of gates	-	2
Gate type	-	Fixed roller gate
Headrace tunnel		
Diameter	m	6.7
Length	m	3,820
Max. flow velocity (at 150 m^3/s)	m/s	4.03
Penstock		
Diameter	m	5.4
Length	m	In the range of 314-360 m*
Powerhouse		
Turbine type	Francis	
Installed capacity of turbines	MW	3 x 50 = 150*
Net head	m	153.5
Net power capacity at transformers	MW	204*
Annual average generation	GWh	1,157
Powerhouse dimensions	m	**
Tailrace		
Length	m	**
Width	m	54
* The total power production capacity of the Project (206 MW) is calculated using the formula: Power = Flow rate x net head x efficiency x gravity and including power produced by the minihydro unit (2.9 MW) turbining the ecological flow (10 m^3/s), with power produced varying with reservoir water depth. ** Powerhouse dimensions and footprint to be determined by the EPC contractor		

4.2.8 Roads and Bridges

The Project includes the construction of the roads and bridges presented in the table below. The layout is provided in Figure 4-3. The design of the roads will be undertaken by the EPC Contractor in the next stage of the project. The total width of roads will be 6 m (lane and shoulder widths combined).

Table 4-4 Roads and Bridges

Code	Description	Length (km)
Rwanda		
1	Completion of the existing road from Bugarama	5.4
2	New dam access road from the incompleted bridge	3.2
4	New serpentine road from powerhouse to surge shaft (joins existing road to be improved)	2.9
DRC		
3	New dam access road Kamanyola	9.6
	Completion of the existing incompleted bridge	-

