Quality Assurance for Detailed Technical and Engineering Designs



Guidelines for Terms of references to be used during the Preparation of Detailed Technical Design for Roads, Bridges, Water supply systems and Buildings.

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1 GENERAL INTRODUCTION

Providing safety for the public by having adequate strength for constructed facilities has been the cornerstone of the framework used by engineers for infrastructure design.

These guidelines on the elaboration of terms of reference for the detailed design of bridge, road, building and water supply system projects will enable LODA and District engineers to elaborate appropriate terms of reference to be used in recruitment of consultants to conduct and validate design reports.

Before the preparation of the terms of reference for the project detailed technical design we should know that the design of the infrastructure takes place in three basic stages, though in practice it is often more of an evolutionary process.

In the first stage, conceptual designs will be developed based on the emerging service plan. The second and third stages are the feasibility study and detailed engineering design. In general different options are presented in feasibility study with their advantages and disadvantages and after their analysis the detailed technical design of the optimal option is conducted.

Conceptual Design (inception report)

It sets out the conceptual framework to be used in the project design, the key design questions and methodology, including information on data sources and collection, sampling and key indicators. The conceptual design also includes a timeline for the project design and drafts of data collection instruments.

The infrastructure conceptual design should provide a sufficient level of detail so that decision makers may have the idea of the cost, functionality, and aesthetics of the proposed system.

Preliminary and Detailed Design

Once a conceptual design is completed and validated by the client the project feasibility study starts and follows LODA guidelines.

It is during the feasibility study phase where public comment is often sought and is useful to the project. Once the feasibility study phase is complete and validated, the detailed technical design of the project will be developed.

The detailed engineering design and specifications will be the basis for the actual construction work. The detailed design will also permit construction firms to make more accurate cost estimates within the construction bid process.

The bulk of detailed design terminates with the completion of the final construction drawings, project specifications, tender documentation (including conditions of contract), and full bill of quantities. The design firm, if different from the construction firm, should play a leading role during construction to ensure that contractors follow the designs, and to react to myriad contingencies and circumstances arising during construction.

The main references given in these guidelines are based mainly on the following design parameters: Introduction, project information sheet, design phases and their minimum contents, required minimum key staff to carry out the detailed technical design, reports and their minimum contents.

These LODA Guidelines indicate in general the minimum requirements related to the preparation of terms of reference for project detailed technical design. But the terms of reference may be different due to the project complexity.

2 Section 1: DETAILED TECHNICAL DESIGN OF ROAD PROJECT

ABBREVIATIONS

Abbreviation	Description
BoQ	Bill of Quantity
CAPEX	Capital Expenditures
EIA	Environmental Impact Assessment
KfW	KfW Development Bank
LODA	Local Administrative Entities Development Agency
OPEX	Operational Expenses
PPE	Personal Protection Equipment
QAC	Quality Assessment Consultant
RDB	Rwanda Development Board
RLDSF	Rwanda Local Development Support Fund
ToRs	Terms of references

2.1 Introduction to the Guidelines for DTED of Roads and Road Drainage

These guidelines on the elaboration of terms of reference for road projects will enable LODA and District engineers to elaborate appropriate ToR to be used in recruitment of consultants to conduct DTED for road projects and to validate design reports.

The services include reconnaissance of the road project, the traffic count and estimation, the topographic survey, the geotechnical study of the road, the pavement study, Hydraulics and hydrological study of the area and the review and updating of Environmental and Social Impact Assessment (ESIA), Resettlement Action Plan (RAP), and preparation of the Bill of quantities and tender documents for the execution of upgrading works of the above mentioned project.

These guidelines cover the entire road design process, from the inception stage through site investigations and materials analysis, hydraulic design and structural design, to the final preparation of drawings and detailed specifications.

Wherever you need to complete or update, this is characterised by a “to do” marked in green.

Furthermore, there are explanatory part that are marked in light green and are starting with “Explanation” as shown in the example below.

INFORMATION SHEET

1	Country	Rwanda
2	Consultancy services	To do: Describe the service in summarized form
3	Road Name	To do: Insert District Name
4	Location of the road	To do: Insert location map
5	Recipient	To do: Insert District Name
6	Executing Agency	To do: Fill the information below Insert District Name P.o. Box: E-mail: Tel :
7	Funding Agency	To do: Fill the information below Insert Name P.o. Box: E-mail: Tel :
8	Project Description	The Government of the Republic of Rwanda, represented by the (*insert the name of the District*) is recruiting a consultant who will conduct consultancy services to conduct Feasibility and Detailed technical study of (To do: Insert bridge name The services include: Reconnaissance of the road project The traffic study and estimation The topographic survey The geotechnical study of the road The pavement study The Hydraulics and hydrological study of the area The Environmental and Social Impact Assessment Preparation of the Bill of quantities and confidential cost estimate and tender documents for the execution of works of the above mentioned project. The upgrading/construction/rehabilitation (to do: *please select the respective case for these TOR*) consist of the improvement of the geometric elements and sealing the road.

		The road upgrade/construction/Rehabilitation will be designed with chip seal/asphalt concrete or gravel road. The estimated total length of the road is around (to do insert the number of km) and will be fixed after the preliminary survey The services will be delivered and documented by three reports: **Inception report** shall contain the preliminary observations with the points that can affect the design of the road project, detailed work program, brief description of the updated working methods / methodology of the consultant in accordance with the Terms of Reference and identify any major issues/constraints and the staff mobilization plan. **The Feasibility study** shall contain the preliminary findings in topographic survey, the geotechnical investigations, the traffic survey, hydrology and hydraulic investigations, identified location of retaining structures and the preliminary designs for the aforementioned alternatives. The report shall include any possible alternatives and the environmental, socio-economic profile assessment of the project and economic analysis. The report shall include the economic analysis and comparison of the alternatives and argue recommendations for choosing the appropriate alternative. The findings from this report shall lead to the development of the details design and Bill of Quantities, ESIA, RAP(optional). **The final report** shall contain the detailed technical and engineering designs of the road, the retaining and hydraulic structures, safety features and the Tender Documents and final Bill of Quantities, ESIA and where required the abbreviated of full resettlement action plan (RAP) (optional). Typical drawings will be attached to the report as annex The language of the reports is English or French
9	Estimated Duration	Total duration of the services: (to do: Fill months of study implementation).....Months
10	Consultancy Services Required and Phase of Selection	The procurement of Consultancy Services will be carried out in accordance with the national Procurement Law of Rwanda and its respective Ministerial Orders and guidelines. Consultancy services for carrying out the road studies will be determined on the basis of a two stage tender, i.e. prequalification with short-listing as stage 1 and evaluation of technical proposals as stage 2. The selection procedure to determine the short-listed firms for implementing the study shall be based on technical quality with price consideration (QCBS: Quality Cost Based Selection).

2.2 Introduction to DTED for Road and Road Drainage

During the quality analysis of quality of detailed technical design of road projects conducted locally in different Districts, we realised some weaknesses mostly linked to poor and incomplete terms of reference (ToR) used in the standard bidding documents to recruit consultants to conduct the detailed technical designs (DTED) of roads).

These guidelines on the elaboration of terms of reference for road projects will enable LODA and District engineers to elaborate appropriate Terms of Reference (ToR) to be used in recruitment of consultants to conduct the detailed technical and engineering designs (DTED) for road projects and support a qualified validation of these design reports.

The services include reconnaissance of the road project, the traffic survey and estimation, the topographic survey, the geotechnical study of the road, the pavement study, Hydraulics and hydrological study of the area and the review and updating of Environmental and Social Impact Assessment (ESIA), Resettlement Action Plan (RAP) or Abbreviated Resettlement Action Plan (ARAP), and preparation of the Bill of quantities and tender documents for the execution of upgrading works of the above mentioned project.

2.2.1 Description of the Road Project

The concerned road is classified as " to do : *insert the class of the road*". It connects the (to do : Insert province, districts, sectors that the passing through). The project study will follow the corridor of the existing road or any other beneficial proposal from the consultant. The width is varying (to do: *insert average width of the existing road*). In some places, it is narrowed.

The road passes through (to do: describe areas ,topography ,land use ,main economic activities ,etc.) agriculture area and some infrastructures are planned to be constructed. Thus, the consultant will need to consult the relevant documents like the District plan and the report related to the land use.

2.2.2 Main Objective of the Consultancy Services for Road and Road Drainage Design

The main objectives of the consultancy services is to conduct the detailed technical and engineering designs study and economic study, environmental and socio-impact study, and elaboration of the tender documents for the construction of (the (to do: insert the name of the road).

2.2.3 Scopes of Consultancy Services for Road and Road Drainage Design

The consultant shall perform all necessary data collection, literature review, planning, engineering, economic, financial, environmental and social analyses, field investigations and related works as described herein with due care and diligence to attain the objectives of the project. The main components of the project for the detailed technical design phases are as follows:

a) The site reconnaissance, visual inspection, evaluation and classification of distresses

b) Conduct the traffic count survey and analysis

c) Conduct the topographic survey of the road and analysis

d) Design of the retaining structures for the soil protection upstream and downstream of the road and those at the inlet and outlet of the drainage

e) Conduct geotechnical investigation on the road project and identified borrow pits and analysis of the tests results.

f) Conduct hydrological and hydraulic study for the appropriate drainage system

g) Pavement design

h) Economic study

i) Cost estimates of the project

j) Preparation of the Tender Documents

k) Conduct Environment& Social Impact Assessment (ESIA), Socio-economic impact assessment and the Resettlement Action Plan (RAP) (optional)

l) Propose the maintenance plan

m) All other works deemed necessary by the consultant .

The raw data collected under this project shall be submitted to the client in editable version, either in Excel files, CAD files or similar technical formats.

As early mentioned, the road will be designed with chip seal technology.

2.2.4 Expected Outputs for the DTED for Road and Road Drainage Design

The expected outputs of the study are:

a) Assessment and recommendation of the required intervention for the improvement of the riding quality, safety, environmental protection, erosion control and slope protection

b) Detailed Engineering Study for the *upgrading/construction* (*please select the correct term*) works;

c) Cost estimates of the planned road project and its bill of quantities (BoQ)

d) Environmental and Social Impact Assessment (ESIA)

e) Development of Environmental and Social Management Plan (ESMP)

f) Preparation of RAP or ARAP where required

g) Preparation of tender documents and technical specifications of the material to be used.

2.3 Feasibility Study and Preliminary Design for Road and Road Drainage Design

Explanation:	For the Feasibility Study please also refer to LODA's feasibility study guidelines of 2020

2.3.1 Technical Dimension

2.3.1.1 Inception Report

This report shall provide the preliminary observations with the points that can affect the design of the road project: detailed work program; brief description of the updated working methods; methodology of the consultant in accordance with the Terms of Reference and identify any major issues; constraints and the staff mobilization plan.

Explanation:	The inception report should be presented to District staff in a meeting and open issues should be discussed and decided on

2.3.1.2 Road Feasibility Study

The Feasibility study shall contain the preliminary findings in bridge location and surveying operation, river hydraulics, soil investigation, socio-economical assessment, environmental impact assessment, preliminary bridge structural design, technical documents and bills of quantities.

The report shall include any possible alternatives and include the economic analysis and comparison of the alternatives and argue recommendations for choosing the appropriate alternative.

Explanation:	The feasibility study is the Avant-Project Sommaire (APS) and shows the advantages and disadvantages, analysis possible environmental and social risk to be mitigated later, shows technical options for the bridge and provides a first rough cost estimate for each option

2.3.1.3 The Site Reconnaissance, Visual Inspection, Evaluation and Classification of Observed Road Damage

These shall be carried out with desk study and review of existing data relevant to the proposed project road and field works. The consultant shall establish the line of the road on the ground. He/She shall record the existing conditions with respect to:

a) Terrain classification
b) The location of topographical constrains, such as ravines, rock outcrops, areas with soft ground, and areas prone to floods
c) Slope steepness and limiting slope angles identified
d) Slope stability and the location of pre-existing landslides
e) Soil and rock types, geological structures, dip orientations, rock strength and rip ability
f) Materials sources, presence and distribution
g) Water sources
h) Soil erosion and soil erodibility
i) Slope drainage and groundwater conditions
j) Drainage stability and the location of shifting channels and bank erosion

k) Land use and its likely effect on drainage
l) Likely foundation conditions for major structures and retaining structures
m) Approximate bridge spans and the sizing and frequency of culverts
n) Produce the linear strip diagram and a concise descriptive report.

2.3.1.4 Traffic Study

During the study, the consultant shall determine the type and volume of existing traffic for the project road and conduct the traffic counts. In the inception report, the consultant shall present to the client the proposed location of the traffic posts and mapped. These data shall be complemented with the O-D survey. The consultant shall undertake road network analyses, in order to identify and quantify any potential for traffic diversion or reassignment that may result from improvements to the adjoining network connections.

Traffic surveys shall include a minimum of one survey of seven (7) consecutive days which include (5) days for 12 hours per day, and two (2) days for 24 hours each day at appropriate locations approved in the inception report in order to record traffic moving at night. The Consultant shall also undertake O-D surveys of 3 days in order to establish the extent of diverted traffic. He shall divide the road into homogeneous sections and conduct the traffic analyses.

Traffic studies will include and should not be limited to:

a) Traffic composition, occupancy, and volume counts
b) Origin-Destination studies
c) Forecasts composed of normal, generated and diverted flows, if any, by appropriate vehicle types considering three scenarios (Low, Medium and High).

The consultant should use the historical traffic data for the determination of appropriate traffic growth rates per category of vehicles (i.e. light, medium and heavy vehicles). In the absence of trends, the expected increase in vehicle registrations, GDP or economic growth and population growth can be used as additional parameters. The consultant will determine the Average Daily Traffic (ADT), the Annual Average Daily Traffic (AADT) and the projected traffic in the design period.

2.3.1.5 Topographic Survey

The consultant will make the topographic surveys in order to have the coordinates (XYZ) and define the quantities of work involved.

The consultant shall carry out topographic survey for the project road including the following;

a) To prepare the topographic map and all other necessary data for the detailed engineering design

b) Ground reconnaissance survey to locate the position of the road sections on the ground and to indicate them on a plan to adequately identify pertinent existing features and the proposed improvements
c) Establishment of horizontal and vertical control points (benchmarks) and Installation of concrete beacons for benchmarks at every 1 km and at intersection of the axes and shall be shown on plan drawings

d) A computation and definition of the geometric characteristics of the centreline. Survey data shall also be given at regular intervals along the curves and the longer tangent alignments. Vertical alignment will be defined and computed
e) All topographical surveys undertaken by the Consultant will be to standards accepted internationally for such work and, after approval of the Client, shall be recorded in standard and electronic survey field books which will become the property of the Client upon completion of the study
f) Topographic profile survey covering at least thirty meters (30m) on both sides of the road centre line and reflecting all natural changes and man-made structures with contour lines;
g) River cross-section survey at major culvert locations.

The field survey shall be carried out in accordance with Geometric Design Manual. A brief summary of requirements is shown below but not limited to:

a) Mapping shall be at a scale of 1:2000 generally
b) Surveys at bridge and major culvert locations shall record river and stream profiles as per the Geometric Design Manual and Bridge Design Manual. Mapping scales shall be 1:500 for bridge and major culvert sites.
c) Vertical and horizontal control points shall be established based on the Rwandan Coordinate System and Datum. Each control point shall be recorded and presented in reports using a standard format approved.
d) The accuracy of the vertical control points shall be as per the Geometric Design Manual recommendation.

2.3.1.6 Hydrology and Drainage Investigation

The Consultant shall carry out hydrological survey by collecting available historical data from ground/stations and remote sensing data.

The Consultant shall review the description of the climatic conditions of the road study area, including details of:

a) Rainfall (monthly distribution and intensity, including rainy days per month);
b) Temperature (minimum, median, and monthly ranges throughout the year)
c) Other climatic features of importance (e.g. wind, erosion...).

The Consultant shall analyse, review the complete description of the features of the road study area including:

a) Information about drainage along the existing road, and the proposed alignment of existing corridor the road and intersection locations, such as sub-soil absorption, flooding of flat area etc.
b) All necessary hydrological and other data for storm water and sub-surface drainage systems design
c) Characteristic of required water crossings and hydrological structures following the drainage design manual

d) All necessary sub-surface investigations required for the design of pavement structure the Consultant shall be fully responsible for obtaining all the data and information necessary for hydrological, hydraulic and drainage designs

e) Runoff rainfall calculation of identified flows at the assessed / planned structures and then design structures considering the return period (25 years for culverts, 10 years for the side drainage) and considering the climate change by 2050.

The Consultant shall be fully responsible for obtaining all the data and information necessary for hydrological, hydraulic and drainage designs.

Sufficient information shall be collected by the Consultant for the road to justify and provide the basis for the selected engineering design options of all crossings, drainage systems and all structures, including initial costing for the different options.

2.3.1.7 Design of Outlet of Culvert

The culvert outlet design should consider:

a) The downspout shall be kept up to the lowest point with safe disposal to avoid the damage of the surrounding properties from the outlet of the culvert and side drains.
b) The outlet of the pipe/culvert should extend beyond the toe of the fill / embankment and should never be discharged on the fill slope without erosion protection. Alternatively, a down-drain pipe can be used, especially in large fills with poor soils and high rainfall areas, where fill settlement may require culvert repairs.
c) Protect cross-drain outlets with rock (riprap), brush, or logging slash to dissipate energy and prevent erosion, or locate the outlet of cross drains on stable, non-erosive soils, rock, or in well vegetated areas.
d) The bioengineering which is the use of grasses on cuts and embankment /fill slopes, should be applied for protection to minimize surface erosion. Use a mixture of good ground cover plus deep-rooted vegetation, preferably with a native species, to minimize mass instability as well as offer surface erosion control protection.
e) Consider to reduce sedimentation by all means (e.g. sedimentation basins and bioengineering, to prevent to the maximum siltation of Lake/river etc.. and adjacent wetlands.

2.3.1.8 Geotechnical /Material Investigation

The Consultant shall compile a catalogue of the relevant geological features of the study area including a description of the soils and rocks encountered along the alignments and their effect and influence on such factors as route location and design. This should include at minimum:

a) A general study of the soils and materials along the routes shall be done. The Consultant shall make detailed soil investigation along the alignment of road sections to identify the

varying soil types, with disturbed samples to be taken at intervals of 1,000m and at least 50 cm depth considering the proposed vertical alignment of the road and frequency as determined by the standards and at such other places considered necessary to determine changes in soil type. Tests are to include complete identification:

1. Atterberg limits
2. Grading of particles larger than 75 microns
3. Soil classification tests, moisture/density relationship
4. California Bearing Ratio (CBR) of proposed subgrade soils.

The testing program shall be presented by the Consultant and accepted by the Client. In specific problem areas where preliminary engineering indicates that soil stabilization is required, the Consultant shall undertake special investigations on soil stabilization options and recommend viable design measures for strengthening the road formation across these sections. These include:

a) Conduct investigation for sources of construction materials for backfill, pavements and structures shall also be carried out, including drilling of stone quarries, and sites of suitable materials surveyed and shown in the engineering plans with vertical log profiles, geological section of quarry and stratigraphy.
b) The consultant shall also indicate the location of the construction materials such as wearing course materials, crushed stones, sand pits and the sources of water for construction in the vicinity of the project. The consultant shall carry out a material availability survey to identify quarries, borrow and disposal areas for the fill/cut material, rock and material for bridge construction etc. and provide materials investigation maps. The minimum number of tests, the nature of the tests and the setting out of borrow pits shall meet the minimum specifications set out in the agreed design standards.
c) Unbound construction materials samples shall be tested where necessary for CBR (%) at 95% or 98% MDD of Mod AASHTO, CBR-swell (%), Atterberg Limits - max LL (%), max PI (%), , particle size - d_{MAX} and grading modulus (GM); grading (sieve analysis). All the tests shall satisfy the requirements of Rwanda or AASHTO standards. Where the two standards differ, the more robust shall be adopted. A soils and material report should be prepared showing exact locations of all construction materials available with an indication of their approximate quantities.
d) The Consultant shall carry out detailed investigations regarding problem soils to include expansive and dispersive soils, saline soils or presence of saline water, organic matter in high quantities, and deleterious minerals such as mica and sulphides that may be encountered along the roads and propose measures that should be reflected in the preliminary and detailed engineering designs.
e) Following the site investigation and the optimisation of the geometric design, the Consultant shall prepare the design for the cut and fill slopes, and any slope stability measures and structures that may be required. The Consultant shall identify areas that may require further investigation for finalising the design of slope stability measures. The Consultant shall prepare a programme for carrying out any additional investigation, and discuss with the Client, who shall instruct whether the additional investigation shall be carried out or included in the tender documentation for construction of the works.
f) The consultant shall design retaining structures for the soil protection upstream and downstream and provide the slope protection measures. The structural calculation should be provided in detail. At some section of the alignment passes along rivers, the consultant shall pay particular attention to provide the protectives measures of the proposed

alignment.

g) All the tests shall satisfy the requirements of Rwanda standards or the AASHTO standard. Where the two standards differ, the more robust shall be adopted. AASHTO "Manual on Subsurface Investigations shall be followed, including all pertinent ASTM test methods.

2.3.1.9 Alignment Design

For the design of the alignment, the client envisages that as far as possible the new alignment should follow the existing route corridor unless there are technical, social and economic justifications including enhancement of safety. However, the Consultant shall thoroughly examine the alignment with due consideration to the proposed design standard and suggest any alignment changes if any, to meet the project objectives.

The alignment shall be optimized as much as possible considering the topography and design criteria. The Consultant will prepare the construction drawings of the axis, the cross sections, the horizontal and vertical alignment with super-elevations, location of the drainage structures, and remediation of the nozzles.

The design shall be carried out taking into account the following, among other factors:

a) Existing crossings and their residual value if any
b) Existing infrastructures
c) Location of the proposed retaining structures, characteristics and other protection structures
d) Land use including existing villages
e) Locations of sources of suitable materials
f) Hydrological and drainage characteristics
g) Environmental and social effects.

2.3.1.10 Design Standards

All the design shall satisfy the requirements of Rwandan national standards or the AASHTO standard. Where the two standards differ, the more robust shall be adopted. These include:

a) The geometric and loading standards for the different options shall comply with Rwandan national standards appropriate to the traffic and engineering characteristics of the road. Alternatively, the AASHTO design manuals and standards can be used.

b) The methodologies employed for the design of pavements, earthworks, drainage and structures shall conform to standards and specifications ensuring maximum use of local available materials where appropriate.

c) The Consultants shall confirm the general design standards for the proposed project road. This shall include:
   - Functional road classification
   - Design standards
   - Different cross-sections for rural and urban areas
   - Design life of road pavement and any structures: Minimum shall be 15 years for the sealed road and 7 years for gravel roads

- All other works deemed necessary by the consultant.

Without compromising the design standard and where possible, the road geometrical characteristics, for this concerned road to be considered in general:

- Width of the carriageway for national road section:(To do :Reference Law No 55/2011 Governing road in Rwanda)
- The shoulder: 1.5 m (for normal cross section in flat area)
- Slope in vertical alignment (preferably max): 8%, where the gradient is more than this, alternatives can be proposed for the protection again erosion
- Slope in cross-section: 2.5-3% for sealed pavement
- The maximum super-elevation is 6% in rural and 4% in urban roads
- Drainage system.

2.3.1.11 Design Speed (km/h)

The design speed parameters are summarized in the following table.

Rural area Terrain			**Urban area**
Rolling & Flat	**Mountainous**	**Steep**	**All**
80	50	50	50-60

Preliminary design parameters shall be confirmed in tables within the feasibility study. These shall include all variations along the length of the road in cross sectional dimensions, estimated traffic volume and preliminary pavement and surfacing design.

The Consultant shall carry out a design and confirm but not be limited to the following:

a) Road Classification
b) Design life
c) Earthworks – estimate of volumes for soft and rock
d) Pavement design– estimate to include carriageway, shoulders, widening through built-up areas,
e) Materials available for construction, estimate of quantities and locations
f) Major cross drainage structures
g) Culverts and side drainage types
h) Bridges and major waterway crossings - existing bridges and their condition, proposed sites for new bridges and site conditions, lengths, widths, span arrangements and proposed bridge type.

All information produced documents and reports from the preliminary design phase will be the property of District.

2.3.1.12 Road Safety

The Consultant will conduct an analysis of the road safety issues. This will determine the vertical and horizontal signalling necessary information and equipment to provide safety and security along

the road. It will pay particular attention to the choice of types of guardrails and panels at sustainability, risk of theft or vandalism, the local ownership of maintenance, ease of replacement.

2.3.1.13 Pavement Design

The consultant will design the pavement based on surveys of the traffic, the topographical, geotechnical, hydrological and road safety, availability of the construction materials. These include:

a) With the results geotechnical investigation, he/she will determine the uniform section with their design values
b) Estimation of traffic volume
c) Estimate the ESAL during the design period and the class of traffic
d) Different structures will be proposed and then with the critical analysis of the consultant, the optimum pavement structures with the minimum pavement layer requirement in terms of material properties will be recommended.

The Consultant will prepare the documents necessary for the performance of this work, including soil investigations relating to structure foundation studies and investigations relating to hydrological drainage especially in marshland areas. The Consultant will also examine with special materials best suited to the earthworks and pavement layers. The Consultant will identify and carefully appraise the quantity from borrow pit /quarry at an economic distance the project road.

It is clear that a summary of geotechnical data obtained either on the existing roadway or on quarry materials must be recorded.

2.3.1.14 Planning of Works Implementation

Explanation:	Reporting is an important aspect of the consultant responsibilities towards the Employer and shall allow the employer's officials in charge of the studies to closely follow and comment on the progress of the study.

To do: The maximum period for carrying out the study assignment should be indicated. This period does not include the validation times of reports by the client which will not exceed two weeks at each stage.

The schedule will clearly show:

- The duration of completion of all preliminary design studies,
- The duration of all detailed pre-project studies,
- As well as all the validation periods for the various studies by the client.

The consultant shall produce a planning of (To do: describe type of works) with detailed feasibility charts/graphs reflecting and based to the types and quantities of site equipment's related to the project zone hydrological conditions. These shall be presented in the aforementioned alternatives

He/she will determine an accurate time period for the execution of the proposed upgrading of

''*Insert the name of the ro*ad''. The consultant shall, according to the above fixed time period calculated with parameters, evaluate and assess the necessary types and the corresponding quantities/number of construction equipment's. To this end, he/she will provide a planning for an efficient site equipment use to be in time with the project zone hydrological condition.

2.4 Economic Study for Road and Road Drainage Design

The consultant will determine the limits of the zone of influence restricted and expanded of the project as well as indication of properties located in that zone. He/she will collect and analyse natural features (topography, climate, vegetation, etc.), demographic (population composition of the zone of influence, namely, youth, women, and so active and their share in the entire population of the country), economic (agriculture, livestock, fisheries, industry, mines and their share on national production) and socio-economic present and future. He/she will analyse the living conditions of populations, to identify patterns of poverty, the impact of project on gender in general and women and children in particular. He/she will take stock of production, consumption, and trade in the area of influence and establish the relationship between traffic and socio-economic activities (movement of people and goods production. He/she will determine the effect of upgrading of road on the economic and social development of Districts and Sectors through. The Consultant will develop projections of changes in socio-economic variables, taking into account the current situation, past trends, projects development courses or programs, and other relevant factors that may affect forward general economic conditions.

2.4.1 Life Cycle, Economic Analysis and Maintenance Strategy

The Consultant shall carry out the road lifecycle analysis and then propose the maintenance strategy of the road with their economic impacts.

The components of the life cycle analysis that the consultant will estimate includes:

a) Alternative project options
b) Analysis period
c) Structural design period
d) Construction/rehabilitation costs
e) Maintenance costs.
f) Road user costs (i.e. VOC)
g) Salvage value
h) Discount rate.

The consultant shall compute the economic indicators such as the net present value (NPV) and the Internal Rate of Return (IRR).

Such an analysis can be undertaken using an appropriate techno-economic model, such as the Road Economic Decision (RED) model which is customized to the characteristics of low volume road or HDM-4.

The discount rate used in calculations will be provided by the National Bank of Rwanda. The Consultant will also perform a probabilistic sensitivity analysis of rate of return based on changes in key parameters of the project (case I: increase of 10% to 20% of the economic cost for the project,

case 2: 10% reduction at 20 % of the anticipated economic benefits, for the project; case 3: down 10%to 20% of the expected growth rate of traffic, etc.).

The Consultant will collect the data necessary for the calculation of operating costs for each category of vehicle maintenance costs of the road and the economic costs of investment. He/she will provide in the report all data, assumptions, and parameters used to calculate the cost of operating vehicles by the model RED or HDM-4. These data will be summarized in a table that clearly reveal these costs by vehicle type, type of traffic, the growth rate per period during the life of the project and periodic maintenance options.

The consultant shall clearly show the methodology used for the determination of traffic growth factor.

The section shall include the economic analysis of different options with calculation of economic rate of return and recommendation for planning of work shall be conducted. Special attention will be given to specific conditions in the country or zone of influence of the project (short and extended) that may affect the cost of the proposed road.

2.5 Environmental and Social Impact Assessment

The Consultant will conduct an Environmental Impact Assessment (ESIA) report considering that the upgrading of the road might induce a number of negative impacts on the physical and social environment of the project area. These impacts might include: Loss of flora and fauna, agricultural land, changing the natural drainage sites, deforestation, changes in the level and quality of groundwater and/or surface water, landslides, erosion, sedimentation in rivers/streams and lake, flooding, wildlife disturbance and interference with the lives of animals and people. These impacts may occur not only on the work site, but also in quarries, borrow pits areas and storage areas of materials for the project.

In addition, other negative environmental impacts from the production of gravel materials may cause air pollution and soil, dust and noise from equipment and use of explosives are other sources of environmental pollution. The Consultant will analyse the initial state of the environment of the future project and examine negative and positive effects that could lead to its implementation on the environment of the areas of influence.

He/she will distinguish visible impacts before, during and after works, the impacts in the short, medium and long term, the direct and indirect impacts. He/she will discuss with all parties, pay particular attention on the effects on the most vulnerable including women, and assess the costs of measures to mitigate these impacts.