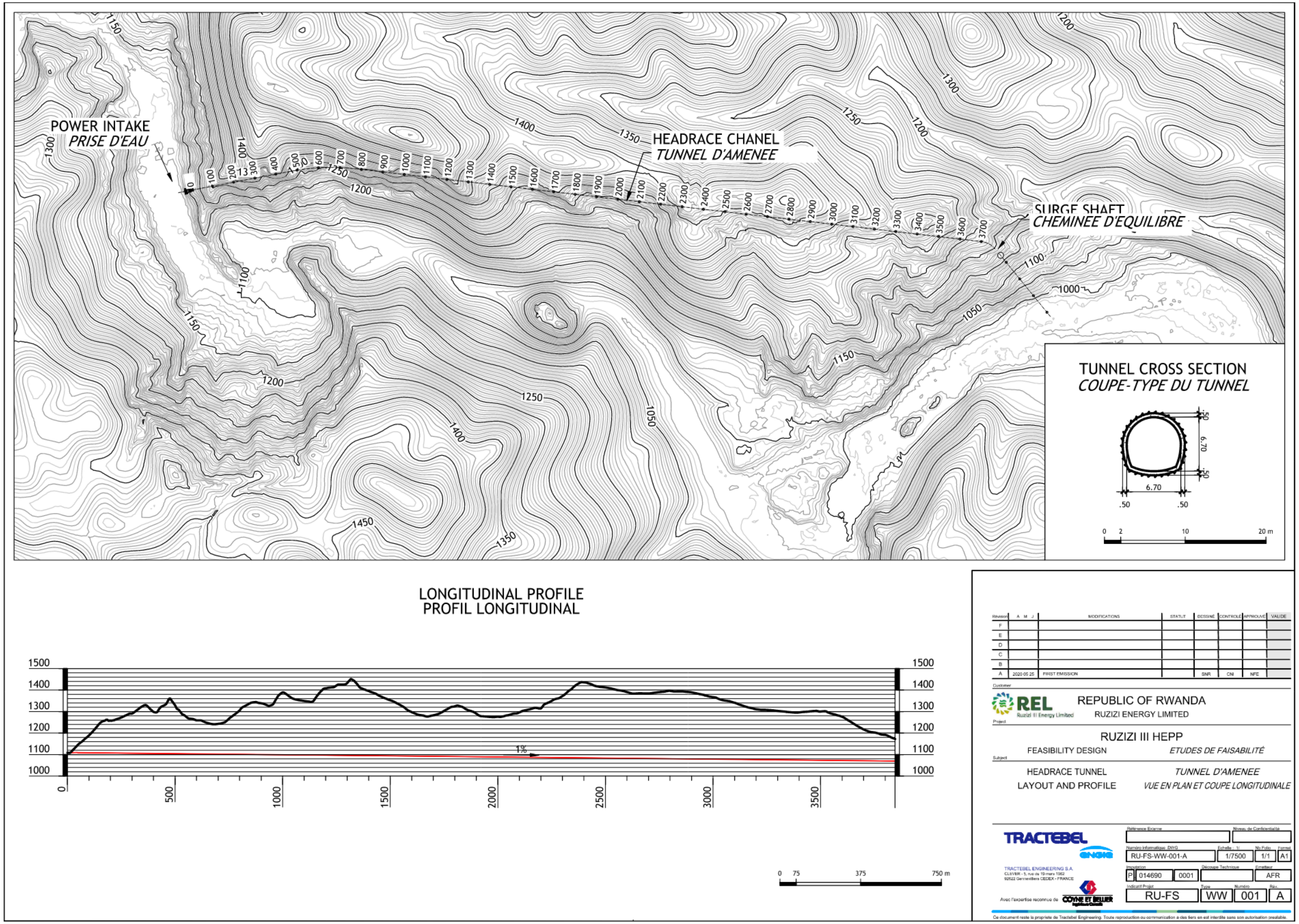

Figure 4-14 Layout and Profile of the headrace Tunnel

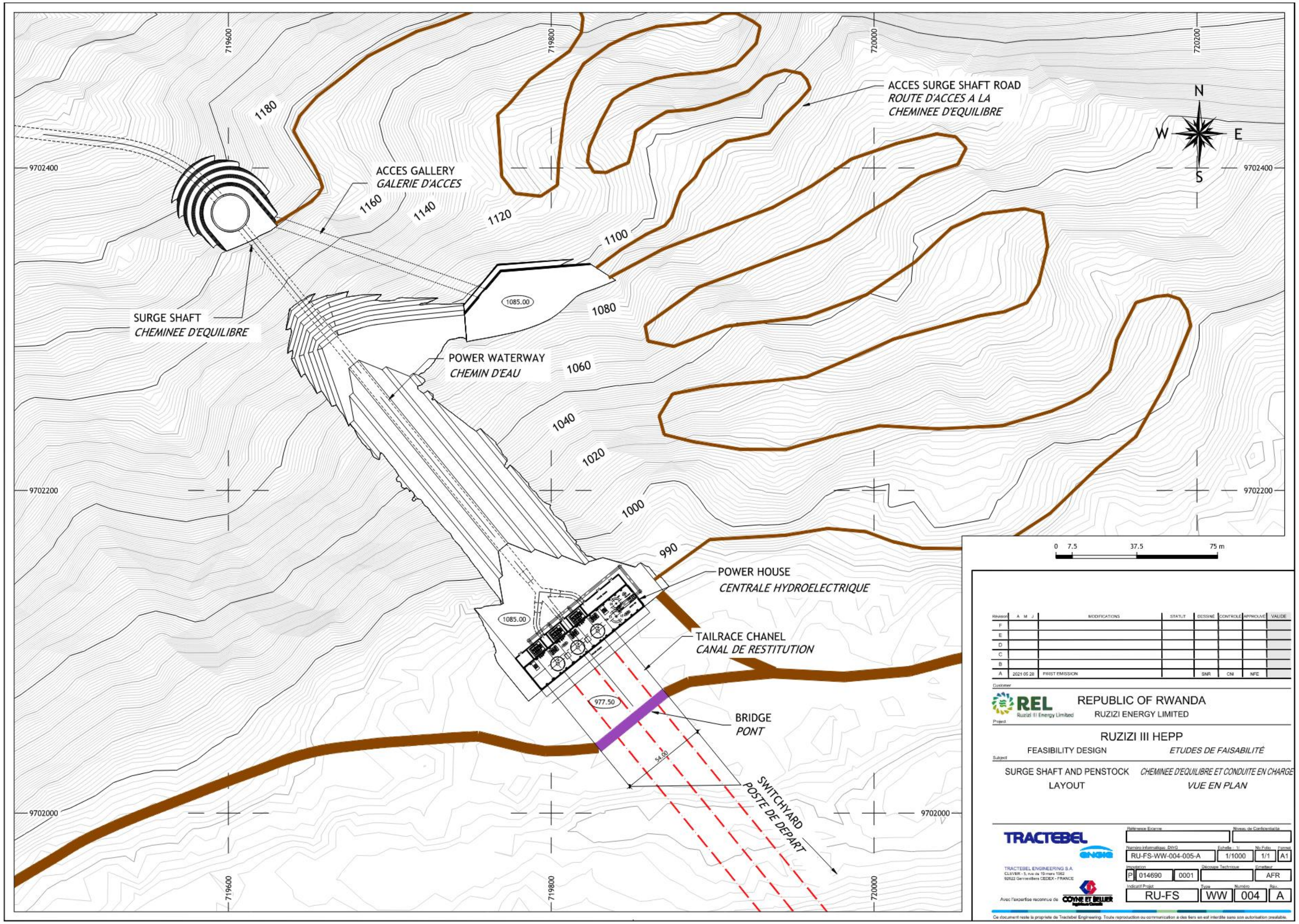

Figure 4-15 Surge Shaft and Penstock Layout

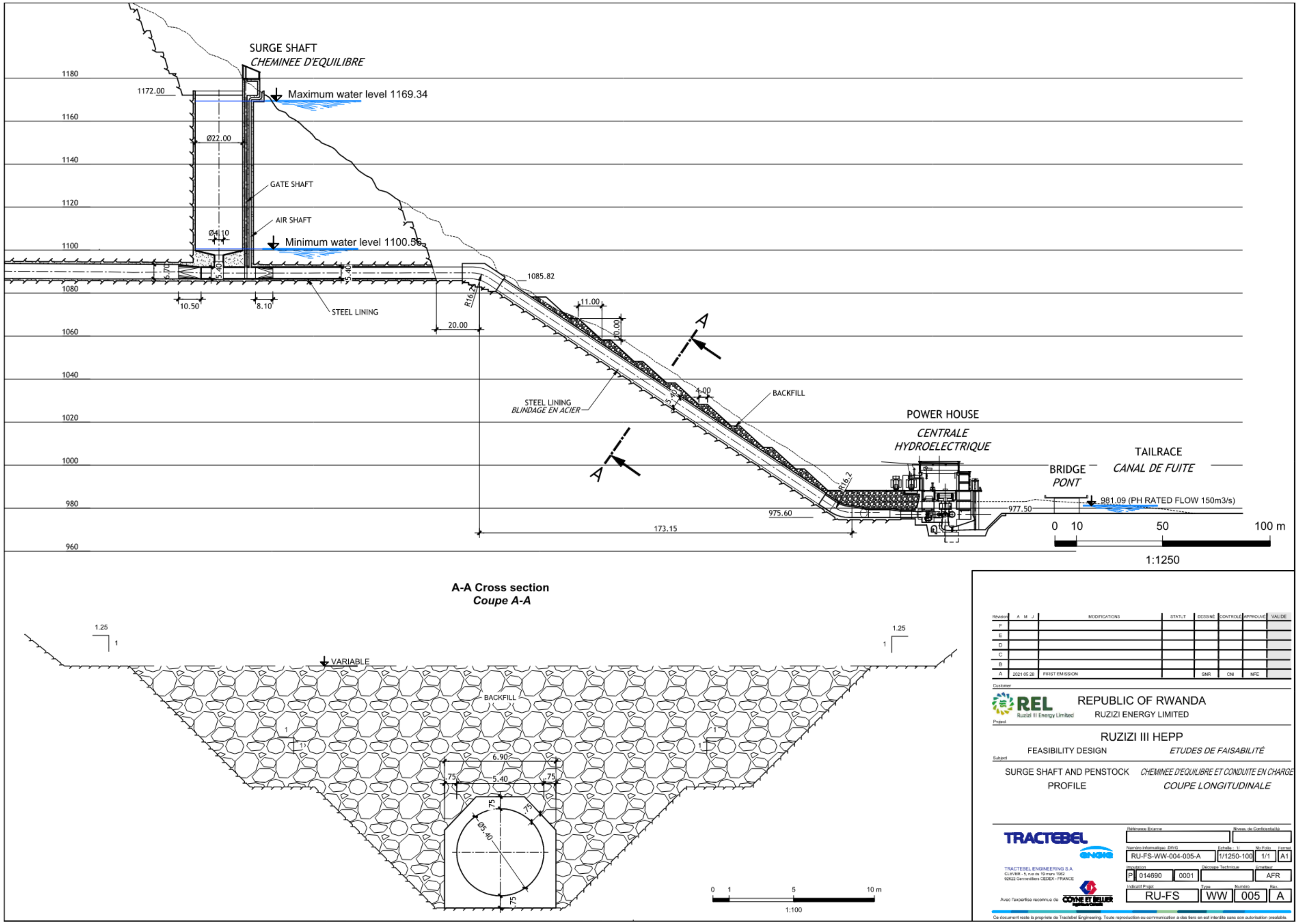

Figure 4-16 Surge Shaft and Penstock Profile

4.2.9 Operators' Village

The operators' village, a permanent accommodation camp, will be constructed near the powerhouse (see

Figure 4-3). During the construction phase, the camp will accommodate expatriate staff and REL's supervisors. Once construction is completed, the camp will accommodate operator staff. The camp on the Rwanda side will have accommodation capacity of 86 bedrooms as the camp on the DRC side will have 12 bedrooms. The camp will be equipped with adequate sanitary systems and a supply of clean water in sufficient quantity. Dispositions for waste managements will be foreseen. Part of the infrastructures of the camp may be used after the construction phase for medical treatment and/or educational purposes for local populations.

4.2.10 Transmission Lines and Switchyard

4.2.10.1 220 kV Switchyard

The Project's transmission switchyard (also called the evacuation switchyard) is a 220 kV switchyard situated downstream of the powerhouse on the DRC side of the river. It is an outdoor, air insulted, double busbar substation with coupling and a so-called associated phase arrangement. The switchyard is connected to the powerhouse step-up transformers via three 220 kV single circuit lines approximately 400 m long (see Figure 4-3).

4.2.10.2 30 kV Overhead Power Supply Transmission Line

The facilities located in the reservoir area, including the dam site and intake control tower, will be supplied with electrical power from the Project's transmission switchyard. A 30 kV overhead line on concrete poles follows the dam access road on the DRC side of the river.

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4.2.10.3 220 kV Overhead Transmission Line

Electrical power generated by the Project is transported from the transmission switchyard to the Kamanyola substation via a 220 kV overhead line that is 7 km in length. The line will have 18 double circuit galvanized steel lattice towers installed. Depending on the geotechnical conditions, the towers will be placed on either reinforced concrete slab foundation or concrete blocks anchored to the rock. The transmission line alignment is shown in the figure below. The width of the transmission line wayleave will be 30 m as per the Ministerial Order N° 0032/CAB/MIN/AFF.FONC/ASM/2023 dated 18 February 2023 which specifically authorises, for reasons of public utility, a wayleave width of 30 m for the Project.

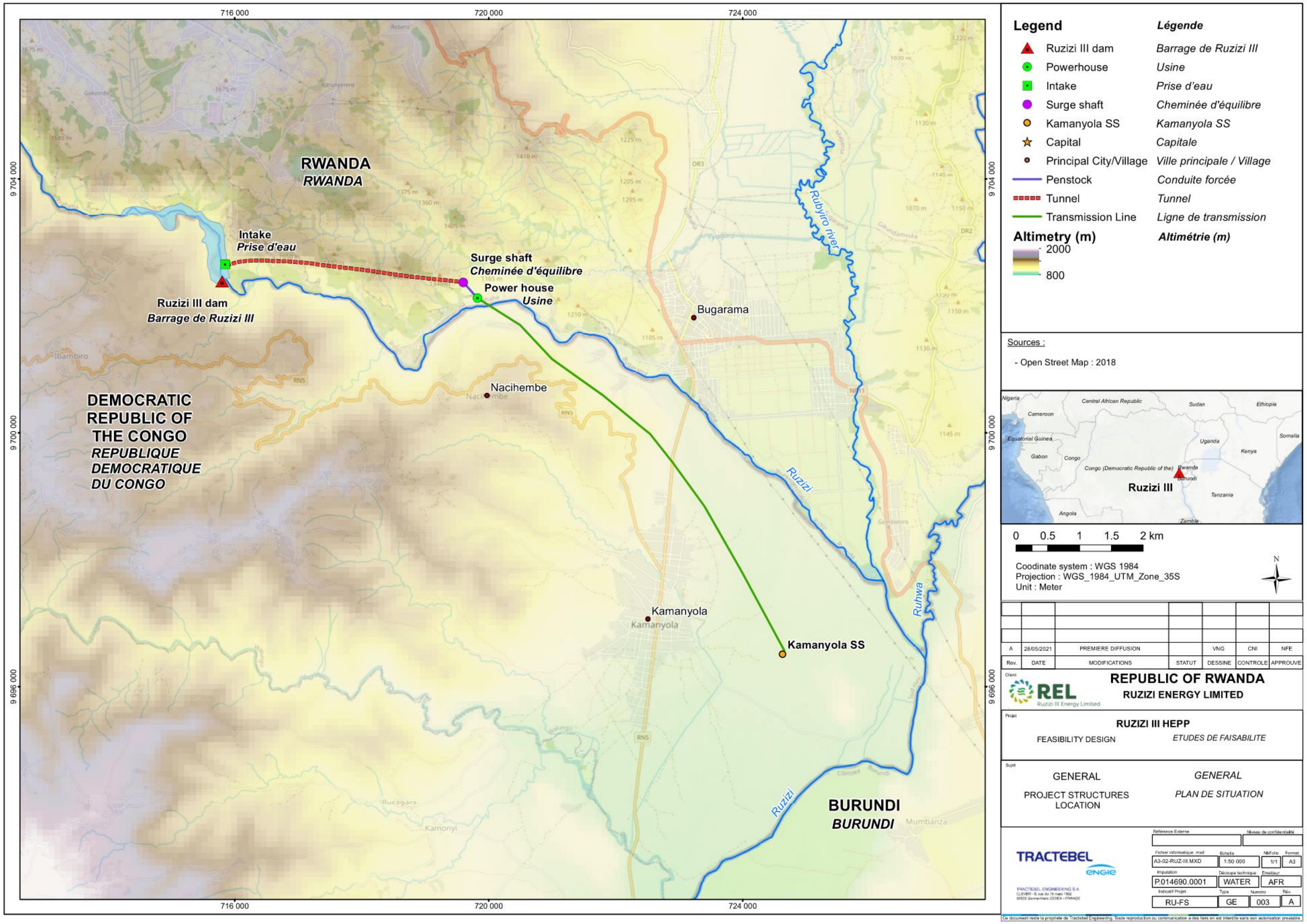

Figure 4-17 Project Structures Layout

4.3 Components for Construction Only

4.3.1 Overview and Layout

The facilities and infrastructure used for construction purposes only are described in the following subsections and comprise:

- Temporary accommodation camp for construction workers.
- Quarries and borrow areas.
- Spoil disposal areas.
- Access roads.
- River diversion works (tunnels and coffer dam).