Concerning the possible negative effects, the recommendations should be made to mitigate or minimize such effects; the following key elements will be considered in this analysis:

a) Assessment of cumulative impacts with consideration of existing and planned projects and developments initiatives
b) The protection of farmland and aesthetic
c) The risk of deforestation, fragmentation or loss of agricultural land, property and other

properties including to determine the costs of these losses to any compensation

d) The risk of soil erosion and loss of vegetation cover, cuts in water circulation, changes in runoff and pollution of aquatic environments
e) Air pollution that may arise from works activities
f) Labour influx and associated aspects like competition for resource use, inflation, the occupational health for workers during the implementation phase and the risks of transmission of disease (HIV/AIDS, and other sexually transmitted diseases) during and after the implementation phase; safety management, gender based violence, etc.
g) Measures for the implementation works of the road in the District and Sector and borrowing of construction materials and other risks associated with the works and operation of the road, etc.
h) Climate change related impacts (impacts from the implementation of the project and impacts likely to affect the project).

The Consultant will consider the policy and guidelines of the Client for environmental and social protection. The Environmental and Social Impact Assessment will be carried out in accordance with REMA's EIA guidelines and in consistence with the requirements of the Law on Environment No. 48/2018 of 13/08/2018 of the Republic of Rwanda and other applicable laws and regulations.

The Consultant, based on the findings of the ESIA shall prepare an Environmental and Social Management Plan (ESMP), where required a Resettlement Action Plan (RAP) or Abbreviated Resettlement Action Plan, and a Physical and Cultural Resources Management Plan (PCRMP). The ESMP should specify impact mitigation plan and environmental monitoring plan requirement; inject costs, responsibility and timeframe for mitigating each impact and monitoring of each environmental parameter. The Impact mitigation plan and monitoring plan should be based on the project phase, i.e. pre-construction. Construction, operation and decommissioning phase.

The study of the possible negative environmental and social impacts will be a separate volume of the report of the study to rehabilitate the project road. The ESIA report should be concise and limited to significant environmental and social issues. Two hard copies with a soft copy (CD) of the report will be submitted to the District . The report will then be submitted to the RDB EIA Unit for approval. The detailed Terms of Reference for Environmental and Social Impact assessment will be validated by the competent authority in accordance with the Ministerial order no 001/2019 of 15/04/2019 establishing the list of projects that must undergo environmental impact assessment, instructions, requirements and procedures to conduct environmental impact assessment.

The description of the project will include the total length of the alignment, the width of the right-of-way, width of verges, drainage requirements, bridges and crossings, ecological, social and economic sensitive components among other necessary information. This will also include an account of activities and features, which will introduce risks or generate impacts (negative and positive) on the environment.

2.6 Profiles of Experts for Road and Road Drainage Design

Explanation:	The team composition might change with the project. For more complex projects, you need more experienced staff and usually more positions. The minimum of years of experience is therefore an orientation that might be slightly changed. The following table summarises the minimum requirement for the qualification of key experts to be deployed during the study elaboration. It should be emphasized that proposed experts must conduct the study for the successful tenderer.

Key experts	Description and profiles
Team leader Road-Engineer	He/She should be a graduate or above in civil engineering with at least 12 years of experience in the road sector (including the direction post of study design and planning studies) He/she must have conducted similar studies as a Team leader with minimum 30 km length each whose at least two (2) in countries of Sub-Saharan He/she will be responsible for coordinating the team of experts and the successful implementation of the study
Geotechnical/ Pavement Engineer	He/she should be graduate or above in Civil Engineering or Geotechnical Engineering with 08 years of relevant experience. He/she should have performed as geotechnical/ pavement engineer at least four (4) road projects studies with a minimum of 15 km length each with two in sub-Saharan countries He/she should have experience in road design
Structural Engineer or Bridge Engineer	He/she should be graduate or above in Civil Engineering or Structure Engineering and have 08 years in the field of structural design or bridge design He/she should have performed as structural/ bridge engineer at least four (4) road projects studies with a minimum of 15 km length each with two in sub-Saharan countries He/she will be responsible for the design and engineering of structures
Highway Engineer	He/She should be graduate or above in Civil Engineering or Highway Engineering and have eight (8) years of experience in road design He/she should have performed as Highway Engineer at least four (4) road projects studies with a minimum of 15 km length each with two in sub-Saharan countries He/she will be responsible for the design of the road alignment with details He/she should have experience in road design
Hydrologist	A Graduate or above in Civil Engineering, Hydraulics/ Hydrology with experience on hydrological and hydraulic studies with: • At least four studies of road projects with a length of at least 15 km each • Experiences in road design projects with respect to hydrological analysis, design of drainage structures and storm water management facilities - Experience in use of drainage design software • Relevant experience in sub Saharan African countries

Key experts	Description and profiles
Environmental Expert	University degree (BACHELOR) or post-graduate studies in environmental sciences, ecology, environmental engineering or environmental economics He/she must have: • Experience in development and conducting ESIAs assignments; at least one of these assignments has been done as a team leader • Fully conversant with the REMA's EIA guidelines and delivery methodologies -including ESMP • The Environmental Expert shall be registered by the Rwanda Association of Professional Environmental Practitioners (RAPEP) and recognized as lead expert in the field of ESIA / ESMP • Three years EIA experience in the Road sector will be a great asset • Over the last three years, at least one relevant experience in developing countries, preferably in Eastern and/or Central Africa
Senior Surveyor	He/ She should have at least A1 in surveying He/she must have at least five (5) years of professional experience in surveying and have worked on at least three (3) road projects He/she should also have 3 years' experience in the field of road's survey
Transport Economist	He/She should have a BACHELOR'S degree or higher degree above in economics / transport economics / and / or a specialization in highway engineering. He/she should have at least eight (8) years of professional experiences in planning, design, monitoring or evaluation of projects (transport, water, energy, or similar fields)He/she should have carried out projects in road feasibility study with relevant experiences in the application of HDM-4, RED, etc., relevant experience in Sub Saharan African Countries and a permanent employee of the firm/associate firm for the last one (3) year or extended work relationship with the firm/associate firm for the last two (5) years
Sociologist or Socio Economist	He/she should have a BACHELOR'S degree or higher degree in Sociology or relevant fields and at least three (3) years of professional experience in sociological works. He/she should have experience in planning, design and monitoring and evaluation of projects (transport, water, energy, food security, and poverty alleviation or similar fields) He/she must have carried out studies in Social Impact Assessment and /or (Abbreviated) Resettlement Action Plans for at least four (4) road projects of similar dimensions

All proposed key staff shall be registered with Institute of Engineers Rwanda (IER) or any other recognized engineering institution. The consultant can propose other non-key staff to accomplish the assignment (these ones will not be evaluated).

2.7 Reports and Time Schedule for Road and Road Drainage Design

2.7.1 Inception Report

This report shall provide the preliminary observations with the points that can affect the design of the bridge project: detailed work program; brief description of the updated working methods; methodology of the consultant in accordance with the Terms of Reference and identify any major issues; constraints and the staff mobilization plan.

Explanation:	The inception report should be presented to District staff in a meeting and open issues should be discussed and decided on. An inception report for the start of the service will be provided to the Client as per the tentative implementation calendar with the content as presented in the study information sheet. The consultant will submit directly to the DISTRICT the required number of copies of this report. After submission, the Consultant should make a presentation of this report to the DISTRICT technical team for validation and continuation of the study.

2.7.2 Feasibility Report

Feasibility reports of studies must cover in separate documents the technical study, structures, the economic study, the study of Environmental and Social Impact Assessment (ESIA) including the Environmental and Social Management Plan (ESMP). These reports, together with all other relevant supporting information and materials used, also include the results of different investigations, notes, drawings, etc. results, and the consultant's analysis and its conclusions and recommendations. The consultant will transmit directly to the client the number of copies of these reports, as shown in the table below.

2.7.3 Final Detailed Technical and Engineering Design Report

According to the schedule defined of these Terms of Reference, the consultant will prepare a report summarizing all the measures adopted for the upgrading of each section of road and a cost estimate (confidential) of the work to be undertaken.

2.7.3.1 Minimum Content of Final for Road and Road Drainage Design Report

a) A detailed record of the traffic intensity and distribution of vehicle classes;
b) Description of the routes;
c) The report of the detailed hydrologic and hydraulic study;
d) A geotechnical report with location, nature and quantity of usable quarries' material, the report will also consider transport distances of materials to the project road;
e) The calculation sheets/notes (civil engineering works and design of the road)
f) Description of construction technical measures;

g) The nature of the work;
h) The draft framework of the unit price schedule;
i) All route diagrams for sealing work, the cross sections types, topographic surveys to establish the necessary plans;
j) The draft framework of the cost estimate;
k) The detailed bill of quantities to be performed;
l) Note on the organization of work (time, site water supply, cut into sections, programming time, etc.).
m) The report for road safety
n) A confidential assessment, which should include details of costs. The costs shall include in particular the following: depreciation of equipment, materials and supplies imported, staff costs, overheads, profits made by the contractor.
o) An outline of the proposed financing. This estimate will be established based on bill of quantities and prices of similar in country and the basis of the tax applies. It will consider the physical contingencies and forecast price increase following the estimated date of start of work.

2.7.3.2 Documents Expected for the Preparation of Tenders for Road and Road Drainage Works and Supervision

Explanation:	In most cases, the standard bidding documents for small works of RPPA will be required for tendering. To prepare and allow Districts to fill in this template, the following documents are required at minimum.

The following documents are required at minimum

a) The invitation to tender
b) Instructions to Bidders
c) The General Conditions related to civil works
d) The Special Conditions
e) The Technical Specifications and Performances indicators
f) Part of the detailed cost estimate and confidential cost estimate
g) Part of unit of prices breakdown from confidential cost estimate
h) The various drawings and implementation files for the preparation of bids and proper implementation of works
i) The geotechnical and hydrological file
j) Topography data every ten (10) m
k) Implementation/construction drawings of the axis scale 1 /2,000
l) Drawing of vertical and horizontal alignments, elevation, location and positioning of works and drainage structures
m) Longitudinal scaled: h = 1/500 L = 1/500;
n) Cross-section type scaled: 1 / 25
o) Cross section scale 1 / 200 with cross-sections every 20 m
p) The model of submission
q) The model of bid security
r) The form of progress of the work
s) Models of guarantee (performance bond, advance)
t) The quantitative picture of the materials to be imported

u) The contract will be unit price-based.

Before the expiration of contract, the Consultant will present and publish the final reports of studies. The detailed final report, the (Abbreviated) Resettlement Action Plan (ARAP or RAP), and the tender documents.

The Consultant will also provide all electronic documents (source files, PDF files and word), and other documents such as editable version of the drawings, excel files of the traffic analysis, signed laboratory tests results).

Number of Copies of Each Report

The following table presents the minimum number of hardcopies for each report. Each report and enclosed documents such as maps, annexes, etc. must also be provided as softcopy.

Documents	Number
Inception report	2
Draft report a) technical study -b) economic study c) environmental and impact assessment d) Plan for Environmental social and Social Management	2
Final reports: a) technical review-b) economic study-c) environmental and social impact assessment d) Plan for Environmental and Social Management. e) the RAP(optional)	2
Tender Document	2
CAD Drawings (hard and softy) PDF and editable version	2
CD-ROM or USB containing reports, detailed model input RED and the output data, the results and elements of the model calibration,	2

2.8 Calendar of Events for Road and Road Drainage Design

Explanation:	The services listed below are made within (To do : Insert number of months) from the date mentioned in the service order after signing the contract, including the time of approval of the various phases

To+0.0: Beginning of studies

To + 0.5 months: Submission and presentation of inception report

To + 1 months: Transmission of the final inception report taking into account client comments

To + 3.5 months: Submission of feasibility study reports (feasibility report) of technical study, economic, environmental and social

To +4 months: Submission of the final feasibility report, ESIA and EIA certificate issued by RDB where required

To+ 6 months: Submission of draft final detailed report

To+6.5 months: Submission Final Detailed study report and draft Tender Documents and, RAP

To + 7.00 months: Submission of tender documents and RAP or ARAB where required

2.9 Payments Modality for Road and Road Drainage Design DTED

The client according to the following percentage will conduct the following payment the Consultant:

Rep-1: Inception report

Rep-2: Feasibility report and Draft ESIA

Rep-3: Final report, RAP Final Tender Documents in English and French

Each payment requires the prior submission of the respective invoice.

The payment schedule for these services are as follows:

Invoice No.1 (upon approval of the report Rep-1): 20% of the contract amount

Invoice No.2 (upon approval of the report Rep-2): 45% of the contract

Invoice No.3 (upon approval of the report Rep-3): 35% of the contract amount.

2.10 Proposed Bill of Quantity for Road and Road Drainage Design

The following bill of quantity should be filled and provided in the financial proposals for these consultancy services:

N°	Description	Unit	Qty	Unit Price	Total
1.0	**Key Staff on site**				
1.1	Team leader Road-Engineer	expert-month	4		
1.2	Geotechnical/ Pavement Engineer	expert-month	2		
1.3	Structural Engineer or Bridge Engineer	expert-month	1		
1.4	Highway Engineer	expert-month	2		
1.5	Hydrologist	expert-month	1		
1.6	Environmental Expert	expert-month	1		

N°	Description	Unit	Qty	Unit Price	Total
1.7	Senior Surveyors	expert-month	1		
1.8	Transport Economist	expert-month	1		
1.9	Sociologist or Socio Economist	expert-month	1		
2.0	**Operation**				
2.1	Office rent & Accommodation	LS	1		
2.2	Transport Cost	LS	1		
2.3	Printing & Transport for documents	Ls	1		
	Total				

2.11 Preparation and Presentation of Project Documents for Road and Road Drainage Design

2.11.1 Feasibility Study Report

The feasibility study is prepared after the preliminary survey is completed. The feasibility report must establish the economic viability and technical soundness of the alternative selected. Thus, it must be preceded by the engineering surveys and investigations of sufficient accuracy and detail as to result in a fairly firm estimation of the cost of the project. It must be based on accurate traffic projections and must contain an economic analysis. It should contain at minimum:

a) A full account of the socio-economic profile of the country and the road influence area must be given in the feasibility report. The transport infrastructure of the stage must be fully described, giving details of the road.
b) The feasibility report may include discussion on different alternative alignments, alternative pavement design for deciding the one most suitable as final option.
c) The report should give a brief description of the scope of the projects, its need, sources of funding, budget and plan provision, and selection of route alignment, cross sectional alignments, drainage facilities and construction technology.
d) The methodology adopted for the various studies must be described. These include traffic surveys; soils; materials and sub-soil investigation, hydrological and drainage studies.
e) The design standards and methodology adopted must be explained.
f) The report must contain a reasonably accurate estimate of costs, giving the basis for adopted rates. Any provision for escalation of costs must be explained.
g) The economic analysis must be based on current costs.

In addition to catering for the uncertainties in the generated and diverted traffic, a sensitivity analysis shall be carried out considering the non-occurrence of the development envisaged and/or

the diverted traffic not attracted as per assumption. For cost benefit assessment, the sensitivity analysis shall include:

a) Base case
b) Pessimistic scenario
c) Optimistic scenario
d) The construction arrangements envisaged must be discussed.
e) The feasibility report must be accompanied by the following drawings:
    - Locality map
    - Plans showing various alternative alignments considered and the selected alignment
    - Typical cross sections showing pavement details
    - Drawings for cross drainage and other structures
    - Road junction drawings
    - Strip plan
    - Preliminary land acquisition plans

The feasibility report shall have the following structure and coverage:

2.11.1.1 Volume1: Main text and appendices

Executive summary

Economic and social setting

a) Country's economic profile, including GDP, agricultural production, industrial output, mining etc. and their growth rates
b) Country's population and growth rates
c) Potential of industrial and other economic growth in the project influence area

Social-economic profile of the project area

The role of similar other facilities in the vicinity, delineation of the influence area, demographic characteristics, influence area economy (district income, per capital income), economic sector, transport profile

Project description

a) Scope
b) Necessity
c) Source of funding and budget provision
d) Selection of route
e) Management
f) Alignment
g) Cross sectional elements
h) Drainage facilities
i) Construction technology

Methodology adopted for the studies

a) Division into homogenous sections
b) Traffic studies like classified counts, Origin-Destination
c) Traffic growth rates
d) Road inventory,
e) Survey and investigation results including at least:
    - Soil surveys
    - Material survey
    - Visual condition assessment
    - Design of cross drainage works

Design report

a) Project road inventory
b) Engineering survey and investigation data
c) Design standards and specifications
d) Special site conditions effecting design
e) Pavement design
f) Design of cross-drainage and other structures

Cost estimates

a) Item rates and rate analysis
b) Escalation

Economic analysis

a) Vehicle operating costs
b) Time costs
c) Accident costs
d) Economic costs and benefits
e) Sensitivity analysis
f) Discussion of results

Conclusion and recommendations

2.11.2 Detailed Project Report for the Road Project

2.11.2.1 General

Both the proposal made and the data collected during the survey and investigation of the project should be presented in a proper and understandable form. These should be prepared in three parts which when read together will constitute the complete project document. The headings are:

a) The report
b) Estimate
c) Drawings

The details to be presented in each parts are explained hereafter for guidance. However, it should be understood that the extent of detailing of an individual aspect would depend upon the size of the concerned projects and its scope.

2.11.2.2 Project Report

For easy understanding and appreciation of the project, the project report is one of the most important parts of the project document and should give a precise amount of different features. The information provided should be dealt under the following heads:

a) Executive summary
b) Introduction
c) Socio-economic profile
d) Traffic surveys including traffic forecasts
e) Engineering surveys and investigations and proposed road features
f) Pavement studies
g) Design standards and specifications
h) Drainage facilities including cross-drainage structures
i) Environmental and social considerations including rehabilitation and resettlement (in separate report)
j) Materials, labour and equipment
k) Rates and cost estimates
l) Economic analysis and financial analysis
m) Construction constraints and programme
n) Miscellaneous
o) Conclusions and recommendations

Note: the design calculations …with regard to the above items should be attached.

2.11.2.3 Executive summary

The executive summary summarises the entire report. All the salient points need to be included. The executive summary should be such that a top executive is able to know all the features of the project that are required for decision making.

2.11.2.4 Introduction

The introduction should cover:

a) ***The name of the project and its broad scope:*** information should give a general idea of the scheme as whole.
b) ***Client / Authority and plan provision:*** Give reference to the order of the competent authority calling for the project and the provision for the work in the relevant development plan
c) ***History, geography, climate, demography, etc.***

- Previous history of the road and its present condition (for the existing roads) or development history for project as regards economic activity, population served, available transport facilities, etc (for a new road).
- Highlight aspects such as prone to flooding of the area, waterlogging…
- The general topographical and geological features of the area.
- Rainfall, annual average intensity and distribution during the year, range of temperature during dry and wet months of low and high water levels in river, …

- ***Necessity:*** Indicate the necessity for the project and the circumstances which have made the execution urgent

2.11.2.5 Traffic Survey and Traffic Forecasts

This part must discuss the type of traffic surveys conducted for various sections, the data collected and the results of future growth. Additionally, it should contain the present the design traffic figures separately for each element of the project (i.e. width of the carriageway, pavement, intersections, etc.). For existing roads, it should specify the accident data with special reference to the known accident prone area. The traffic foresting methods should be specified and well defined following the requirement laid out in the ToR.

2.11.2.6 Engineering Surveys and Investigations and Proposed Road Features

This section should cover the following:

a) **Route selection:** Considerations governing the route selection and discuss the merits and demerits of alternative routes and the reasons for selecting the proposed route.
b) **Alignment:** the general alignment of road and its details, section by section, with reference to topographical and geological features, obligatory points, such as bridge sites, important population centers, existing or prospective industrial centers, etc. Also discuss points of general importance, like high banks, heavy cuttings, nature of gradients, radii of curves, sight distance, nature of soil along that alignment etc.
c) **Right of way, roadway, carriageway and other cross section elements:** Discuss the proposals regarding the right of way, acquisition of structures alongside roadway, carriageway width, etc. in case of an existing roads, compare the cross sectional elements with the existing widths.
d) In case of the existing roads or where relevant, the above subject should cover aspects, such as road inventory, road condition survey, geotechnical investigations, bridge inventory study, bridge condition survey, etc.

2.11.2.7 Pavement Studies

Road design: Present the special features of road design, for example, fixation of grade line vis a vis High flood level or water level, high embankments, treatment of cut sections, design of road junctions, removal of geometric deficiencies in the case of existing roads, remedial measures for land-side prone location. Discuss any deviations from the prescribed standards, with the reasons for the same. (Attach the calculations)

Pavement design: Present soil investigation data for pavement design in a tabular form. Discuss the methodology of collecting these data, uniform sections and bring out the pavement design proposals with respect to alternatives considered.

Masonry works. Bring out the proposal for retaining walls, breast walls, pitching, parapet walls, etc. (Attach the calculations)

2.11.2.8 Design Standards and Specifications

Give reference to the standard specifications, in accordance with which the works are proposed to be executed. Highlight where any modifications are proposed or special specifications are advocated.

2.11.2.9 Drainage Facilities Including Cross-Drainage Structures.

a) Discuss the investigations carried out for designing the drainage measures and bring out the salient points in respect of high flood level, water table, ponded water level, seepage flows, …
b) Give details of the surface/sub-surface drainage measures proposed, e.g. longitudinal side drains, catch water drains, longitudinal transverse sub-drains, blanket courses, etc. Attach design calculations / drawings as necessary
c) Highlight if any special measures are proposed to check soil erosion and assist soil conservation
d) Discuss the proposal regarding small cross-drainage structures, i.e., culverts. Give details of the proposed structures in a tabular form with cross reference to the standard designs adopted on the detailed drawings enclosed. The table should also indicate special features of each structures like design high level flood, deck level, waterway, etc. attach water-way calculations
e) State whether the structures to be built with regard to standard designs. If so, give reference to the relevant drawings. Otherwise, attach design calculations and drawings.

2.11.2.10 Environmental and Social Consideration Including R&R

Significant beneficial and detrimental impact of the proposed works on the environment in terms of air pollution, damage to life system, stream pollution, soil erosion, drainage pattern, landscaping, etc. Discuss the planning and design measures proposed to minimize / eliminate the adverse effects. Also discuss the resettlement and rehabilitation action plan.

2.11.2.11 Material, Labour and Equipment

Materials

Present the results of the soil and materials survey with reference to various sections of the road, bringing out clearly the sources from which the materials are to be obtained and their suitability of use in the works. Attach borrow material charts, quarry charts, results of tests on materials.

Labour

Discuss the requirement of labour for the work, whether it is to be imported, skilled labour needed, housing facilities, etc.

Equipment

List the total equipment of labour for the implementation of the project. The list of equipment required to be maintained after construction, like settlement gauge for high embankments.

2.11.2.12 Rates and Cost Estimates

1) Give reference to the schedule of rates adopted and the year of its publication. Indicate whether the schedule is current or any correction have to be applied. The schedule of rates must be realistic including the cost of machinery input, etc to avoid revision of estimates.
2) Bring out the items for which suitable rates are not available in the schedule and for such items give reference to the analysis of rates attached to the estimate.

2.11.2.13 Economic and Financial Analysis

The DPR must contain the economic analysis carried out establishing the viability of the project.

2.11.2.14 Miscellaneous Items

a) **Parking places:** Provision of adequate areas of parking spaces at suitable locations is an important feature of road networks, particularly in urban situations. On rural highway also, depending upon the intensity of traffic, parking places are required to be provided in complexes with wayside amenities for trucks as well as passenger cars and tourist vehicles. Near fuelling stations, rest or units with other type of amenities for travellers or truckers, there should be suitable lay-bys adjacent to the highway.

b) **Traffic and Traffic Safety:** It is commonly said that traffic safety is dependent on provision of three E's, (i.e. Engineering, Enforcement and Education). In the project preparation stage care can be taken only on the engineering aspect. Geometric and structural provisions in the project should, therefore, conform to the engineering standards and elements essential for the design speed, capacity, etc of the concerned project. Since pedestrians and cyclists constitute a large percentage of the fatalities, especially on urban roads, adequate safety provisions, like,

segregation, provision of side-walks, footpaths, cycle tracks, crossing facility at intersection, proper lighting, etc. where relevant, shall, have to be provided.

c) **Dumping grounds:** one of the essential requirement of road planning and design is to make proper provision for utilization of unwanted surplus materials resulting from construction excavations in earth work and rock, etc. are normally tried to be adjusted between cut and fill sections or utilization low level areas within reasonable leads. Where no such thing is possible or if the surplus material is of unwanted nature (like dismantled old road crust, elements of dismantled structures, stumps and root system for trees, rejected bituminous mixes, etc.) these require to be dumped in specially earmarked places. Depending upon the requirement of space suitable fallow land or naturally depressed low lands in need of filling may be identified within easy and economic leads for dumping of such materials. The project estimate may make suitable provisions for such arrangement.

2.11.2.15 Conclusions and Recommendations

This should cover conclusions and recommendations about the project as a summary.

2.11.2.16 Estimate

The project estimate should give a clear picture of the financial commitment involved and should be realistic.

The estimate should consist of:

a) **General abstract of cost**: this should give the total cost of the scheme with a general break-up under major heads (with further subdivisions as necessary) e.g.: land acquisition; site clearance, earthwork, subbases and bases, bituminous work / cement concrete pavement; cross-drainage and other miscellaneous items, percentage charges for contingencies, work-charged establishment, quality control, etc. The General Abstract of cost should also include the cost of shifting utilities, like, electric lines, telephone poles, underground cables, sewers, water pipes, cost of arboriculture, cost of removal of trees and compensatory afforestation.
b) **Detailed estimates for each major head**: These should consist of:
    - Abstract of cost
    - Estimate of quantities
    - Analysis of rates for items not covered by the relevant schedule of rates; and
    - Quarry / material source charts

Where the project work is proposed to be executed in stages, the estimate should be prepared for each stage separately.

2.11.3 Drawings for DTED for Road and Road Drainage

2.11.3.1 General

Project drawings should depict the proposed works in relation to the existing features, besides other information necessary for easy and accurate translation of the proposals in the fields. For easy understanding and interpretation, it is desirable that the drawings should follow a uniform practice with regard to size, scales, and the details to be incorporated.

2.11.3.2 Drawing Size

Drawings should be adequate size to accommodate a reasonable length of the road or a structural unit in full details.

The drawings usually required for a road project include the following:

a) **Locality map-cum-site plan:** This is combination of a key map index map drawn on a single sheet. This will be the first sheet in folio of drawings for a particular section of the road. However, where the length of the section is substantial, it may become necessary to separate out the locality map and the site plan. The former being accommodated in one sheet and the latter on a series of sheets.
   a. The locality map should show the location of the road with respect to important towns and industrial centres and the existing means of communication in the neighbourhood to give a bird's eye view of the proposed work. The map may be to a scale of 1:250,000.
   b. The site plan should show the project road and its immediate neighbourhood covering the important physical features, such as, hills, rivers, tanks,…It may be to a scale of 1:50,000 and should show the kilometres from the beginning to end.
   c. The sheet containing the locality map-cum-site plan should have a legend to explain the abbreviations and symbols used in subsequent drawings sheets.

b) **Land Acquisition Plans:** These should be prepared on existing village maps or settlement maps giving the details of property boundaries and their survey numbers. If for any reason detailed land acquisition plans are not possible, rough plans should be prepared. Inter alia, the plans should show the final centreline of the road; the right of way boundaries, buildings, wells, monuments, trees, etc. affected by the road alignment, type of land, i.e. irrigated, wet, dry, barren, forest, etc. and the nature of crops.

c) **Plan and longitudinal section:** Plan and longitudinal section for one km length of the road should be on a single drawing sheet as far as possible the plan should be at the top and the longitudinal section at the bottom on the indicated scale. Common scale adopted is 1:2000 for the horizontal, and 1:200 for the vertical, but this may be changed suitably for hilly stretches.
   a. The plan, among other things, should show the final centreline of the road, right of way limits, roadway of the existing road where applicable, existing structures, drainage, courses, intersecting roads, electric and telephone lines, cables, location of cross drainage structures, design details of horizontal curves, benchmarks, position of Point of transits (POT), locations of cross sections, contours, north point, etc.

b. The longitudinal section should show the profiles of the proposed road, the general ground, and the existing road where applicable. In addition, it should show details, such as, the gradients, location and set out data for vertical curves, super-elevation, details of horizontal alignment, the design High Level Floor, location of drainage crossings and intersecting roads, pavement design features, continuous chainage, etc.

d) **Typical cross-section sheet:** Cross-section elements, like, width of the carriageway and roadway, side slopes, and pavements cross fall will generally remain constant for most of the road length. Instead of repeating these details on every cross section, it would be desirable to show these on a typical cross section sheet. The number of typical cross sections to be drawn will depend on the type of project, the terrain traversed, etc. Generally, it may be necessary to show at least one cross section each for road in fill, cut and curve.

e) **Detailed cross-sections**: A few detailed cross-sections may be presented serially along the continuous chainage. These should show the ground levels, existing road levels where applicable, and the proposed road levels. The area of cut and/or fill involved should be indicated as also the type and thickness of the different pavement courses. For rest of the cross sections computer charts showing tabulated level details and distances may be appended.

f) **Drawings for cross-drainage structures:** A large number of small cross – drainage structures, (i.e. culverts) will be required to be constructed. Unless there is a special problem, it should normally be convenient to adopt standard designs for these. If a standard design is not used for any reason, a separate drawing should be prepared for each cross drainage structure. A convenient scale is 1:50.

g) **Road junction drawings:** The junction drawings should show the existing features of the intersecting roads, the proposed improvements, and traffic control devices, like, signs, pavement marking, etc. A scale of 1:500 will be found convenient for this purpose.

h) **Drawings for retaining walls and other structures:** These drawings should clearly show the foundation and structural details as also the materials proposed to be used. The scale chosen should be large enough to show all the details comprehensively.

i) Drawings showing the location of construction materials

j) Drawings of parking along the road

k) Location of various road signs

2.12 Main References

Explanation:	Please familiarize yourself with the content of the documents listed below to have a better background on the requirements of road and road drainage design

- Law governing roads in Rwanda N°55/2011 of 14/12/2011
- Final_Drainage_Design_Manual__Final_Dec2014_RTDA
- Final_Road_Pavement_Design_Manual_Final_Dec2014_RTDA
- RSB 267-1 2015 Rwanda Standards Board Guidelines for Feeder Roads Design (Jan 2015)
- OVERSEAS ROAD NOTE 31(fourth edition ;a guide to the structural design of bitumen surfaced roads in tropical and sub-tropical countries
- TRH20;The structural design, construction and maintenance of unpaved roads and TRH3;Design and construction of surfacing seal
- AASHTO Guide for Design of Pavement Structures 1993

3 Section 2: DETAILED TECHNICAL DESIGN OF A BRIDGE PROJECT

ABBREVIATIONS

Abbreviation	Description
BoQ	Bill of Quantity
EIA	Environmental Impact Assessment
KfW	KfW Development Bank
LODA	Local Administrative Entities Development Agency
PPE	Personal Protection Equipment
RDB	Rwanda Development Board

3.1 Introduction to the DTED Guidelines for Bridges

Providing safety for the public by having adequate strength for constructed facilities has been the cornerstone of the framework used by engineers for bridge design.