The layout of facilities and infrastructure are shown in Figure 4-3.

4.3.2 Temporary Worker Accommodation Camp

An estimated 500-1,000 workers (skilled and unskilled) will be required for Project construction during the peak construction period. A temporary accommodation camp for workers will be installed on the left bank (Rwanda) between the dam site and powerhouse site (see Figure 4-3). The design of the camp (including definition of capacity) will be undertaken by the EPC Contractor.

The camp buildings will be provided by the Contractor on dedicated areas. Other necessary buildings will also be provided by the Contractor. The camps will be equipped with the necessary sanitary and water supply installations.

The Contractor will implement a water treatment plant for wastewater and ensure waste is managed in alignment with DRC and Rwanda regulatory requirements and in alignment with the World Bank ESS 3 – Resource Efficiency and Pollution Prevention and Management. Vol. IV – ESMP includes the framework Waste Management Plan and a framework Pollution Prevention and Control Plan, and these plans will be developed into detailed plans by the EPC Contractor prior to the start of construction.

The camp will be designed and operated in alignment with (i) ILO 1961 Workers' Housing Recommendations (R115) and IFC and EBRD 2009 Workers' Accommodation Processes and Standards.

The temporary camps will be dismantled at the end of the Works.

4.3.3 Quarries and Borrow Areas

Based on the project reference design, preliminary estimates of quantities needed for extracted materials is presented in Table 4-5 below.

Table 4-5 Estimated Quantities of Extracted Materials

Category of Material	Estimated Quantities	Use
Clayey Material	177,164 m^3	Central Core for Dam body
River Sand (Fine Aggregates)	50,550 m^3	Dam filter material and Concrete Works
Coarse Aggregates	101,101 m^3	Concrete Works and Base Material for Road Works
Rock fill & Ripraps	776,364 m^3	Dam slopes protection works + powerhouse works
Subbase Material (Murrum)	31,818.00 m^3	Road Construction

The potential quarry sites which have been identified by REL in Rwanda, DRC and Burundi are listed in Table 4-6 together with an indication of the quantity of material available from each site. However, the EPC contractor will be responsible for selecting the choice of materials and sites for the quarries taking into account material quality and haulage distance economics. Consequently, the selected sites may correspond to sites identified by REL or alternative sites.

Because the sitting of the quarries and borrow areas will be defined at a later stage, they are not included in the scope of the ESIA. However, Vol. IV - ESMP includes the process for REL's review and approval of the sites proposed by the EPC Contractor so that there is avoidance or minimisation of environmental and social impacts. REL will engage an ESIA consultant to conduct the environmental and social impacts for the establishment and exploitation of the quarries and borrow areas and any necessary access roads. The ESIA and RAP will meet international standards and demonstrate alignment with lenders' E&S policies.

Table 4-6 Potential Sites for Quarries in DRC, Rwanda and Burundi

Country	Site	Type of material	Quantity available
DRC	Bwegera	River Sand	Large quantities of sand replenished during rainy season
	Kirindangumi	River Sand	
	Ruvubu/ Nyabulindima River	Site 1 fine to coarse gravel; Site 2 river Sand, coarse grained gravelly sand	Large quantities of sand replenished during rainy season Estimated 180 m^3/day
	Nyarubare	Basalt Aggregates	Not specified in study
	Mt. Rubona	Sandstone Aggregates	Not specified in study
Rwanda	Ntangara River	River Sand, Medium to coarse grained Sand with mica flakes	Not specified in study
	Kirimbi River	River Sand, Fine to medium with visible organic matter and mica	Sand available perennially Estimated 180 m^3/day
	Kirimbi Delta	River Sand, Fine to medium grained with micas	Not specified in study
	Kigoya River	River Sand, Dark Brown Silty Sand	Not specified in study
	Karundura River	Whitish Grey, medium to coarse grained sand	About 180m^3/day
	Gihungwe	Mafic, fine grained columnal basalt	About 1.6 Million m^3 of aggregate reserve
	Quartzite APD	Light grey, slightly foliated, Quartzite Schist (suitable for riprap and retaining wall masonry works)	About 500,000 m^3 of exploitable material
	Tunnel Spoils	Quartzite Schist (may be suitable for riprap, retaining masonry works, road base material)	Not specified in study
	Gishoma Peat Power Plant	Lateritic Clayey Soil for Dam Core	About 300,000 m^3 of suitable material
	Nyagahanda	Lateritic Clayey Soil	About 50,000 m^3 of suitable material
	Mashyuza	Murrum material	To be defined by the EPC Contractor
	Mashesha	Murrum material	To be defined by the EPC Contractor
	Gombaniro	Murrum material	To be defined by the EPC Contractor
	Kibangira	Murrum material	To be defined by the EPC Contractor
	Gatebe	Murrum material	To be defined by the EPC Contractor
Burundi	Rukana II	Lateritic Clayey Soil	About 300,000 m^3 of suitable material
	Rukana I	Basalt rock	About 700,000 m^3 of suitable material
	Nyakagunda	Fine to medium sand with occasional cobbles	Estimated 50 m^3/day during wet season, 14 m^3/day during dry season

Source: Construction Material study by REL, August 2022

The Construction Materials Study prepared by REL concluded the following:

- Abundant and suitable impervious material for the dam core structure is available at the Gishoma Peat borrow area (Rwanda) and its surrounding areas. A key consideration is the need to create a new road which traverses through steep terrain and area prone to landslides. The Rukana II (Burundi) Borrow areas are also potential candidate sites for EPC contractor consideration.
- For River Sand requirements, the Ruvubu/Nyabulindima Rivers on the DRC side provide materials seemingly free of mica when compared to sources on the Rwanda side. Mica poses a challenge to the quality and durability of concrete. The nearest site in Burundi offers small quantities. Challenges to consider regarding the DRC sources is related to poor road conditions, unpredictable insecurity situation within DRC territory as well as complications related to cross border issues.
- Potential basalt quarry sites in both DRC and Rwanda have material with acceptable suitability for construction. Test results for aggregates showed the Ruganzu quarry to be the best in terms of quality however this site has been excluded due to the presence of cultural heritage. While the quality of material from the APD site is not considered suitable for general construction, the material may be suitable for rockfill and riprap material. Burundi's Rukana I Basalt site is also a likely suitable candidate.
- For road subbase (murrum) material, several existing borrow areas have been identified and material samples tested in the laboratory have suitable properties/characteristics.

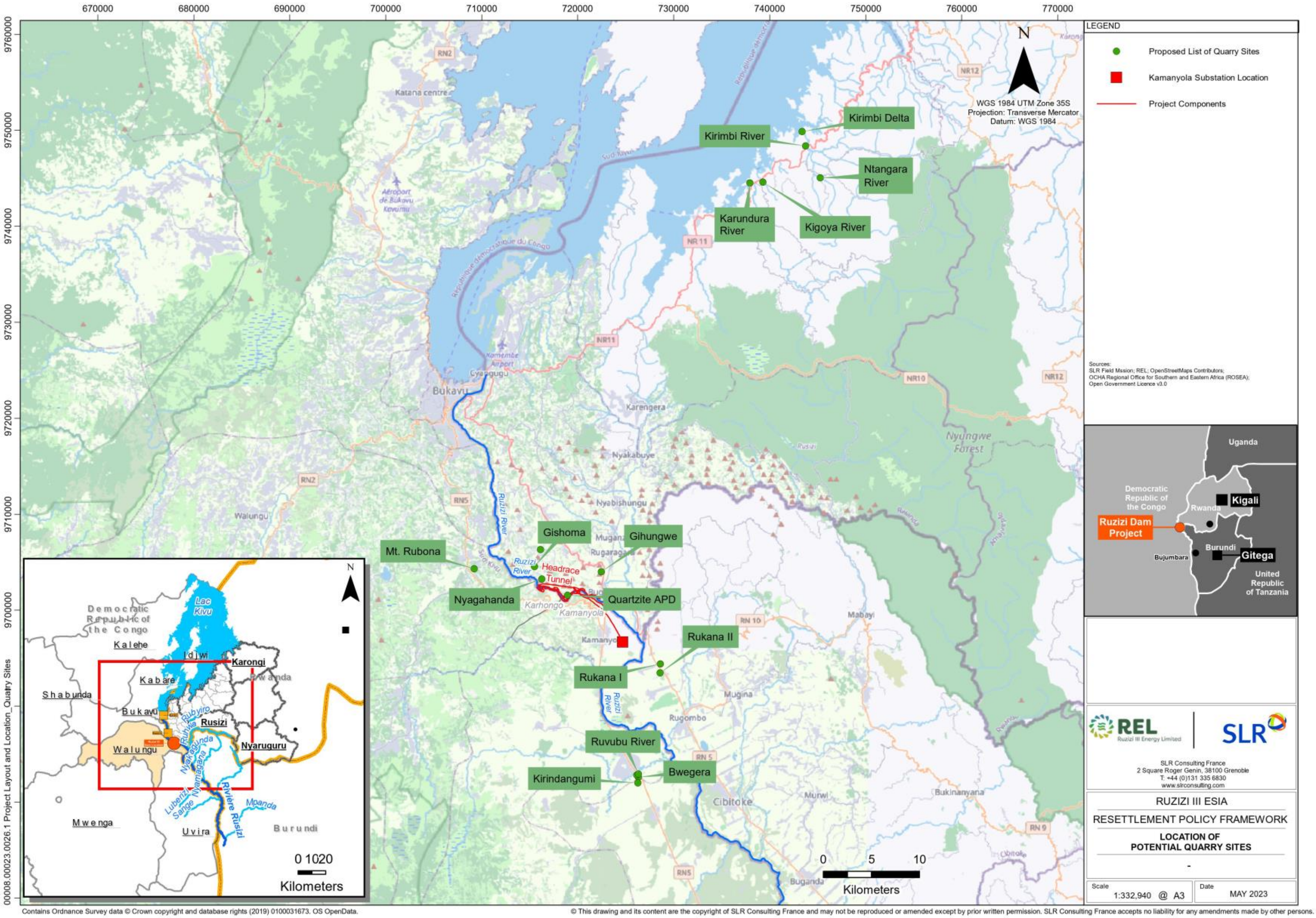

Figure 4-18 Location of Potential Quarry sites in DRC, Rwanda and Burundi

4.3.4 Spoil Disposal Areas

Information regarding volume, use, disposition of spoils is unknown at the time of writing and will be determined by the EPC Contractor. Spoil disposal areas will be identified by the EPC Contractor at a later stage. The Feasibility Study has identified a potential spoil area shown in Figure 4-3.

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4.3.5 Construction Access Roads

The permanent roads and roads which will be used only during construction are described in Section 4.2.8.

4.3.6 Diversion Tunnels

The Project plans for two concrete-lined diversion tunnels with a capacity to divert the peak discharge of the construction flood (452 m^3/s). The construction flood corresponds to the combined flows of the maximum turbined discharge from Ruzizi-III (154 m^3/s), Ruzizi-I spillway operating with one gate open (57 m^3/s) and a peak discharge from a 20-year return period flood on the catchment between Ruzizi-I and -III (241 m^3/s). The two tunnels will have their inlet inverts at an elevation of 1,107 m asl, a slope of 1% and a length of approximately 180 m. They will both have a diameter of 4.8 m. The sections are characterized by vertical walls on the lower half of the height and an arched roof. The tunnel profiles are provided in Figure 4-19.

4.3.7 Cofferdam

The role of the cofferdam is to protect the site from floods and divert the river flow into the diversion tunnels. The cofferdam will be made of alluvial material recovered from the river, and its crest will reach the 1,120 m asl level, fine sorted materials will ensure its sealing, and the upstream recharge will be protected by large-diameter riprap.

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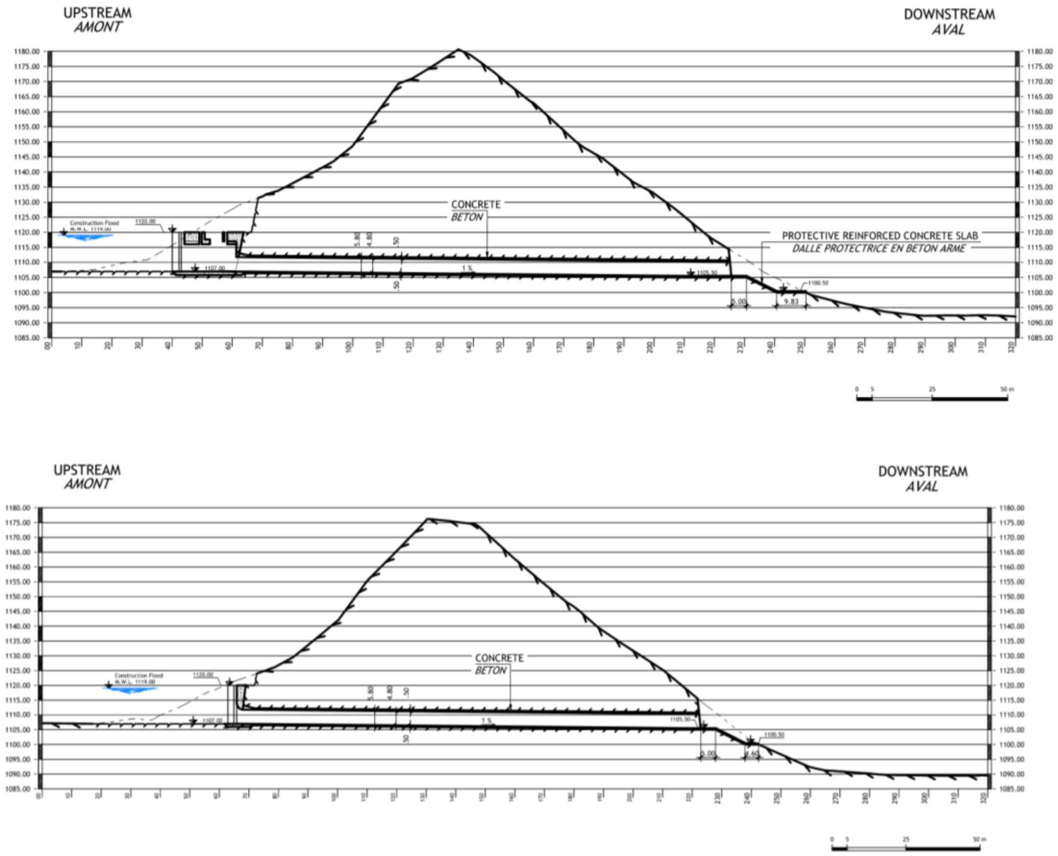

Figure 4-19 Diversion Tunnels Profiles

4.4 Construction Activities and Reservoir Filling

4.4.1 Construction Contracts

The construction works will be executed by an EPC Contractor. An EPC Contract is a prominent form of contracting agreement in the construction industry. The EPC Contractor carries out the detailed engineering design of the Project, procures all the equipment and materials necessary, and through various subcontracts then constructs the Project to deliver a functioning facility to REL.

4.4.2 Construction Schedule

The construction schedule for the Project is estimated by the Feasibility Study (Tractebel, 2022a) to be approximately 56 months.

- At the start of the Contract, the Contractor shall mobilize the personnel and equipment on the site to start the first activities. At the same time, various studies of the civil engineering, the hydro-electro-mechanical equipment, and transmission lines shall start.
- The preparatory works concern mainly the access infrastructures to the project site and the camp on the Rwanda side as well as construction facilities.
- Once the state of roads allows to access the main construction fronts (dam site, tunnel adits, surge shaft, etc) the excavation activities will start.
- On the reservoir area the surface excavations for the spillway from top to bottom will be performed followed by the excavation of the intake tower and deviation tunnels intakes.
- At the same time preparation of underground excavations is set up in three different fronts (upstream, intermediate adit and downstream).
- The excavation of deviation tunnels will be performed followed by the concreting of inner lining.
- Once the intakes of the deviation tunnel are ready the river is diverted, and the cofferdam construction starts. Following the cofferdam, the excavation and foundation treatment of the dam can start.
- The concrete works of the powerhouse are separated in two stages. The schedule presents the works necessary to provide the erection bay operational as soon as possible to allow starting the handling of heavy components of equipment.

4.4.3 River Diversion Works

The construction of the dam requires the dewatering of the site where it will be located. The dewatering is carried out by means of an upstream cofferdam to protect the construction area from flooding. It will divert the river during construction by means of two tunnels (approximately 180 m long).

4.4.3.1 Stage 1

Two concrete-lined tunnels will be excavated through the rock spur that is the left bank abutment of the dam (Rwanda side), while the river flows in its natural bed. The tunnels will be designed for a capacity of 452 m^3/s (the diversion flood). One of the tunnels will be re-used later as a bottom outlet tunnel. The tunnels are horseshoe-shaped in cross-section, rest on a base plate at elevation 1,107 m asl, are 180 m long, have a 1% inclination and an internal diameter of 4.8 m. Underground excavation work for the tunnels, it will be done with the drill and blast technique.

4.4.3.2 Stage 2

Once the two diversion tunnels are completed, the river will be dammed with a cofferdam and will be diverted through the tunnels. The cofferdam embankment will be made of alluvial material. Specifically selected fine material from the river alluvium will make the imperviousness of the embankment. The upstream slope will be protected with selected coarse rockfill. The crest of the cofferdam will be set at elevation 1,120 m asl.

No downstream cofferdam will be required to protect the dam construction works because the diverted flows re-join the Ruzizi downstream of a natural fall, some 16 m below the dam site elevation.

4.4.3.3 Stage 3

Once the dam, spillway, intake tower and first stage concrete of the bottom outlet tower are completed, the diversion tunnel that will be re-equipped as bottom outlet will be closed with stoplogs. Once it is closed, its hydraulic steel structures will be installed and the second stage concrete will be cast, for completion of the structure. Once the gates are installed and the structure completed, the upstream stoplog will be removed. During the installation of the bottom outlet equipment, the Ruzizi flows will be derived though the second diversion tunnel which is designed so that it can convey the maximum flow rate of Ruzizi I powerhouse, i.e. 154 m^3/s, so that it remains possible to access to the stoplog of the bottom outlet tunnel. Once the bottom outlet is completed, this second diversion tunnel will be completed to install the minihydro.

4.4.4 Power Supply, Water Supply and Wastewater

4.4.4.1 Power Supply

The main worksites will be supplied with electricity through generator plants installed by the EPC Contractor for the construction period. A network of distribution lines will link the generator to the workplaces.

4.4.4.2 Water Supply

The water requirements will be determined by the EPC Contractor during the detailed design. It can be anticipated that water will be required for industrial uses (e.g. washing & screening of aggregates, concrete batching, field compaction, dust suppression, wet-drilling) and domestic uses (e.g. drinking, food preparation and other canteen operations, laundry, bathrooms and other sanitary facilities located within the Project temporary facilities such as accommodation camps and offices.

The source of water will be defined by the EPC Contractor in the detailed design phase. However, it can be expected the water will be abstracted from the Ruzizi River, and if necessary treated to applicable standards and distributed to construction facilities through buried pipelines. It is unlikely that river water will be used as potable water and may need to be transport to the worker camps.