Bridges in Rwanda Districts are generally stream crossings. It was observed especially during rainy seasons the rainy water overflowing bridges destruction of road drainage structures in different districts. This is in general due to poor design of the bridges.

These guidelines on the elaboration of terms of reference for bridge projects will enable LODA and District engineers to elaborate appropriate ToRs to be used in recruitment of consultants to conduct DTED for bridge projects and to validate design reports.

These guidelines cover the entire bridge design process, from the inception stage through site investigations and materials analysis, hydraulic design and structural design, to the final preparation of drawings and detailed specifications.

Wherever you need to complete or update, this is characterised by a “to do” marked in green.

Furthermore, there are explanatory part that are marked in light green and are starting with “Explanation” as shown in the example below.

Explanation:	This is for further explanation and should be deleted once the document is finalized

3.2 Information Sheet

Explanation:	Please fill the information sheet at the end, when having completed the other sections of the document

1	Country	Rwanda
2	Consultancy services	To do: Describe the service in summarized form
3	Road Name	To do: Insert District Name
4	Location of the Bridge	To do: Insert location map
5	Recipient	To do: Insert District Name
6	Executing Agency	To do: Fill the information below

		Insert District Name P.o. Box: E-mail: Tel :
7	Funding Agency	To do: Fill the information below Insert Name P.o. Box: E-mail: Tel :
8	Project Description	The Government of the Republic of Rwanda, represented by the (insert the name of the District) is recruiting a consultant who will conduct consultancy services to conduct Feasibility and Detailed technical study of (To do: Insert bridge name). The services include reconnaissance of the bridge project, the traffic study and estimation, the topographic survey, the geotechnical study of the bridge site, structural design, Technical drawings, and hydrological study of the area, the study of Environmental and Social Impact Assessment and preparation of the Bill of quantities and tender documents for the execution of works of the above mentioned project. The services will be reported in three report: a) **Inception report** shall contain the preliminary observations with the points that can affect the design of the bridge project, detailed work program, brief description of the working methods / methodology of the consultant in accordance with the Terms of Reference and identify any major issues/constraints and the staff mobilization plan. b) **The Feasibility study** shall contain the preliminary findings in topographic survey, the geotechnical investigations, the traffic survey, hydrology and the preliminary designs for at least two alternatives including their costs. The report shall include any possible alternatives and the environmental, socio-economic profile assessment of the project. The report shall include the comparison of the alternatives and argue recommendations for choosing the appropriate alternative. The findings from this report shall lead to the development of the details design and detailed Bill of Quantities and ESIA. **c) The final report** shall contain the details designs of the bridge, the retaining and hydraulic structures, safety features and the Tender Documents and ESIA. The language of the reports is English or French

9	Estimated Duration	Total duration of the services: (to do: Fill months of study implementation).....Months
10	Consultancy Services Required and Phase of Selection	The Procurement of Consultancy Services will be carried out in accordance with the Procurement Law of Rwanda. Consultancy services for carrying out the bridge studies will be determined on the basis of Short-listing. The selection procedure to determine the short-listed firms for implementing the study shall be based on technical quality with price consideration (QCBS: Quality Cost Based Selection).

3.3 Introduction to DTED for Bridges

Providing safety for the public by having adequate strength for constructed facilities has been the cornerstone of the framework used by engineers for bridge design.

Bridges in Rwanda Districts are generally stream crossings. It was observed especially during rainy seasons the rainy water overflowing bridges destruction of road drainage structures in different districts. This is in general due to poor design of the bridges.

3.3.1 Description of the Bridge Project

The District of (to do: insert the name of district) intends to carry out the Consultancy services for the design of (to do: insert name of the bridge) located on (insert the name of the road) road in (to do: insert the name of district) District.

(to do: insert the name of bridge) bridge is located on (to do: insert the name of road) road in (to do: insert the name of district) district. The road connects (to do: insert connected locations). The existing bridge has been damaged by (to do: specify reason e.g. flooding). This old bridge should be replaced with a new bridge than can withstand the traffic loadings safely and taking into consideration of the climate change effects.

3.3.2 Objective of the Services for the DTED of a Bridge

The main objective of the services is the complete study and preparation of tender documents which will lead to the construction of the (to do: insert the name of the bridge) and the access ramps connecting the existing road.

3.3.3 Scopes of Services for the DTED of a Bridge

The consultant shall provide and guarantee the highest quality of detailed engineering for civil woks design, topographic survey, geotechnical investigation, detailed engineering design, technical specifications, unit prices analysis and cost estimates, construction drawings, environmental and social impact assessments.

The consultant shall carry out but not limited to:

a) Topographic survey for the project including the following to prepare the topographic map and all other necessary data for the detailed engineering design
   - Establishment of horizontal and vertical control points (benchmarks)
   - Topographic profile survey covering the crossing area with contour lines
   - Surface water runoff survey

b) Carry out subsoil investigation including boring and laboratory tests and other necessary tests, provide sub-soil investigation maps. The consultant shall make detailed soil investigation with disturbed / undisturbed samples to be taken at intervals and frequency as determined by the standards and such other places considered necessary to determine changes in soil type,

c) Carry out hydrological survey by collecting available historical data from relevant authority. The catchment areas, run-off coefficient depending on the terrain type, existing vegetation, land use and geological type, hydraulic slope and design flood discharge for appropriate return periods shall be determined for the proposed structure and the corresponding water level established. The flood return period(s) utilized for the design of drainage system shall be selected to determine the optimum period from hydrographic data pertinent to the topography and terrain through which the crossing sections is located,

d) Identify existing public utilities (if any) and propose possible relocation site with the utility relocation maps. Also provide cost estimates for relocation of utilities,

e) Carry out the environmental and social impact assessment according to existing and current regulatory framework i.e. policies, lows, regulations and guidelines as published by REMA, RDB and other relevant legal and institutional framework,

f) Carry out detailed designs including detailed plans and construction drawings, detailed cost estimates, associated contract documentation to include detailed specifications, bill of qualities (BoQ) with detailed breakdown and description of unit rates, and implementation schedule for project,

g) Elaborate the tender documents for the execution works,

h) Present the maintenance plan of the proposed bridge.

3.3.4 Expected Outputs for the DTED of a Bridge

The expected output of the study are:

h) Assessment and recommendation of the required intervention for the design of the infrastructure of good quality, safety, environmental protection, erosion control and bridge protection

i) Detailed Engineering Study for the bridge construction works

j) Cost estimates of the project and the BoQ

k) Updated environmental and social economic impact;

l) Development of Environmental and Social Management Plan (ESMP);

m) Preparation of Resettlement Action Plan (RAP)

n) Preparation of tender documents.

3.4 Feasibility Study and Preliminary Design for a Bridge

Explanation:	For the Feasibility Study please also refer to LODA's feasibility study guidelines of 2020

3.4.1 Technical Bridge Dimension

3.4.1.1 Inception Report

This report shall provide the preliminary observations with the points that can affect the design of the bridge project: detailed work program; brief description of the updated working methods; methodology of the consultant in accordance with the Terms of Reference and identify any major issues; constraints and the staff mobilization plan.

Explanation:	The inception report should be presented to District staff in a meeting and open issues should be discussed and decided on

3.4.1.2 Bridge Feasibility Study

The Feasibility study shall contain the preliminary findings in bridge location and surveying operation, river hydraulics, soil investigation, socio-economical assessment, environmental impact assessment, preliminary bridge structural design, technical documents and bills of quantities.

The report shall include any possible alternatives and include the economic analysis and comparison of the alternatives and argue recommendations for choosing the appropriate alternative.

Explanation:	The feasibility study is the Avant-Project Sommaire (APS) and shows the advantages and disadvantages, analysis possible environmental and social risk to be mitigated later, shows technical options for the bridge and provides a first rough cost estimate for each option

3.4.1.3 Bridge Location and Surveying Map

In selecting the location for a bridge, the consultant often has to reach a compromise between the easiest river crossing and the shortest road alignment. The choice of location then becomes an

economic decision. The cheapest bridge site and the one that has potentially the longest service life is a location that:

- Is on a straight reach of the river;
- Is beyond the disturbing influence of larger tributaries;
- Has well defined banks;
- Has reasonably straight approach roads;
- Permits as square a crossing as possible;
- Has good foundation conditions.

The site should allow the maximum gradient of the approach roads to be appropriate to the types of vehicle likely to travel on the road as well as offering vertical curves and sight distances suitable for the maximum speed of vehicles using the bridge.

The consultant will prepare the topographic map, sections and all other necessary data for the detailed engineering design.

3.4.1.4 River Hydraulics

The required design hydraulic data are as follows:

- Design flood level
- Flow volume and velocity
- Maximum flood level
- Bed characteristics - particle size
- Channel shape and flood plain width
- Scour depth
- Clearance of floating debris.

The general order of hydraulic design is:

- Establish the height of the superstructure, i.e. clearance above the DFL (Design Flood Level)
- Establish trial positions for the abutments according to the bed shape at the proposed crossing
- Make a provisional decision regarding the number of piers that will result in the lowest overall cost of superstructure, piers and abutments
- Calculate the general scour and the local scour due to abutments and piers, and draw the worst case profiles on the cross sections
- Check that the backwater caused by the restriction to flow does not cause damage to surrounding land upstream of the bridge or affect the height set for the superstructure
- Prepare preliminary designs of abutments and piers.

3.4.1.5 Soil Investigation

The weight of the traffic, superstructure, abutments and piers will all be carried by the soils supporting the abutment and pier foundations. In order to design appropriate foundations the consultant has to determine the nature and location of the different soil types occurring at the site of the bridge and its approaches, to depths containing strata sufficiently strong to support the bridge and embankments without significant deformation.

This information is obtained by analysing samples taken from a grid of bore-holes or test pits covering the whole of the proposed site, and by testing the samples for density, shear strength, plasticity and penetration, in order to provide quantitative data for foundation design.

The level and nature of the ground water also affect the foundation design and the engineer must take into account the impact of bridge construction on the ground water and hence the stability of nearby works and slopes.

Field soil tests:

- Density measurements
- Shear vane tests
- Penetration strength tests
- Dynamic cone penetrometer soundings
- Plate bearing tests.

Laboratory soil tests:

- Liquid limit
- Plastic limit
- Density.

Sieve analyses carried out on coarse-grained, non-cohesive soils also assist in their identification and classification.

3.4.1.6 Bridge Structural Design

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in bridge structural analysis and design will be to produce a structure capable of resisting all applied loads without failure during its intended life.

3.4.1.7 Design of Substructures and Foundations

These are the elements of a bridge that support the superstructure, i.e. abutments, piers and their foundations. The designs are conservative and take account of all the external forces from live and dead loads that substructures are normally expected to sustain.

Abutments

In addition to supporting the dead load of the superstructure, the abutments of a bridge must:

- Resist the vertical and horizontal live loads placed on them by vehicles and the elements
- Retain the approach embankments and the live loads applied to them
- Provide a smooth transition from the road surface to the deck running surface.

The abutment essential features should be:

- A foundation slab, which transmits the weight of the abutment and a proportion of the superstructure directly to the supporting soil, or which forms a capping slab to a system of load-bearing piles
- A front wall with bearing shelf that supports the superstructure and usually retains the soil of the embankment
- Wing walls or retaining walls may be separate from the abutments or, if they are short, may be built integrally with them. These walls retain the road embankment or river bank adjacent to the abutment and are usually built so as to bisect the angle between the road and the river bank, though they can be set at any angle to the abutments and may be built parallel to the road or perpendicular to it.

Piers

Piers also perform a support function. They convey vertical and horizontal loads from the superstructure via the bearing shelf, stem and foundation slab to the supporting soil. in many instances, piers stand on saturated soils for most or all of the year: they do not retain soil embankments but are designed to withstand hydraulic pressures and impact loads. Piers are often more susceptible to scour damage than abutments and need to be orientated carefully with respect to flow direction. Their foundations should be located well below maximum scour depth.

Determination of allowable bearing Pressure

Non-cohesive soils

The allowable bearing pressure under foundations in non-cohesive soils is governed by the permissible settlement of the structure due to consolidation of the soils under the applied loading.

Cohesive soils

Most cohesive soils at foundation level *are* saturated and have an angle of shearing resistance equal to zero, provided that no water is expelled from the soil as the load is applied. This is accepted as the basis for calculating the ultimate bearing capacity of foundations where the load is applied relatively quickly.

3.4.1.8 Concrete Superstructures

Concrete will often be the natural choice of material for the bridges on roads where a long service life and minimum maintenance are required.

Design details

Vertical profile over the bridge

The vertical profile of the road over the bridge can be determined once the high flood level, floating debris or navigation clearance and slab depth are known. If the deck level is required to

be higher than the adjacent
road, the superstructure will describe a hogging vertical curve over the bridge.

Bearings

The simplest form of bearing is made by casting the concrete slab onto the abutment bearing shelf, with only a layer of bitumen felt separating the two concrete surfaces. This may be satisfactory for very short spans, say up to 6m, but for longer spans there is a risk that thermal movement will damage both the supporting structure and the slab.

These bearings consist of discrete strips of black natural rubber, extending over the full width of the slab (or beam) soffit at the support point, with a maximum width of approximately 300mm and a maximum thickness of approximately 25mm. At the free end of the span, the bridge deck locates by friction between the rubber strip and the concrete deck, with no positive mechanical means to develop resistance against transverse loadings. At the fixed end, dowel bars passing through the pad at frequent intervals provide the necessary restraint, both longitudinally and transversely. To allow rotations to occur and the deck to expand laterally, the dowel bars are usually fitted with rubber caps where they pass into the concrete deck slab.

Expansion joints

An expansion joint is required at each end of each span. Though the fixed end moves less than the free end, similar joints are usually installed at both.

Construction joints

Construction joints often provide paths for the seepage of water, leading to leaching of lime from the concrete and corrosion of the reinforcement. For this reason, it is
preferable for the slab to be cast in one continuous pour. If the engineer knows that this will not be possible because the batch volume required is too much for one day's working, it is better for him to mark on the drawings a permissible location for construction
joints. If a joint is unavoidable, it should be parallel to the centre line and preferably located at the high point of the transverse camber.

Slab reinforcement

The maximum length of reinforcing bar generally available is 12m. When a longer bar is needed, e.g. for a 12m span, two bars must be lapped. As a general rule the lap length should be at least 40 times the diameter of the bar. The main bars should not be lapped near the centre of the span, and laps should be staggered so that they do not cause a line of weakness across the slab.
The lapping of bars should be avoided whenever possible so as to ensure good continuity, minimise congestion of reinforcement and so produce better compaction of concrete around the steel.