4.4.4.3 Wastewater

Wastewater treatment will be defined by the EPC Contractor during the detailed design. However, it can be anticipated that domestic wastewater is likely to be treated by modular unit type wastewater treatment plants, which include preliminary treatment (physical screening), secondary treatment (biological and chemical), and tertiary treatment (e.g. chlorination disinfection and sand filter).

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The quality of treated effluents will be monitored on a regular basis and will comply with the national standards for sanitary wastewater discharges to surface waters and the discharge standards set out in the World Bank EHS Guidelines before discharge into the Ruzizi River.

Treated wastewater will be stored in an impounding tank and may be used for industrial process or dust suppression where it is available. Wastewater from offices, warehouse and workshops will be directed to septic tanks. Sewage trucks will regularly maintain these septic tanks and transport the effluents to the wastewater treatment plants. Oily effluents collected in oil separators will be collected and transported to a specialized facility in Rwanda for treatment and disposal.

4.4.5 Materials Origins and Wastes

4.4.5.1 Rockfill Embankment Material

The material will be sourced from excavation works and from a borrow area, as described in Section 4.3.3.

4.4.5.2 Quantities of Material

Table 4-7 Estimated Quantities of Construction Materials

Item	Type	Quantity	Unit
Upstream cofferdam			
Clay core	Earth and Rock	14,701	m^3
Filter/Drain/Transition	Earth and Rock	29,403	m^3
Rockfill	Earth and Rock	30,235	m^3
Rip rap	Earth and Rock	3,920	m^3
Dam			
Excavation - Open air - Soil	Earth and Rock	13,554	m^3
Clay core	Earth and Rock	162,463	m^3
Filter/Drain/Transition	Earth and Rock	64,019	m^3
Rockfill	Earth and Rock	635,620	m^3
Rip rap	Earth and Rock	90,206	m^3
LB platform			
Excavation - Open air - Soil	Earth and Rock	6,520	m^3
Excavation - Open air - Rock	Earth and Rock	58,680	m^3
Shotcrete - Open air	Concrete	94	m^3
Spillway			
Open air spillway - Inlet, weir, chute, energy dissipation			
Excavation - Open air - Soil	Earth and Rock	10,800	m^3
Excavation - Open air - Rock	Earth and Rock	97,200	m^3
Concrete - Open air - structural	Earth and Rock	8,581	m^3
Reinforcement steel	Steel	520	Tonnes
Bottom Outlet			
Inlet			
Excavation - Open air - Rock	Earth and Rock	7,139	m^3
Concrete - Open air - structural	Concrete	3,073	m^3

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Item	Type	Quantity	Unit
Reinforcement steel	Steel	292	Tonnes
Shotcrete - Open air (incl. wire mesh)	Concrete	41	m^3
Tunnel			
Excavation - Tunnel - Rock I-III	Earth and Rock	4,756	m^3
Concrete - Underground - Structural (incl. formwork)	Concrete	1,499	m^3
Reinforcement steel	Steel	229	Tonnes
Shotcrete - Underground	Concrete	236	m^3
Energy dissipation			
Excavation - Open air - Rock	Earth and Rock	954	m^3
Concrete - Open air - structural	Concrete	434	m^3
Reinforcement steel	Steel	33	Tonnes
Shotcrete - Open air	Concrete	9	m^3
Diversion Tunnel			
Portals			
Excavation - Open air - Rock	Earth and Rock	8,739	m^3
Concrete - Open air - structural	Concrete	600	m^3
Reinforcement steel	Steel	36	Tonnes
Shotcrete - Open air	Concrete	43	m^3
Tunnel			
Excavation - Tunnel - Rock I-III	Earth and Rock	4,756	m^3
Concrete - Underground - Structural	Concrete	1,499	m^3
Reinforcement steel	Steel	229	Tonnes
Shotcrete - Underground	Concrete	236	m^3
Power waterways			
Power intake			
Excavation - Open air - Rock	Earth and Rock	7,258	m^3
Concrete - Open air - structural	Concrete	6,500	m^3
Reinforcement steel	Steel	389	Tonnes
Shotcrete - Open air	Concrete	34	m^3
Headrace tunnel			
Excavation - Tunnel - Rock I-III	Earth and Rock	138,750	m^3
Excavation - Tunnel - Rock IV-V	Earth and Rock	46,250	m^3
Concrete - Underground - Structural	Concrete	40,300	m^3
Reinforcement steel	Steel	1,900	Tonnes
Shotcrete - Underground	Concrete	3,920	m^3
Surge tank			
Excavation - Open air - Soil	Earth and Rock	19,825	m^3
Excavation - Open air - Rock	Earth and Rock	19,825	m^3
Excavation - Shaft - Rock	Earth and Rock	34,265	m^3
Concrete - Underground - Structural	Concrete	8,265	m^3
Reinforcement steel	Steel	248	Tonnes

Item	Type	Quantity	Unit
Shotcrete - Open air	Concrete	145	m^3
Shotcrete - Underground	Concrete	1,011	m^3
Steel-lined tunnel and penstock			
Excavation - Open air - Soil	Earth and Rock	127,400	m^3
Excavation - Open air - Rock	Earth and Rock	54,600	m^3
Excavation - Tunnel - Rock I-III	Earth and Rock	3,848	m^3
Random fill	Earth and Rock	81,478	m^3
Concrete - Open air - structural	Concrete	5,149	m^3
Concrete - Underground - Structural	Concrete	1,558	m^3
Reinforcement steel	Steel	268	Tonnes
Shotcrete - Open air	Concrete	225	m^3
Shotcrete - Underground	Concrete	148	m^3
Access tunnel			
Excavation - Open air - Soil	Earth and Rock	10,000	m^3
Excavation - Open air - Rock	Earth and Rock	11,600	m^3
Excavation - Tunnel - Rock I-III	Earth and Rock	9,925	m^3
Excavation - Tunnel - Rock IV-V	Earth and Rock	1,080	m^3
Concrete - Underground - Structural	Concrete	3,270	m^3
Concrete - Underground - Backfill	Concrete	165	m^3
Reinforcement steel	Steel	100	Tonnes
Shotcrete - Underground	Concrete	275	m^3
Powerhouse			
Excavation - Open air - Soil	Earth and Rock	81,131	m^3
Excavation - Open air - Rock	Earth and Rock	50,387	m^3
Random fill	Earth and Rock	27,510	m^3
Rockfill	Earth and Rock	13,255	m^3
Rip rap	Earth and Rock	3,128	m^3
Concrete - Open air - backfill	Concrete	300	m^3
Concrete - Open air - structural	Concrete	17,000	m^3
Reinforcement steel	Steel	1,530	Tonnes
Steel - structural	Steel	110	Tonnes
Switchyard			
Random fill	Earth and Rock	48,500	m^3
Concrete - Open air - backfill	Concrete	2,400	m^3
Concrete - Open air - structural	Concrete	2,000	m^3
Reinforcement steel	Steel	100	Tonnes
Roads			
Earthworks	Earth and Rock	75,790	m^3
Excavation - Open air - Soil	Earth and Rock	45,898	m^3
Excavation - Open air - Rock	Earth and Rock	81,693	m^3
Fill	Earth and Rock	185,921	m^3

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Item	Type	Quantity	Unit
Subbase	Earth and Rock	31,818	m^3
Roadbase	Earth and Rock	31,565	m^3
Concrete - Lateral drainage channels	Concrete	5,010	m^3
Concrete - Drainage channels on slopes	Concrete	1,953	m^3
Gabions	Earth and Rock	39,024	m^3
Minihydro Civil Works			
Excavation - Open air - Rock	Earth and Rock	1,072	m^3
Concrete - Open air - backfill	Concrete	195	m^3
Concrete - Open air - structural (incl. formwork)	Concrete	2,955	m^3
Reinforcement steel	Steel	191	Tonnes

Source: TRACTEBEL, 2022a

4.4.5.3 Spoil

Civil works will be designed by the EPC Contractor in the next stage of the Project to optimise the reuse of excavated material for the dam construction. At the current stage in the Project the quantities of spoil and identification of spoil disposal sites has not been carried out. Nevertheless, it can be anticipated that not all excavated material may be used for backfilling purposes, and that there will be a need for some spoil disposal.

4.4.5.4 Wastes

The typical waste generated by hydropower schemes such as Ruzizi-III include the following:

- **Non-hazardous waste**: Waste from the camps and canteens, paper, cardboard, plastics, wood and vegetation, inert wastes from construction and demolition (concrete, scrap iron, bricks, etc). The amount of domestic waste to be generated from the workers' camp can be estimated at 0.5 kg/per person/day, or about 500 kg/day for 1,000 workers.
- **Hazardous waste:** Engine oils and used hydraulic fluids, residues of paint, solvents and resins, fluids from transformers, medical wastes, sludge from septic tanks, and various concrete additives. Quantities of hazardous waste are variable and project specific. The EPC Contractor bidding documents require the Contractor to prepare a waste management plan, which will require preparation of a detailed inventory of wastes, estimation of quantities and identification of management solutions in alignment with Rwanda and DRC regulations and Good International Practice.

4.4.6 Traffic

A detailed construction traffic study will be conducted by the EPC contractor in the next phase of the Project. However, for the purpose of this ESIA a preliminary estimate of the order of magnitude of truck movements has been made. The Feasibility Bill of Quantities estimates that a total of 2.5 million m^3 of earth and rock will need to be moved and 110,542 m^3 of concrete will be needed.

The Feasibility Study indicates that the duration of the civil works is 1,168 days. Therefore, assuming that a typical tuck has a capacity of ~60 m^3, there will be in the order of 36 return-trip truck journeys per day on average, and during periods of peak activity there may be up to c. 50-60 return trips per day. It is not possible at this stage to determine the number of trucks on each stretch of road, but the overall figures indicate that during peak activity periods there may one truck passing along an access road every 5 to 10 minutes during daylight hours.