Drainage

If the bridge is single span with a hogging vertical curve and the joints between deck and abutments are sealed, surface water can be allowed to run off the bridge into the road drainage channels and

no drains are required on the bridge superstructure. If the bridge is multi-span or has a flat or sagging profile with a low point on the bridge, drains must be installed on the deck. The simplest way is to provide a 100mm diameter PVC pipe at the kerb line, dishing the concrete around it, and setting a metal gully grating in the surfacing. The engineer must take care to see that the discharge does not cause damage to services or sub-structures and ensure that close attention is given to the compaction of the deck concrete around the pipe.

Surfacing

The standard slabs are designed to be used with 75mm of asphalt surfacing. This provides some degree of waterproofing and protection of the surface of the structural slab. In some countries it is common practice to use the upper surface of the slab as a running surface. This is not recommended, but should the engineer wish to avoid using asphalt, the minimum cover to reinforcement in the top of the slab should be increased to 75mm and kerb joint and drainage details have to be modified accordingly. Bridges serving gravel roads may need more than 75mm cover to counteract the abrasive action of stones embedded in vehicle tyres.

Services carried on the bridge

It will sometimes be necessary to make provision for services and utilities such as electricity or telephone cables to be carried on the bridge. These services can be readily accommodated in PVC ducts cast into the verges behind the kerbs. The ducts cost very little and could be included even if there were no immediate need. It steel pipes are attached to the deck; they must have provision for expansion at the fixings.

Provision for pedestrians and cyclists

Wherever there is likely to be significant movement of pedestrians and cyclists across the bridge, a segregated pathway is recommended. This pathway can be provided by an addition cantilevered out from the bridge superstructure; but such additions tend to be less robust than the main structure and there is a possibility of critical asymmetric overloading of the deck, should a large number of people congregate on the pathway.

3.4.1.9 Culverts

There are many similarities between bridges and culverts, and they perform similar tasks. Bridges, however, usually accommodate longer spans: they consist of free standing abutments and a separate articulated superstructure which carries the traffic.
Culverts are often made of pre-fabricated pipes or boxes or are cast in one or two pieces: they are usually set low in an embankment and less often bear the direct
weight of traffic.

Where the waterway opening is less than about 15m^2, and particularly where the road crosses the waterway on a relatively high embankment, a culvert will usually be cheaper than a bridge.

Culverts may be constructed using a variety of materials from vitreous clay to glass reinforced plastics,
but the most common and cheapest forms of construction are:

- Precast concrete jointed pipes
- Corrugated steel pipes made of prefabricated panels
- Single or multi-cell reinforced concrete boxes, prefabricated or built in situ.

Single precast concrete pipe culverts are commonly used for small openings up to $2m^2$ while multiple concrete pipes with common headwalls or corrugated steel pipes cater for larger areas. In general alternatively, reinforced concrete box culverts are used with internal box sizes up to 4m x 3.5m. Twin or multiple boxes may be required for larger waterway openings.

In difficult ground conditions a flexible steel pipe has an advantage over a rigid concrete culvert through its ability to accommodate a certain amount of differential settlement over the length of the culvert without overstressing the material. A culvert made of rigid concrete sections will not be tolerant to differential settlement unless it is specifically designed for such conditions either by increasing its structural strength or by segmenting the culvert along its length to allow it to flex. In theory such a solution may appear to be satisfactory, but the provision of watertight joints to permit flexing to occur can be costly and the satisfactory performance of the joints cannot always be guaranteed. Leakage from culverts, particularly those carrying embankments, can have serious consequences, since weakening of the embankment material may lead to an embankment failure.

If properly constructed, a reinforced concrete culvert is likely to have a service life in excess of 60 years and will almost certainly be more durable and require less maintenance than a steel pipe. By comparison, a corrugated steel pipe culvert, well protected against corrosion by plating and bitumen coating, can be expected to have a working life in the order of 30 to 40years in a non-aggressive environment. It is usual to design culverts to last the life of the highway. Despite the best efforts of the engineer, it must be expected that some culverts will become silted or obstructed by debris. For this reason, pipes of internal diameter less than 0.6m are not recommended since they are difficult to clean.

3.4.1.10 Erosion Control

The construction of a road and associated drainage structures may have the effect of taking general water run-off from a slope and channelling it. This concentration of flow is almost certain to cause erosion damage to many types of soil.

Before or at the entrance to culverts it is important to control the flow velocity, particularly since an abrupt change in direction of flow may occur at these points making erosion damage more likely. Control may be achieved by reducing the gradient, installing check drains or by building a drop inlet.

It is also important to control the velocity of flow at the outlet because erosion damage to the road embankment or surrounding farmland occurs more frequently at the discharge end.

A curtain wall is often necessary at the outlet of a culvert carrying more than a minimal flow, in order to prevent scour undermining the structure.

A concrete or rip rap apron may be required to dissipate the energy of the discharge, or it may be necessary to contain the flow in a paved channel until the natural gradient becomes small enough not to induce fast flows with consequential deepening of the channel.

3.4.1.11 Location and Alignment

The proper location of each culvert is important because it affects the drainage pattern and hence the strength of the surrounding soils, the area of waterway, ditch and culvert maintenance, and erosion damage.

There are four rules which, though obvious to experienced engineers, are worth listing here:

- Where a road crosses a valley, the lowest point requires a vent, whether there is an established stream or not.
- Where there is an established stream, the culvert should follow the existing alignment, unless the alignment can be improved.
- The gradient of the culvert should be the same as the gradient of the stream.
- Measures may be necessary to ensure that the watercourse does not move. This could cause severe damage and the consequent change of location of the culvert would be expensive.

As well as venting at the lowest point, it is good practice to install culverts for cross drainage at regular intervals down a long grade. This avoids the necessity of building a large culvert at the bottom of the grade and may also provide the opportunity for safer dispersal of water in smaller mitre drains on the lower slope. The appropriate frequency of these cross drains is best decided on the basis of local experience and depends on gradient, soil characteristics, intensity of rainfall and related factors. As a general rule, there should be at least one culvert every 300m, unless the road follows a ridge.

The gradient of the culvert is important because it affects future maintenance. If it is too steep, it will encourage erosion at the outlet. If it is less steep than the stream, there is likely to be a sediment problem. A gradient of 2 to 4 per cent is advisable where silts are carried in the flow; a minimum of 0.5 per cent is recommended for clear water.

It is also important to set the culvert invert at the same level as the natural stream bed. Culverts are frequently set low to avoid humps in the road above, which results in silting and a consequent reduction in the waterway. Where the road embankment is not high enough to provide adequate clearance above the pipe, the ditch has to be lowered on both sides of the road or the embankment raised. This may necessitate widening the side slopes and demonstrates the importance of detailing drainage structures early in the design of a road.

Where an established stream is met at an angle to the road alignment, it is usually better to follow the line of the stream with a skewed culvert, even though the construction cost will be increased by the greater length. An abrupt change in the direction of flow at the inlet and outlet of a square crossing may be accommodated without problem for most of the year, but when heavy rains cause maximum flow the change of direction can result in severe erosion or wash-out.

3.4.1.12 Headwalls

Headwalls must be provided to retain and protect the embankment at the ends of a culvert and help to counteract the dislocation of jointed pipes due to the spreading forces at the base of large embankments. They also divert debris from falling into the waterway, reduce seepage of water into the embankment and prevent small animals from burrowing alongside the pipe. Where conditions favour erosion, headwalls should incorporate deep curtain walls and side slope protection in the form of gabions or hand-pitched stone.

Since large headwalls are expensive to build, it is advisable initially to make the culvert pipe long enough to reach the toe of the embankment and to monitor the effects for a year: a small headwall may be adequate, provided that side slopes are shallow enough not to need retaining, embankments are relatively low or one-piece pipes are employed, and there is no build-up of water. Headwalls are usually made of masonry or concrete.

3.4.1.13 Concrete Pipe Culverts

On rural access earth roads, sections of concrete pipe are butted together and the embankment material is compacted around them. This is not the most permanent construction but is cheap and often serves adequately for several years. A far better quality culvert is obtained by surrounding the pipe with concrete. The concrete cladding resists the tensile forces that open the pipe joints and strengthens the pipe against bending. If the subgrade is likely to settle under the weight of the embankment, the concrete surround should be reinforced no matter what the depth of cover between pipe and road surface.

3.4.1.14 Reinforced Concrete Box Culverts

Reinforced concrete box culverts may be constructed either as a monolithic box or as a U section with a simply supported top slab propping the side walls. Twin or multiple cell box culverts are used where the horizontal opening is more than about 4m. These too may be constructed with monolithic top slab and walls or with a separately cast lid.

Culverts with separately constructed top slabs are simpler to construct because they require less complicated steel reinforcement and, though containing more material, they generally offer a more economical form of construction. For this reason monolithic boxes are not considered further.

The side walls of the culverts detailed in this chapter are constructed monolithically with the base slab and are propped at the top by the simply supported roof slab. Owing to the reversal of the bending moment in the walls and bottom slab, reinforcement to both faces of these elements is required but the top slab of a single cell culvert requires only bottom reinforcement.

For a twin box culvert with a separately cast top slab, the outer walls are again propped apart and the centre wall may be positively located to the top slab by the provision of dowel bars. The top slab of a twin box culvert is designed as a two span continuous beam spanning over the central wall and requires top reinforcement in the region of the central wall.

3.4.2 Bridge Building Materials

It is assumed that the consultant is familiar with the structural use of steel, concrete and timber. The notes on building materials are intended only to:

- Specify properties of building materials to be used for bridge construction
- Clarify certain aspects of their use
- Draw attention to potential problems
- Provide a consolidated list of the numerous references.

3.4.2.1 Concrete

In general the designs are based on the use of Class 30 concrete using 20mm coarse aggregate (30/20 concrete), the ordinary structural concrete is produced using ordinary Portland cement, Portland blast furnace cement, sulphate resisting Portland cement and Portland pulverised fuel ash cement.

Aggregates used in making concrete should conform with RSB standards or other standards used in Rwanda. Concrete for use with steel reinforcement is more likely to achieve the standard of compaction required if the maximum aggregate size is limited to 20mm.

Where there are significant amounts of sulphates in the soil or ground water, it is prudent to take precautions to prevent deterioration of the concrete, which is in contact with the ground. Breakdown of the concrete mass can result from reaction between sulphate and hydrates. Concrete made with less than 3.5 per cent tricalcium aluminate is considered resistant to sulphate attack.

The basic concept of making a dense, impermeable concrete with adequate cover to reinforcement is still best defence against the penetration of pollutants which attack the concrete mass or the steel reinforcement.

The total chloride content of the concrete mix should not exceed 0.3 per cent of the cement, or cement plus pozzolan mixture, when steel reinforcement is used, or 0.2 per cent when using sulphate resisting Portland cement in mass or reinforced concrete.

In order to avoid detrimental alkali-silica reaction, it is better to use aggregate known to be non-reactive. The alternative is to restrict the total sodium oxide content of the cement to less than 3.0kg per cubic metre of concrete.

Besides ensuring that the materials are of adequate quality, the single most important factor influencing both strength and durability of concrete is the water/cement ratio of the mix. When specifying concrete, the maximum free-water/cement ratio by weight should generally be limited to 0.5. In calculating the free water available in the concrete it is important that any moisture on the surface of the aggregates is included. In marine situations or near the coast, the free-water/cement ratio should be no more than 0.42 to avoid premature deterioration due to corrosion of reinforcement or damage to mass concrete by salt scaling or sulphate attack. Careful mix design is necessary to ensure ease of placing concrete without violating the maximum free-water/ cement ratio.

Cover to reinforcement and curing of concrete must also be carefully specified and supervised on site if the structure is to have an adequate service life. The cover of 50mm shown to reinforcement in the standard designs is intended as a minimum for a structure in a moderate environment. In a

severe environment, such as a marine situation in a hot climate, cover may need to be increased to 75mm or even 100mm to achieve the required lifespan. To ensure that the cover is as impermeable as possible, the concrete must be moist cured with clean non-saline water as soon as surface finishing is complete for exposed surfaces, or as soon as forms can be safely stripped from formed faces (3days for side forms, 14 days for structural supports or as advised by local engineers). This curing process should consist of covering the concrete with wet hessian and covering the hessian with polythene sheeting, which must be sealed around the edges to stop the hessian from drying out. The hessian and polythene should be kept in place until the concrete is at least 7 days old, if possible 14 days.

Special measures are necessary for concreting in hot weather and when there are drying winds and low humidity. Aggregates should be kept shaded, cool mix water should be used and the time between mixing and placing should be kept to a minimum.

3.4.2.2 Steel Reinforcements

Steel reinforcement for concrete shall consist of steel bars or steel wire fabric, except where otherwise shown. Steel bars shall consist of deformed and/or mild plain round steel bars in accordance with BS 4449 or equivalent valid standard in Rwanda.

The basic mechanical properties of the most used steel reinforcements are given in the following table:

Designation	Nominal grade	Characteristic strength, N/mm2	Minimum elongation
Mild steel	250	250	22
High yield steel	460	460	12

3.4.2.3 Structural Timber

The durability of a timber bridge will be conditioned by climate, biological factors and design. The most important climatic factor is moisture, since large seasonal or daily variations in the moisture content of the timber will cause it to shrink and swell, which may lead to cracking. The two most important biological factors are wood-destroying fungi and insects.

Hardwoods are generally more durable than softwoods, especially against termite attack. A design life ranging from 5 years for untreated softwood to 20 years or more for hardwood heart timber can reasonably be assumed. Treatment with chemical preservatives to protect the timber against insect attack and fungi decay can extend this design life considerably.

The need for treatment is determined by the type of timber, the sizes of the timber sections, and the design life required. A few species have a high natural resistance to insect attack and decay, and their heartwood may be used without treatment.

Durability can be enhanced by good design. When detailing, the engineer should:

- Provide for drainage of the timber superstructure to prevent retention of water
- Provide for drainage of the approaches to prevent water running onto the deck
- Keep the ends of logs, beams or trusses away from soil and water
- Avoid soil and debris from the deck being trapped in pockets or against the timber superstructure
- Space timbers and design joints to accommodate movement from shrinkage or swelling.

Requirements for Timber Bridge and maximum vehicle load: 5 Tonnes

S/No	Bridge span (m)	Required minimum diameter of wooden beams (cm)
1	2	21
2	3	24
3	4	27
4	5	30
5	6	33

3.4.2.4 Required Minimum Laboratory Tests on Bridge Building Materials

The minimum required laboratory tests to be provided on building materials are specified by material in this section.