4.4.7 Reservoir Clearing and Filling

Clearing of the reservoir footprint (46 ha) may be needed prior to reservoir filling. However, it expected that clearing of trees and vegetation will not be carried out. The vast majority of the land cover in the footprint is agricultural land. However, there are some trees and scrub, which will probably not need to be clearedas the environmental gain in terms of reservoir water quality will be negligible, and the management of the removed vegetation will incur additional costs.

With an annual average flow of 109.9 m^3/s, the Ruzizi River would theoretically fill the Ruzizi-III reservoir in less than 24 hours. However, for dam structure stability reasons it would be better to fill the reservoir more slowly and part of the river flow will have to continue flowing downstream for ecological and socioeconomic reasons during reservoir filling. Therefore, the Feasibility Study assumes 12 days for reservoir filling.

4.4.8 Construction Methods for the Transmission Line

4.4.8.1 Site Preparation, Establishment and Reinstatement

Works would commence with site clearance and ground preparation of working areas, creation of access tracks and associated laydown areas. This would typically involve the removal and appropriate storage of topsoil (for later reinstatement). Some working areas may require the use of crushed stone potentially overlain on a reinforcing geotextile membrane if the ground conditions are soft.

4.4.8.2 Access Tracks

Where possible, existing roads and access tracks would be used for the works. However, some access tracks will need to be established by the Construction Contractor. Access tracks would be approximately 4.5 m wide although could be wider in places depending upon topography and access requirements.

4.4.8.3 Tree and Vegetation Removal

The removal (or height reduction) of trees and ground vegetation would be required ahead of soil stripping or any excavation and foundation works. Tree removal and vegetation clearance would be kept to a minimum within the 30 m wide wayleave. It is noteworthy that the land cover of the vast majority of the transmission line wayleave is agricultural land and there are very few trees or almost no natural vegetation.

4.4.8.4 Temporary Construction Compounds

Because of the relatively short length of the transmission line (7 km) it is probably unlikely that temporary construction compounds will be required at intervals along the transmission line.

4.4.8.5 Installation of the Transmission Line Towers and Conductor Lines

Following construction of the working areas and the clearance of the wayleave, the construction of the transmission lines would begin with the construction of the foundations for the towers. In flat or moderately hilly areas, the foundations would generally comprise either standard pad and chimney, concrete block designs or be piled depending on ground conditions. Pre-mixed concrete would be delivered to site along with steelwork for the foundation frames and bases. The foundation would comprise reinforcing steelwork cylinders encased in concrete, with 'stubs' projecting through the concrete above ground to which the tower legs would be attached. The modular lattice towers would be erected in sections, with a mobile crane.

The conductor lines would be delivered to site on drums using HGVs as would the tensioning and pulling machines. The preparation of the working corridor is undertaken in advance of the conductor stringing. This may require the use of scaffolding in some instances to protect members of the public and assets from transmission line construction works. Items that may require protection include roads, tracks, buildings, and lower voltage transmission lines. The works may also require the crossing over or diversion of lower voltage local distribution lines. This would typically be undertaken in advance of the Project's construction works and in a manner that ensured continuity of local energy supplies to local communities. Some tree and vegetation removal would also be required to enable the stringing works to take place, particularly in wooded areas.

The conductor lines are installed in sections between approximately 10 towers at a time. The pilot wires are run at ground level (and over any temporary scaffolding protecting obstacles and roads) along the full length of the section, between the 'pulling site' and the 'tensioning site' where the new conductor is positioned. If necessary, a corridor of up to 5m wide would be cleared of trees and vegetation. However, such clearance would be avoided where possible by passing the pilot wire around areas of tree and vegetation. The pilot wires are then lifted and fed through running wheels on the cross arms of all the towers in the middle of the section, and then fed around a special machine at the final tower or pulling site in the run of towers being strung. In order to keep the conductor lines off the ground and avoid any damage to property, the tensioning site has a similar machine that stops the conductor line running freely when the pulling machine 'pulls' the pilot wire. When the pilot wire is tensioned, it pulls through the conductor line avoiding contact with the ground through the towers before connecting to the final tower in the run. The required tension and height above ground are made and the process begins again for the next section of towers.

4.4.9 Manpower Requirements

The construction will require between 500 and 1,000 workers at the site (Tracebel, 2021) and the duration of the construction is expected to be in the order of 56 months. It can be expected that about 80% to 90% of the workforce will work at the dam site and the access roads. The other 10% to 20% will be mobilized for the construction of the transmission line. The operation of the scheme will require only a small number of staff, probably in the order of 50 people.

4.5 Operation and Maintenance

4.5.1 General

The Project is situated downstream from the existing Ruzizi-I and -II hydropower schemes, both of which operate with hydropeaking. Consequently, once the Project is implemented the Ruzizi cascade will need to operate in a coordinated manner, and Ruzizi-III and will operate with periods of peak and off peak flows. The timing of the release of peak and off peak flows from the Project is driven by the demand for electricity and the Power Purchase Agreement (see Figure 4-20). The daily energy demand considered in the Project's Power Purchase Agreement is provided in the figure below and it shows that the peak and off peak energy demand periods are as follows:

- Off peak energy demand during the night (22:00 to 04:00).
- Ramp up in energy demand in the early morning (04:00 to 06:00).
- Period of peak demand during the morning (06:00 to 08:00).
- Lowering of energy demand during the day (08:00 to 16:00).
- Second ramp up of energy demand and period of peak demand in evening (16:00 to 20:00).

- Lowering of energy demand to off peak levels in the late evening (20:00 to 22:00).

The electrical power generated by the Project is transported to the Kamanyola 220 kV substation, developed by EGL and which will be operated by SINELAC. The Kamanyola substation will act as the dispatching centre and will coordinate the transport of electrical power to Burundi, DRC and Rwanda.

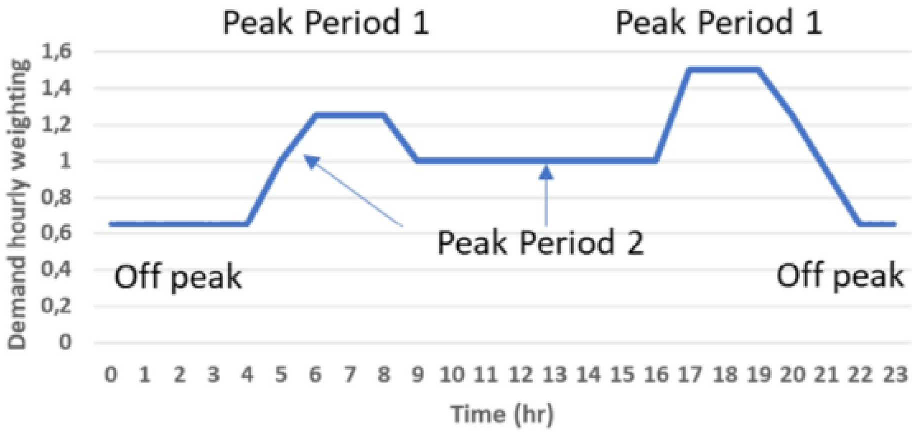


Figure 4-20 Daily Energy Demand Distribution Considered in the Ruzizi-III Power Purchase Agreement

4.5.2 Annual Energy Generation

The Project's feasibility Study (Tractebel, 2022a) has estimated energy production for the Ruzizi-III powerplant and the Ruzizi cascade as a whole using the software programme MIKE HYDRO Basin. Energy production has been estimated using simulations for 2 operating schemes and the results are presented in the table below for two cases: (i) relative distribution of flows, where operators aim to maintain the relative distribution of flows in order to meet the requirements of the power purchase agreement, and (ii) peak hour placement of flows, where operators aim to release the maximum installed capacity flows during the peak hours and to replenish the reservoir storage during off-peak hours.

Table 4-8 Key Characteristics of the Power Waterway Components

Operating Scheme	Mean Annual Energy (GWh)		Firm Energy (GWh)*	
	Project	Cascade	Project	Cascade
Relative distribution of flows	1,197	1,544	989	1,269
Peak hour placement of flows	1,153	1,496	945	1,226
* Non-exceedance probability of 5% Source: Tractebel, 2021				

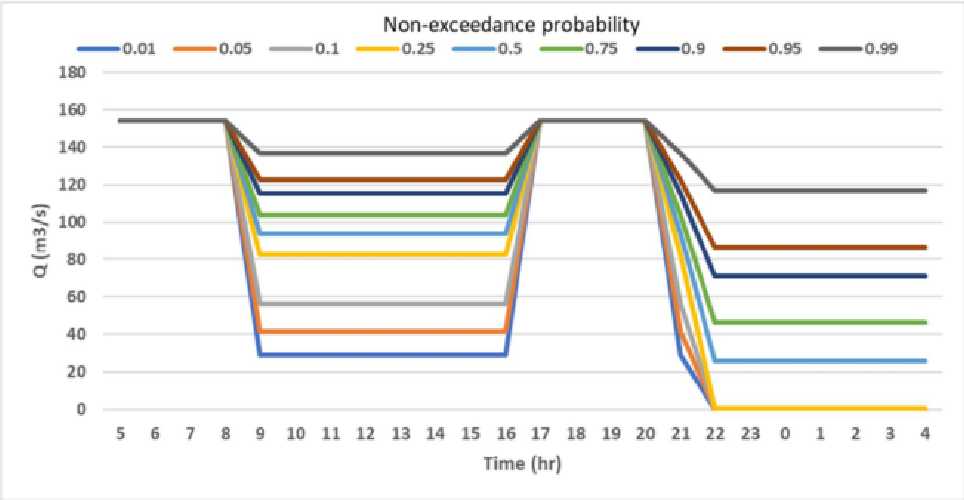
4.5.3 Powerhouse Daily Operations

The Project's feasibility Study (Tractebel, 2022a) has assessed how Ruzizi-I, -II and -III reservoir and powerhouse operations can be optimised once the Project is implemented. The findings of the assessment are summarised as follows:

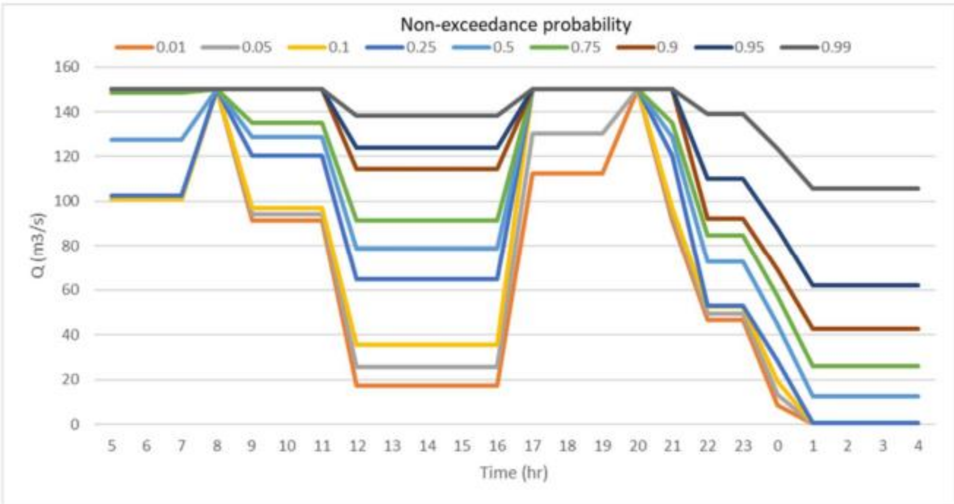
- Ruzizi-I: It is optimal to release peak flows during the morning and afternoon period of peak energy demand, and to replenish reservoir storage during periods of off peak energy demand.
- Ruzizi-II: Operation is constrained by the lack of available storage volume (because of sedimentation) and the 3-hour lag for the flows from Ruzizi-I to reach Ruzizi-II. Consequently, it will be frequent that releases during peak energy demand periods are below the maximum installed capacity.

- Ruzizi-III: The operation will be as for Ruzizi-I, i.e. to release peak flows during the morning and afternoon period of peak energy demand, and to replenish reservoir storage during periods of off peak energy demand.

The variations in turbined flows over 24-hours for the Ruzizi cascade hydropower schemes for different inflow conditions are presented graphically in Figure 4-21.



Ruzizi-I



Ruzizi-II

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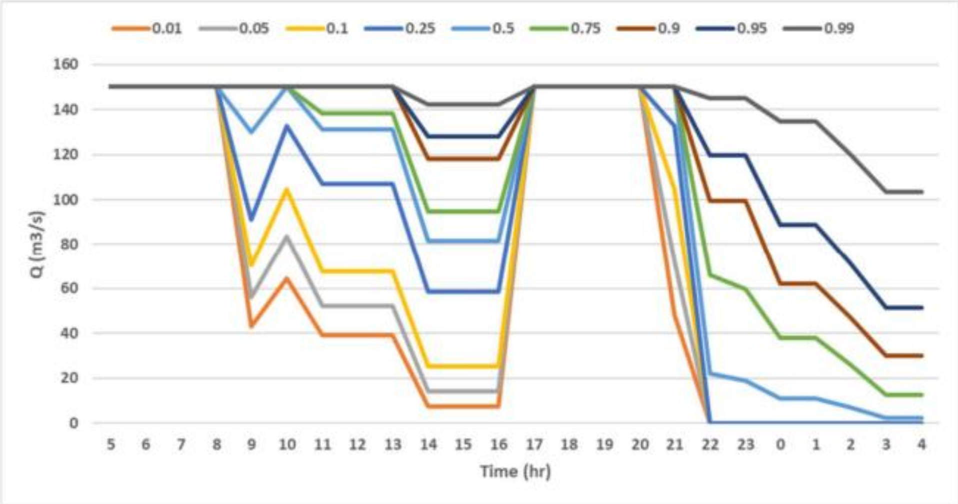

Ruzizi-III

Explanatory Note: Non-Exceedance Probability (NEP) is the likelihood that a specified flow rate is not exceeded. The NEP of 0.01 corresponds to a low river flow and the NEP of 0.99 corresponds to high river flow

Figure 4-21 Optimised Turbined Flows for Ruzizi-I, -II and -III

4.5.4 Variations of Reservoir Water Level and Downstream Flow

The hydropeaking mode of operation has implications in terms of variation of reservoir water level, and variation of river flow and river water levels downstream of the powerhouse.

Reservoir water levels will fluctuate, to varying degrees, between the FSL and the minimum operating level during the course of 24 hours. Consequently, the maximum change in water level will be 12 m, which will occur during periods of low seasonal river flow, when off peak flow is at the lowest. During periods of high seasonal river flow, there will be smaller changes in reservoir water levels.

The lowering of the reservoir water level by 12 m will reduce the reservoir surface area from 46 ha to 20 ha, effectively temporarily reducing the size of the reservoir by 40%.

Hydropeaking will also result in hourly variations in river flow rates in the reach downstream from the Project powerhouse. During normal river flow conditions, the highest flow rate will be the maximum turbining capacity of the powerhouse (150 m^3/s), and the lowest flow rate will be ecological flow (10 m^3/s) plus the off peak flow.

To summarise, the river flow rate immediately downstream from the powerhouse can change from 150 m^3/s to 10 m^3/s during a 24-hour period. The magnitude of variations in river flow rate decreased with distance from the powerhouse as discussed in Chapter 10 – Eflow Assessment.

4.5.5 Sediment Management

A sediment management plan will be prepared during the EPC design activities and will consider both structural and non-structural measures to manage sediment. For comparison, it is noteworthy that the Ruzizi-II reservoir capacity has been reduced to 40% of the initial capacity after 24 years of operation (1989-2013). The framework sediment management plan that will be developed into a detailed plan early during project preparation by the EPC Contractor is provided in Vol. IV – ESMP.

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4.5.6 Transmission Line Maintenance

The Project has not at this stage prepared a transmission line maintenance programme. However, it can be anticipated that the 220 kV transmission line would be operated remotely and would require very little maintenance. The lines would be subject to annual inspections from the ground and the inspection would identify any visible faults or signs of wear or safety risks, including the presence of any physical structures or tree regrowth in the wayleave infringing on safety clearance and require attention. Inspections would also confirm when refurbishment is required.

Small 4-wheel drive vehicles could be used to carry out routine maintenance works. Trucks would probably only be used to bring new materials and equipment to site and remove old equipment if major repairs were required. Maintenance of the wayleave corridor would be undertaking using manual cutting to minimise the intrusion into the vegetated corridor.

Refurbishment of the transmission line may be required throughout the life of the Project and this could involve:

- The replacement of conductors and earth wire.
- The replacement of insulators and steelwork that holds the conductors and insulators in place.
- Painting or replacing the tower steelwork.
- Replacement of tower furniture (anti-climbing devices, colour identification plates, danger of death notices, number plates).

4.5.7 Maintenance of Hydromechanical Equipment

The Project will prepare an Operation and Maintenance (O&M) Plan, including the Instrumentation Plan and the Emergency Preparedness Plan, in alignment with the requirements of the World Bank ESS4 Community Health and Safety. The preliminary plan will be available for the Lenders' review at the appraisal stage and the final plan will be available not less than six months before starting the initial reservoir filling.

The plan will set out details of the organizational structure, staffing, technical expertise and training required; equipment and facilities needed to operate and maintain the dam; O&M procedures; and arrangements for funding O&M, including long-term maintenance and safety inspections. The O&M plan will reflect changes in the dam's structure or in the nature of the impounded material that may be expected over a period of years.

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4.6 Associated Facilities

The AFD, EIB, KfW, EIB and World Bank recognise Associated Facilities.

The World Bank definition of "Associated Facilities" that is included in the Environmental and Social Framework, 2018 is as follows: *"….facilities or activities that are not funded as part of the project and, in the judgment of the Bank, are: (a) directly and significantly related to the project; and (b) carried out, or planned to be carried out, contemporaneously with the project; and (c) necessary for the project to be viable and would not have been constructed, expanded or conducted if the project did not exist"*. This definition is also adopted by the AFD and KfW.

The EIB definition considers the following as Associated Facilities: (i) assets and facilities directly owned or managed by the promoter that relate to the project activities to be financed, (ii) supporting activities, assets and facilities owned or under the control of parties contracted for the operation of the promoters business or for the completion of the project (such as contractors); (iii) associated facilities or businesses that are not funded by the EIB as part of the project and may be separate legal entities yet whose viability and existence depend exclusively on the project or whose goods and services are essential for the successful operation of the project.

In the frame of the Ruzizi III HEPP, facilities considered as "Associated Facilities" are described in the following paragraphs and presented in Figure 4-22. These facilities are required as part of regional inter-connection projects and are developed with financial assistance from EIB, KfW and AfDB, who have similar E&S requirements to the World Bank. The Associated Facilities will need to comply with the same Environmental, Social, Health and Safety requirements as the Ruzizi-III Project.

The lenders potentially supporting the Ruzizi III Project will review the projects to develop the Associated Facilities, and clear by appraisal related instruments to ensure compliance. The associated facilities are at different stages of planning and implementation. The lenders would need the following: (i) progress report for Kamanyola - Bujumbura 220 kV Transmission Line construction works; and (ii) timeline to update/complete and clear feasibility Studies, ESIAs and RAPs for other Associated Facilities. The World Bank will need the EIAs and Terms of Refence for updated studies for the transmission line projects to be re-disclosed locally.

Undertaking of E&S due diligences for the associated facilities are included in Ruzizi III HEPP ESCP.

4.6.1 Kamanyola 220 kV Substation

The Kamanyola 220 kV substation is situated in DRC. It is developed, financed, constructed, owned, ensured, operated and maintained by the Contracting States with financial support from KfW. The Ruzizi-III 7-km-long 220 kV transmission line will connect to the Kamanyola substation. The substation will include the dispatching centre and a coordination centre for the operation of Ruzizi-I, -II, -III (and -IV when operational). The substation will be operated by SINELAC. A Feasibility Study, ESIA and RAP in alignment with international standards has been prepared with funds from the KfW. However, it is planned that these studies be updated to reflect recent developments in the Ruzizi III Project. With regard to the ESIA for the substation, an updated version of the ESIA/RAP Terms of Reference has been approved by lenders and the ESIA/RAP is expected to be available Q3 2025.

4.6.2 Kamanyola - Buhandahanda 220 kV Transmission Line

The Kamanyola-Buhandahanda transmission line is situated in DRC and is developed by EGL with financial support from the EIB and KfW. Pre-Feasibility studies for the 68.5 km line have been completed. However, the studies will need to be updated to take into account (i) changes made to the Ruzizi-III project since the feasibility studies were undertaken, (ii) the Ruzizi-IV project, and (iii) conception of the regional electricity market which is being developed. The Terms of Refence for the updated ESIA/RAP have been approved by KfW and the ESIA/RAP is expected to be available Q3 2024.

4.6.3 Kamanyola - Bujumbura 220 kV Transmission Line

The project is developed by REGIDESO and comprises a 77 km line of which 2.4 km are situated in DRC and 74.6 km in Burundi. The project has been developed with financial support from AfDB and KfW. Feasibility studies, ESIA and RAP have been prepared and project affected people have been compensated. The start of construction works is programmed for Q2 2022 and completion scheduled for Q4 2024.

4.6.4 Kamanyola - Kibuye 220 kV Transmission Line

The proposed line is 82 km long, mostly in Rwanda, but with a short section in DRC. The project is developed by Rwanda Energy Group (REG) with financial support from the EIB. A pre-feasibility study and ESIA were prepared in 2014. However, the feasibility study and ESIA will be updated and a RAP prepared.

4.6.5 Other 220 kV Transmission Lines

Other transmission lines in DRC that are planned in a longer term, comprise (i) the line from Bahandahanda to Goma West which will allow an interconnection of the Kamanyola-Bahandahanda line to connect to the existing line connecting to Rwanda, and (ii) the line from Kamanyola to Kiliba and Uvira. The routing of these lines is shown in Figure 4-22.

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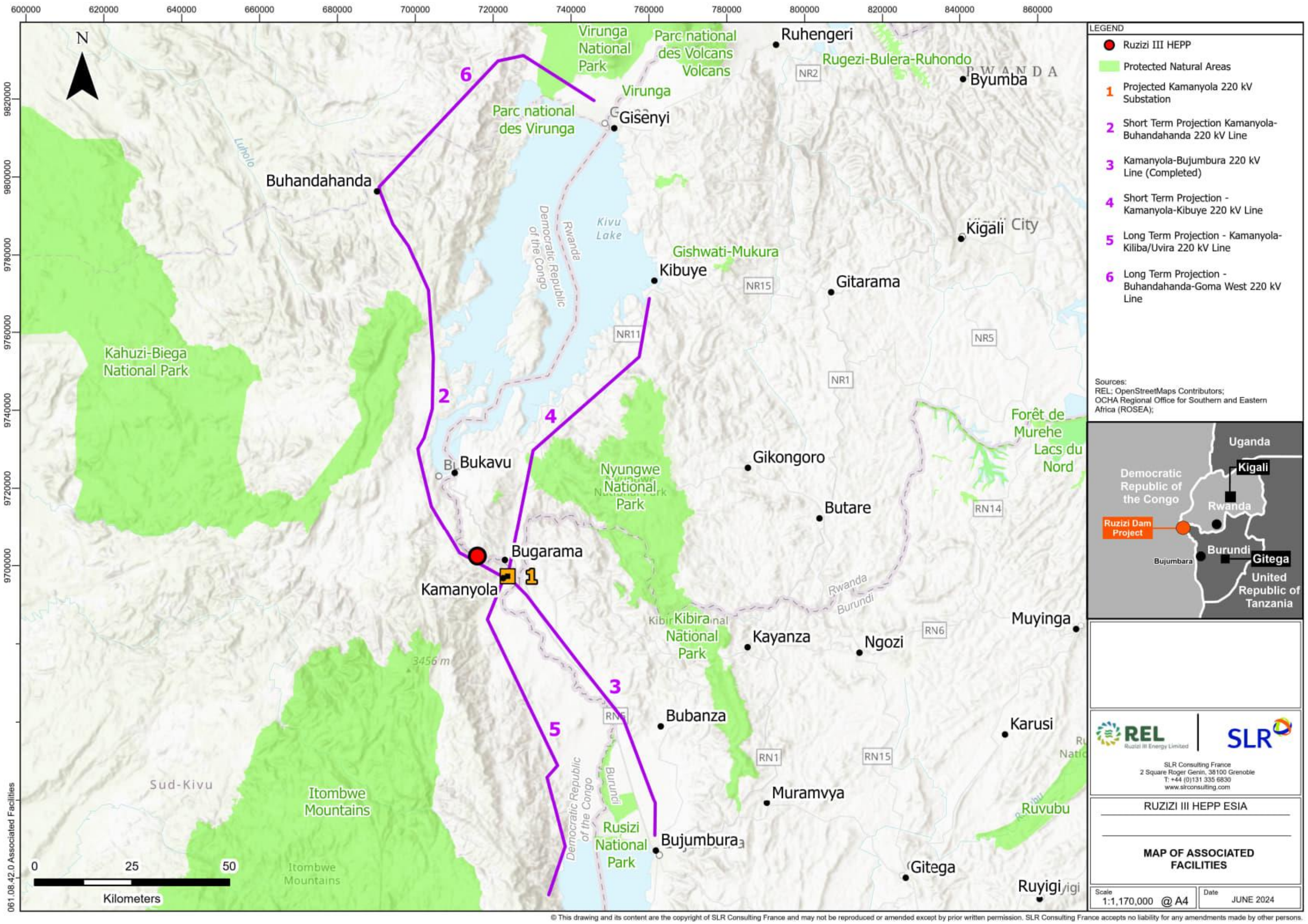

Figure 4-22 Associated Facilities Layout

4.7 Decommissioning

The general objective of the decommissioning process is to carry out the definitive dismantling, partial or total, of the facilities. This objective consists particularly in returning the site in accordance with the regulatory framework constituted by conventions and local, regional, national and international legislation with due observance of REL and lenders' E&S policies and under the best possible economic conditions. The overall aim is to leave Project land and any equipment and infrastructure that remains in a condition that allows it to be transferred with minimal residual liabilities or risk to public safety and the environment. For example, land would be returned to the communities.

The decommissioning of the facilities is expected to be similar to that planned for other existing hydropower facilities in the region. However, the final decision regarding the decommissioning may not be possible prior to performing a specific decommissioning ESIA. At the time of writing a decommissioning ESIA is not a regulatory requirement in Rwanda and DRC, but the environmental laws and regulations will evolve in the coming years.

4.7.1 Hydroelectric Power Production Facilities

The Project has a minimum economical life expectancy of approximately 50 years. The actual length of service is however difficult to estimate. The decommissioning of the HEPP facilities could involve removal of the dam and the powerhouse and returning the Ruzizi River to its original situation, but this is unlikely. Depending upon the length of service, the Ruzizi III reservoir may have established a new valuable ecosystem also beneficial to local communities. In this instance, removal of the civil works could create a considerable negative effect. In general, decommissioning of a hydropower project requires as much planning as the construction of the Project in the first place. Considerable consultation would be required. It could be assumed that prior to decommissioning the Ruzizi III HEPP, the other dams on the Ruzizi River would also be decommissioned and would provide valuable lessons for planning for decommissioning of the Project.

4.7.2 Transmission Line

The Ruzizi III transmission line would be made up of a variety of materials, from concrete and steel for the foundations, steelwork for the tower and aluminium/steel for the conductors. All these materials have an expected lifespan, which varies depending on how the transmission line is used and where it is located. The transmission line has a minimum design life expectancy of approximately 50 years. After construction, the components of the Project would become an integral part of the regional transmission network. As such the lifespan of the transmission line may be longer than the anticipated 50 years, depending on their condition, refurbishment and the future transmission network requirements. If the transmission line is no longer required as part of the network of electricity transmission, it may be removed. Upon removal, much of the material would be suitable for recycling. Similar access would be required as outlined for construction.

Fittings, such as dampers and spacers, would be removed from the conductors. The conductors would be cut into manageable lengths or would be winched onto drums in a reverse process to that described for construction. The fittings would be removed from the towers and lowered to the ground. The tower may be dismantled by crane, with sections cut and lowered to the ground for further dismantling and removal from site. Depending on the space available, it may be possible to cut the tower legs and then pull the tower to the ground using a tractor. The tower can then be cut into sections on the ground. Unless there is a compelling need for removal of all the foundations, to avoid ground disturbance steel work may be removed to ground level with subsurface elements left in situ.

The lifespan of equipment within the Project switchyard would be approximately 40 years. If its useful life has expired, it would be removed and replaced as the switchyard would form an important part of the regional transmission network. Much of the material removed from the switchyard would be suitable for recycling. Similar methods of installation and equipment would be required as for construction.

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