Concrete materials

Sand

- Sieve analysis
- Sand Equivalent
- The absorption of fine aggregates
- chlorides content
- Reactive alkali content

Gravel

- Los Angeles Test
- The absorption of coarse aggregates
- chlorides content
- Reactive alkali content
- Sieve analysis
- The flakiness index

Cement

- Setting time
- Soundness
- fineness

Concrete

Fresh concrete

- Slump test
- Compacting factor

Hardened concrete

- Compression test

Steel reinforcements

- Steel reinforcement Tensile test
- Bending test

Soil

- Sieve analysis
- Soil Waterberg limits
- CBR Test
- Shear test
- Modified Proctor test
- Density
- Moisture content
- Drilling (If required)

3.4.3 Environmental and Social Impact assessment (ESIA)

The Environmental and Social Impact Assessment (ESIA) to be submitted to RDB should include at least the following:

- A project brief of the project should be submitted to RDB for approval
- Descriptions of the institutional and legal framework, regulations and standards should be considered
- Analysis of all stakeholders, public, private; if a concept was drafted on how to engage the stakeholders (consultations, interviews, etc.).
- Definition describing geographical, climatic, social, economic, etc should be provided
- Primary & secondary users as well as beneficiaries of the project should be identified
- All environmental impacts (positive & negative) and risks related to the project should be identified
- A respective plan should be provided on how to mitigate or minimise the environmental impacts and risks identified
- All social impacts (positive & negative) and risks related to the project should be identified such as loss of agricultural land/crops, employment, economic growth, quality of life, etc.
- A respective plan should be provided on how to mitigate or minimise the social impacts and if risks are identified (especially for resettlement, expropriation, compensation)
- An ESMP draft that reflects all identified impacts and risks should be provided

Sufficient meetings and consultations should be organised during preparation of the feasibility study and ESIA.

The ESIA should be approved by RDB and the respective certificate for the project should be issued.

3.5 Final Report for the Detailed Technical and Engineering Design

3.5.1 Minimum Content of DTED Final Report for a Bridge Project

The minimum content of the final detailed technical design report must provide information and data on the following points:

- A detailed record of the traffic intensity and distribution of vehicle classes
- Description of the bridge
- The report of the detailed hydraulic study
- A geotechnical report with location, nature and quantity of usable quarries' material, the report will also consider transport distances of materials to the project road
- The bridge detailed structural design
- Detailed description of building materials and required laboratory tests to be carried out by the contractor
- Detailed ESIA
- Description of construction technical measures and method
- The draft framework of the unit price schedule
- All bridge drawings, the cross sections, topographic surveys to establish the necessary plans
- The detailed bill of quantities to be performed
- Note on the organization of work (time, site water supply, construction operations, programming time, etc.)
- The report for construction safety measures
- A confidential assessment which should include details of costs.

3.5.2 Bridge Drawings

- Site plan
- Longitudinal sections
- Transversal sections
- Subsurface data
- General arrangement drawing
- Foundation layout
- Concrete drawing
- Reinforcement detail drawing
- Parapet drawing
- Bearing detail drawing
- Miscellaneous detail drawing
- Bending schedules.

3.5.3 Documents Expected for the Preparation of Tenders for a Bridge Project

Explanation:	In most cases the standard bidding documents for small works of RPPA will be required for tendering. To prepare and allow Districts to fill in this template, the following documents are required at minimum.

The following documents are required at minimum:

- The book of particular technical clauses,
- The works evaluation method,
- A quality assurance file,
- The framework of the unit price schedule,
- The sub-detail of unit prices,
- The bill of quantities framework,
- All the drawings resulting from the detailed design studies essential for the establishing of execution plans,
- The geotechnical soil survey report for the structure's foundations.

3.5.4 Implementation Schedule and Reporting for a Bridge Project

Explanation:	Reporting is an important aspect of the consultant responsibilities towards the Employer and shall allow the employer's officials in charge of the studies to closely follow and comment on the progress of the study.

To do: The maximum period for carrying out the study assignment should be indicated. This period does not include the validation times of reports by the client which will not exceed two weeks at each stage.

The schedule will clearly show:

- The duration of completion of all preliminary design studies,
- The duration of all detailed pre-project studies,
- As well as all the validation periods for the various studies by the client.

3.5.5 Minimum Key staff for Bridge Design and Construction

Explanation:	The team composition might change with the project. For more complex projects, you need more experienced staff and usually more positions. The minimum of years of experience is therefore an orientation that might be slightly changed

N°	Description	Minimum years of experience
1	Team leader Road-Engineer /Structural engineer	10
2	Geotechnical Engineer	10
3	Structural Engineer or Bridge Engineer	10
4	Hydrologist	5
5	Environmental Expert	5
6	Senior Surveyor	5

3.5.6 Bridge Loading Test

Explanation:	This test is conducted after the end of bridge construction before the provisional handover. The cost must be a separate item in the confidential Bill of Quantities

This test is conducted after the end of bridge construction before the provisional handover. The cost should be taken into account as an item of BoQ.

Bridge Testing objectives:

- To assure the client that the delivered work is able to withstand the test loads
- To check that the mechanical operation of the structure is consistent with its calculation modelling.

Standard : EN 1991-2.

Loading operation is in three phases:

- Loading of the supports
- Balanced symmetrical loading of beams
- The asymmetrical loading of the beams

3.6 Main References for DTED for a Bridge Project

Explanation:	Please familiarize yourself with the content of the documents listed below to have a better background on the requirements of bridge design

- RTDA Bridge Design Manual December 2014
- DFID Design manual for small bridges, 2000
- AASHTO. 2010. *LRFD Bridge Design Specifications*. American Association of State Highway and Transportation Officials, Washington D.C.

4 Section 3: DETAILED TECHNICAL DESIGN OF WATER SUPPLY SYSTEM PROJECT

ABBREVIATIONS

Abbreviation	Description
BoQ	Bill of Quantity
CAPEX	Capital Expenditures
EIA	Environmental Impact Assessment
KfW	KfW Development Bank
LODA	Local Administrative Entities Development Agency
OPEX	Operational Expenses
PPE	Personal Protection Equipment
QAC	Quality Assessment Consultant
RDB	Rwanda Development Board
RLDSF	Rwanda Local Development Support Fund
WSS	Water Supply Systems

4.1 Introduction to the Guidelines for DTED for WSS Projects

During the quality analysis of quality of detailed technical design of water supply projects conducted locally in different Districts, we realised some weaknesses mostly linked to poor and incomplete terms of reference (ToR) used in the standard bidding documents to recruit consultants to conduct the detailed technical designs (DTED) of water supply).

These guidelines on the elaboration of terms of reference for water supply projects will enable LODA and District engineers to elaborate appropriate Terms of Reference (ToR) to be used in recruitment of consultants to conduct the detailed technical and engineering designs (DTED) for water supply projects and support a qualified validation of these design reports.

The services include to ensure the sustainability of the Water Supply Systems and avoid that systems are oversized / undersized, to ensure that sufficient water quantity is available, ensure compliance with drinking water standards as well as protection of equipment from corrosion / scaling / damage, to verify different solutions and to ensure that the most feasible option is selected, to ensure availability of data basis for the design such as topographical, to ensure clear identification of all assets and their locations also for later maintenance requirements, to ensure technical reliability of WSS to avoid damages / leakages, to ensure consistency of all documents and avoid planning mistakes, the Environmental and Social Impact Assessment, preparation of the bill of quantities and confidential cost estimate and tender documents for the execution of works of the above mentioned project.

Wherever you need to complete or update, this is characterised by a “to do” marked in green.

Furthermore, there are explanatory part that are marked in light green and are starting with “Explanation” as shown in the example below.

4.1.1 Information Sheet for the WSS Project

Please fill the information sheet at the end when you have all required information already inserted in the rest of the document. It serves as a brief summary and description of the project.

1	Country	Rwanda
2	Consultancy services	To do: Describe the service in summarized form
3	Project Name	To do: Insert District Name
4	Location of the system	To do: Insert location map
5	Recipient	To do: Insert District Name
6	Executing Agency	To do: Insert District Name P.O. Box: E-mail :

		Tel :
7	Funding Agency	To do: Insert Name P.O. Box: E-mail : Tel :
8	Project Description	The Government of the Republic of Rwanda, represented by the (To do: *insert the name of the District*) is recruiting a consultant who will conduct consultancy services to conduct Feasibility and Detailed Technical Study of (To do: *Insert project name*). The services include: (i) To ensure the sustainability of the WSS and avoid that systems are oversized / undersized (ii) To ensure that sufficient water quantity is available (iii) Ensure compliance with drinking water standards as well as protection of equipment from corrosion / scaling / damage (iv) To verify different solutions and to ensure that the most feasible option is selected (v) To ensure availability of data basis for the design such as topographical, (vi) To ensure clear identification of all assets and their locations also for later maintenance requirements (vii) To ensure technical reliability of WSS to avoid damages / leakages (viii) To ensure consistency of all documents and avoid planning mistakes (ix) The Environmental and Social Impact Assessment (x) Preparation of the Bill of quantities and confidential cost estimate and tender documents for the execution of works of the above mentioned project. The form and content of a design report will largely, depend on the nature and complexity and size of the project. Large and complex projects require reporting during the design stages: • Inception Report • Preliminary Design Report • Detailed Design Report • Tender documents • Engineer's Estimate. For small and uncomplicated schemes, one detailed design report may be sufficient. The contents of each report are presented separately in this section and should be adjusted to suite the requirements for a particular project. **I. Inception Report**

		The Consultant shall carry out a comprehensive literature review immediately after signing the contract and will present his/her findings in the inception report. Literature review shall cover scholarly articles, books and other sources (e.g. dissertations, conference proceedings, policy statements, manuals, procedures, strategy papers, and existing laws) relevant to design/construction and related areas of research, or theory. The Consultant shall then provide a description, summary, and critical evaluation of each work. The purpose of the literature review is to offer an overview of significant literature published on the topic/project. **II. Preliminary Design Report** The consultant shall prepare and submit a report on preliminary design to the client for approval, which shall contain the project design brief and outline design drawings. The report shall also include: (i) A geotechnical report (ii) An Environmental and Social Impact Assessment Report (iii) EIA certificate issued by RDB and (iv) Topographic Survey Report. **III. Detailed Design Report** This report shall include detailed Engineering Report on all investigations, technical, economic, environmental and social investigations, structural design and calculations. **IV. Tender Documents** Tender documents form the basis on which a civil engineering Contractor will prepare his tender and carry out and complete the contract works. These documents should detail all the requirements of the project in a comprehensive and unambiguous way. These documents also identify all the rights and duties of the main parties to the contract. Collectively they constitute a binding contract, where by the contractor undertakes to construct works in accordance with the details supplied by the Engineer and the Employer agrees to pay the Contractor in stages during the execution of the works in the manner prescribed in the contract. The tender documents should be based on the standard RPPA documents. **V. Engineer's Estimates** The Consultant will be expected to have prepared a confidential pre-bid cost estimate and submitted the same to Client together with the bidding documents. As far as possible this should be based on unit costs derived from recent projects of a similar magnitude, complexity and remoteness from or proximity to ports or major urban areas. Detailed estimates of recurrent costs should be based on unit costs provided by the operating authority or from schemes of a similar size and nature. Anticipated revenue should be based on the recommendations made regarding tariff structures or provided by the operating authority.

		The language of the reports shall be English or French
9	Estimated Duration	Total duration of the services: To do: *insert the number of the months (e.g. 6 months)*
10	Consultancy Services Required and Phase of Selection	The procurement of Consultancy Services will be carried out in accordance with the National Procurement Law of Rwanda and its respective Ministerial Orders and guidelines. The selection procedure to determine the short-listed firms for implementing the study shall be based on technical quality with price consideration (QCBS: Quality Cost Based Selection).

4.1.2 Study Area of the WSS Project

The "To do: *insert the project name*" provide clean water to "To do: insert number of beneficiaries, names of villages, names of cells, name of sector and name of district". For example, the project study is a rehabilitation/upgrade of the existing water supply network or an extension or a new water supply scheme.

4.1.3 Main Objective of the Consultancy Services for the DTED for a WSS Project

The main objective of the consultancy services is to conduct the detailed technical and engineering designs study and financial and economic study, environmental and socio-impact study, and elaboration of the tender documents.

4.1.4 Scopes of Consultancy Services for the DTED for a WSS Project

The consultant shall perform all necessary data collection, literature review, planning, engineering, economic, financial, environmental and social analyses, field investigations and related works as described herein with due care and diligence to attain the objectives of the project. The main components of the project for the detailed technical design phases are as follows:

(i) *Calculation of water demand* and establish methods of estimating water demand

(ii) *Determine available water sources* by considering quality, quantity, cost, technology and protection

(iii) *Conduct raw water quality test*: The raw water quality must be determined in order to establish whether the water can be supplied in its raw form or whether it needs treatment

(iv) *Design of water intake*: The extraction should be done in a sustainable manner without creating an environmentally and physically adverse effect on the water body. Therefore, detailed hydrologic studies including analysis of historic data must be performed

(v) *Conduct geotechnical investigation*: This is required for big structure location only examples reservoirs, pumping stations, treatment unit etc.

(vi) *Water treatment*: Establish required water treatment method

(vii) *Pumps*: Pumps and pumping station design

(viii) *Hydraulic calculations* to design transmission and distribution networks

(ix) *Design of water storage* tanks and distribution reservoirs

(x) *Cost estimate* of the project: Break down the different cost items in the confidential Bill of Quantities

(xi) *Standard Bidding Documents*: Preparation of the Tender Documents

(xii) *Maintenance plan*: Propose the maintenance plan

(xiii) All other works deemed necessary by the consultant.

The raw data collected under this project shall be submitted to the client in both PDF format and editable version, either in Excel files, CAD files or similar technical formats.

4.1.5 Expected Outputs of the DTED Consultancy for the WSS Project

The expected outputs of the study are:

(i) Detailed Technical Design for the *construction* works

(ii) Cost estimates of the planned project and its bill of quantities (BoQ)

(iii) Environmental and Social Impact Assessment (ESIA)

(iv) Development of Environmental and Social Management Plan (ESMP)

(v) Preparation of tender documents and technical specifications of the material to be used.

4.2 Feasibility Study and Detailed Design Stage of the WSS Project

4.2.1 Technical Dimension of the WSS Project

4.2.1.1 Ensure the Sustainability of the WSS and Avoid that Systems Are Oversized / Undersized

The consultant should conduct the needs assessment / demand forecast by estimating water demand for a community as the first activity of the design process. This starts with the delineation of the proposed supply areas and followed by a socio-economic baseline survey.

This survey involves counting the number of potential users. It is often impractical to count all the potential consumers. However, statistical methods and sampling, information obtained from National Institution of Statistics (NIS) and from the district may be used to improve the estimates. Because water supplies are meant to serve for several years, the estimate of the future population is also required.

To calculate the water demand for a water supply scheme, it is necessary to:

(i) Determine the numbers of consumers falling within the different consumer categories at various stages of the design period.

(ii) Determine the average day unit water demand figures for the various consumer categories concerned.

The common categories of consumption are:

- Domestic (which are further categorised into high, medium and low income categories)
- Commercial/productive use
- Institutional categories.

In each category, consumption should be estimated and projected independently.

4.2.1.2 Ensure that Sufficient Water Quantity is Available

The consultant should select suitable sources that can meet estimated current and projected demand.

Selection of a suitable source or combination of sources of water is one of the initial steps in designing a water supply scheme. The source or sources must be capable of supplying sufficient water of acceptable quality for the scheme. the cost of construction of the source intake, technology and expertise to exploit and maintain the source of water and associated water treatment and transmission facilities as well as its protection must be considered.

Sources which require little or no treatment of raw water such as springs, wells and boreholes should be given the highest selection priority provided their yields are sufficient to meet the water demands of the scheme. In selecting surface water sources; rivers with upland mostly forested catchments should be given preference.

4.2.1.3 Ensure Compliance with Drinking Water Standards as well as Protection of Equipment from Corrosion / Scaling / Damage

The quality of water supplied is an important consideration for any water supply project development. The consultant shall conduct raw water quality tests and establish whether the water can be supplied in its raw form or whether it needs treatment. The assessment of raw water quality is particularly important because it is the result of the water quality analysis that guides the decision on the treatment method required to treat the water.

The level of treatment depends on the intended use of the water. Water supplied for domestic use must meet the national water quality standards for drinking water before transmission and distribution to consumers.

For water quality parameters where national standards do not exist, or outdated, WHO standards should be used. Even if water is clean at the source, it should be disinfected as it can be infected during distribution or storage.

At design phase and design review water sample for quality test should be taken at the source and later will be taken at water distribution points before works handover to ensure if the water comply with National standards

4.2.1.4 Ensure that the most Feasible Option is Selected

The consultant should make sure that alternative option or solution are studied and presented with advantages and disadvantages as the best option is selected. At this stage you have to check if the selected option will also facilitate the later operation and maintenance of the WSS.

4.2.1.5 Ensure Availability of Data Basis for the Design

The consultant should perform:

(i) topographical
(ii) hydrological and
(iii) geotechnical surveys.

The Consultant has to check:

- If ground or soil conditions have required bearing capacity to withstand proposed civil structure or an impact on the costs such as excavation of trenches.
- If ground elevations for proper calculation of system hydraulics are studied.
- If locations of the proposed infrastructure are aligned to the demand and location of the communities etc.

4.2.1.6 Ensure Clear Identification of all Assets and Their Locations also for Later Maintenance Requirements

The consultant shall make sure that all site locations especially civil and hydraulic structures (Intakes, treatment unit, pumping stations, reservoirs, valve chambers, water taps etc) are clearly identified by geographical coordinates. He/she has to make sure if locations and structures are marked by unique labels throughout the overall design.

4.2.1.7 Ensure Technical Reliability of WSS to Avoid Damages and Leakages

The consultant should provide the design criteria used in the study and formulas to calculate and size the system as per best practices and international standards to ensure that later the constructed infrastructure will not be damaged or require rehabilitation before its usual lifespan.

4.2.1.8 Ensure Consistency of all Documents and Avoid Planning Mistakes

The consultant should make sure that a complete set of technical drawings for the preliminary design is elaborated and check if there is a correlation and relation between the drawings and the other design documents.

4.2.1.9 Technical Documents to be Provided in Water Project Design

4.2.1.9.1 Hydraulic Flow Diagram

The consultant should ensure the technical feasibility, to avoid overflows, damage of mechanical equipment by water hammer etc.

A Hydraulic flow diagram is required to show the hydraulics of the overall system, its intakes, the water treatment unit, its reservoirs, its pumping stations, taps, pressure break tanks, etc. and the respective hydraulic levels.

The consultant must show also if provided levels are in line with the provided hydraulic calculations.

4.2.1.9.2 Overview Plan

To be sure of clear identification of all assets and their locations, the consultant should provide the overview plan which shows all structures to be built on the georeferenced map identifying each location. This must also contain the labelling system mentioned under section 3.1.6.

4.2.1.9.3 Hydraulic Section Including Longitudinal Profile

To ensure the proper washout of reservoirs and pipes for maintenance purposes (cleaning) and extraction of air that obstructs water flows, we have to be sure that the hydraulic sections reflect the calculations prepared, if all structures (incl. road crossings etc.) indicated in the sections. The hydraulic section should indicate whether drainage chambers at lowest points and air vent chambers at highest points are included to ensure proper emptying of pipes in case of maintenance.

4.2.1.9.4 Civil Works Drawings

Layout drawings (civil) should be provided to form the basis of preliminary bill of quantities (BoQ). In case of guarded buildings, make sure that the guard room and sanitary facilities for the guards are included in the design and drawings. Make sure that basic details are provided such as reinforcement, structural, formwork and other necessary details.

4.2.1.9.5 Drawings for Small Civil Structures

Drawings for small civil structures should provide standard details, for example, for manholes, valve chambers, etc. to ensure basis of preliminary costing.

4.2.1.9.6 Electromechanical Drawings

To ensure the technical feasibility of the proposed electromechanical design, optimised layouts to cater for operation and maintenance requirements, you must provide drawings with sufficient details for structures with electromechanical equipment such as pumping stations.

The drawings should also show the location of pumps including foundations, surge equipment, piping, lifting equipment for pumps (overhead crane or similar) and sufficient space for maintenance, generator room or electrical / control room. Dimensions of electromechanical equipment should be mentioned. Minimize as far as possible the number of connection fittings, especially elbows.

It is recommended to separate the pump's building or room from the generator / control room to avoid any accident that can occur on contact of water electricity with such high intensity.

4.2.1.10 Indicative Bill of Quantities

The Bill of Quantities (BoQ) should be prepared to provide investment cost estimations. Clear language / terminology should be used allowing later works bidders to easily understand the content. The item description should consider specifications, as these can greatly impact on the construction cost. It is therefore desirable for the item description in the BoQ to consider for each item its own specifications.

4.2.1.11 Tender Document

Tender documents form the basis on which a civil engineering Contractor will prepare his tender and carry out and complete the contract works. These documents should detail all the requirements of the project in a comprehensive and unambiguous way. These documents also identify all the rights and duties of the main parties to the contract. Collectively they constitute a binding contract, where by the contractor undertakes to construct works in accordance with the details supplied by the Engineer and the Employer agrees to pay the Contractor in stages during the execution of the works in the manner prescribed in the contract.

4.2.1.12 Main Water Supply Project Component and Their Technical Specifications

To ensure long-term sustainability of the WSS and avoid damaging the system, suitable technical specifications for the proposed materials should be elaborated and should refer to the nationally recognised standards. If these do not yet exist, clear reference should be made to international standards used.

4.2.1.12.1 Water Intake

The water intake can be a simple structure made in clay, filters and protection. It can also be a big structure depending on water source type, location and size. Locating and designing a water supply intake factors such as hydrologic, environmental, geotechnical and economic require careful consideration. Long term hydrologic data should be collected and analysed to arrive at the most suitable and reliable concept.

4.2.1.12.2 Water Treatment Plant (WTP)

In most cases, it will be necessary to treat water in order to purify it fit for drinking and other domestic uses. Most important in water treatment is the removal of pathogenic organisms and toxic substances such as heavy metals, which may cause health hazards. Other substances may also need to be greatly reduced if not completely removed. Such substances include suspended matter (which causes turbidity); iron and manganese compounds which impart bitter taste or yellowing of dirty washing; excessive carbon dioxide which corrodes concrete and metals; hardness; total dissolved solids and organic matter.

Laboratory water quality test should be used when deciding on the types and extent of treatment required following international standards

Based on results of raw water quality test, you should determine and design infrastructures and relevant equipment for the raw water treatment according to the applicable standards and codes.

The treatment system shall be designed preferably for a conventional water treatment process. Intakes, clarifiers (flocculation and sedimentation tanks), filters and clear water reservoirs should be preferably constructed in reinforced concrete. No single water drop should be distributed without prior treatment even if water seems to be clear at the source point it can be infected during its distribution or storage by the water supply system components.

The works should be designed for a continuous 24-hour operation.

All major process units (chemical feeders, mixing basins, flocculation tanks, etc.) which require frequent servicing or cleaning should be provided at least as duplicate.

Sedimentation tanks and filters should preferably be provided in triplicate, in order to limit the temporary overloading when one unit is being serviced or cleaned to 50%.

However, in small treatment works (of capacity less than 500 m3/day), it may not be practicable to have process units in duplicate or triplicate as they will then be too small.

In case of clean water sources, disinfection is required to avoid any risk of water infection that can occur during storage and distribution.

As a general principle, all kinds of electrical, mechanical and automatic equipment is to be kept to the absolute minimum possible for operation and maintenance reason.

4.2.1.12.3 Pumping Station

The pumping station is composed by the pump shelter/house, the electrical room, electrical equipment, operation and security rooms.

The pump shelter should have enough space and pumps should be installed in position that sufficient space for maintenance is available. The building should have enough ventilation and should have a lockable door. Overhead crane or similar lifting equipment for pumps should be installed in the pump room.

The pumping station should be connected to the electric grid where possible as diesel power generator is not environmentally friendly and much more expensive in terms of operation and maintenance. In case diesel is used, the pump room should be separated from diesel generator room.

The operation building should have security guard and sanitary rooms. For the pumping station combined with the treatment unit, chemicals should be stored in a separate room covered by concrete slab for roof protection (case of metallic roof structure and iron sheet). Pumping station should be fenced for security reasons.

Pump installations with delivery heads exceeding 300 meter should be avoided. Such high pressures put considerable strain on pumps and pump pipe work systems and they are likely to cause considerable operation and maintenance problems. Surface pumps, electric motors, diesel engines and diesel electric generators should be placed on concrete platforms, especially designed and isolated from the rest of the floor slabs of the pump houses.

(i) Pump Selection

Pumps are hydraulic machines which convert mechanical energy (imparted by rotation) into water energy used in lifting (pumping) water to higher elevations. The mechanical energy is provided by electrical power (motor) or diesel, gas or steam prime movers using either vertical or horizontal spindles.

(ii) Considerations for Pump Selection

The type of pump selected for a particular installation should be determined on the basis of the following fundamental considerations:

- Yield of the well or water source;
- Daily needs and instantaneous demand of the users;
- The “usable water” in the pressure or storage tank;
- Size and alignment of the well casing;
- Total operating head pressure of the pump at normal delivery rates, including lift and all friction losses;
- Difference in elevation between ground level and water level in the well during pumping;
- Availability of power;
- Ease of maintenance and availability of replacement parts;
- First cost and economy of operation;
- Reliability of pumping equipment; and
- Pump start-up problem and time.

(iii) Installation of Pump Controls

Water Level controllers can be used to start and stop pumps either at high level or low level. Low control is provided for pump protection to stop the pump in the event that the supply reservoir empties as high level control is provided to stop and start the pump according to demand at the delivery reservoir

Three types of level controllers are popularly used:

- Float Switch - This is the simplest device and operates via a float activating lever which makes and breaks the electrical circuit. High and low level switching is adjusted by stops on a string. The advantage of these devices is their low cost, though they tend to be the list reliable of the options available.

- Paddle Switch - The paddle switch is suspended above water level and makes and breaks the electrical circuit by changing from the vertical to the horizontal position. The device is reliable, economic and simple to install, though is restricted to fairly small level differentials.
- Electrode Control - This is an electric device operated by means of suspended electrodes. Though the most expensive option, it is easy to install in difficult sites and provides precise level control.

Level controllers are generally operated by making or breaking the control circuit on a relay (often incorporated into the motor starter), which starts and stops the pump motor.

(iv) Electrical Installation

In rural areas, where a national electric power supply grid exists, reserve power supply sources such as electric generators and diesel engines should not be provided.

Correct electrical installation for all pumps is essential to ensure adequate safety and operational efficiency. The following must be considered:

- Control Panels

A properly specified control panel is vital for the long life and efficient operation of all pumps with various options being available.

- Cable Size

The appropriately sized cables must be used to avoid excessive voltage drops over the cable length. Voltage drops should be less than 5% from the power source to the pump, this being calculated by use of the voltage drop.

Voltage drop ≥ L x A x Vd

Where L= Cable length (m); A = Pump operating current (Amperes)

Vd = Voltage Drop Amp/m for the cable size selected

(v) Design Period

Pump houses and pump pipework installations should be designed for the 'Ultimate' year requirements. However, pumps and their power sources should normally be designed for periods not exceeding their economic life

The economic life time of a water pumping equipment under normal operation with scheduled (at least every 3 months) planned preventive maintenance (PPM) is 15 but can also be stretched to 20 years.

4.2.1.12.4 Transmission and Distribution Network

The purpose of the pipeline design is to properly control frictional energy losses to move the desired flows through the system by conserving energy at some points and burning it off at other points. This can be accomplished by careful selection of pipe sizes and the strategic location of control valves, break pressure tanks (BPT), reservoirs, tap stands, etc.

Designing pipelines requires the appliance of basic hydraulic principles that govern the behaviour of water flowing in a closed conduit. The pipes, connections and joints should correspond to the applicable standards and codes as well as common pipe connection regulations.

The pipes and connections must be in conformity with the applicable standards and codes, with regard to the terminology, classification, symbolization, the conditions of manufacture, the characteristics and the tolerances, the conditions of preparation of the test-tubes, the technique of the tests, the marks of identification and the applicable clauses of reception. They must satisfy all the conditions or normal subjections of usages, in particular with regard to the interior pressure, the external loads, the live loads and the reaction of the ground or the supports.

The right pipes must be cylindrical. The axis of the right pipes must be rectilinear, and the faces of the ends of the right pipes and fittings must be exactly of square with the axis of the parts. These ends will be established to allow the perfect connection of the joints. The interior surface of the pipes and the fittings must be smooth. During operation, no repair of such defects must be made without the authorization of the representative of the Client. The supplies must resist without damage with all the efforts which they have to support in service and during tests. They must be tight under all test or operating conditions. They must resist in a durable way all the external factors, either by themselves, or on the one hand by their lining with regard to the action of water, or, on the other hand, by their external coating with regard to the action of the ground or, in a more general way, peri-urban environment.

The supplies must in no way modify the physical qualities, chemical or bacteriological composition of water circulating normally in the network considered. All the supplies such as pipes, valves, accessories and other important parts must carry the following indications: mark factory, plugs or plates allowing the identification of the material and the authorized pressure rating, the nominal diameter and length (pipes).

Network pipes and equipment shall be protected from damage by high pressure and water hammer in case of power outage. At bends where the pipe changes its direction; make sure that thrust blocks and manholes are foreseen. Make surge equipment is foreseen to protect the mechanical equipment (pumps) of the system,

The study will ensure tight connection of pipes and leakages are avoided during pipe laying. For welded pipes (e.g. HDPE), ends of the pipes cut shall be clean without any shavings that impact the tightness of the welding joint. pipes shall be fitted accurately without any projecting sides. For connection of pipes using connecting sleeves (e.g. ductile iron), sealing shall be applied. For flanged connections (e.g. steel), bolts shall be long enough and flanges faces shall be clean with no scars.

The study shall ensure protection of pipes since improper bedding, obstacles underneath the water filled pipe and missing compaction of the covering layers above the pipes will cause damage / leakage. Trenches shall be straight without bends. Trenches shall be cleared from all obstacles before the pipes are laid. Sand bedding shall be implemented to protect the pipe. Once the pipes are laid and the trenches are backfilled, ground shall be properly compacted.

(i) Ductile/Cast iron pipes and Fittings

The pipes and connections must correspond to the standards. The cast iron pipes and connections can be buried underground, fitted above the ground or be installed in pumping stations, tanks, etc.

In the last case, the use of the pipes and flanged connections are obligatory. At the interior of a tank, the pipes are covered outside with nontoxic painting.

The minimum iron wall thickness of pipes DN 40 to DN 2 000 is given as a function of the nominal size (DN) and pressure class (C) in the following table.

Table 1: Pipe nominal size (DN) and pressure class (C)

DN	External Diameter DE mm	Minimum Wall thickness (mm)		
		Class 40	Class 30	Class 25
60	77	3.0		
80	98	3.0		
100	118	3.0		
125	144	3.0		
150	170	3.0		
200	222	3.1		
250	274	3.9		
300	326	4.6		
350	378		4.7	
400	429		4.8	
450	480		5.1	
500	532		5.6	
600	635		6.7	
700	738			6.8
800	842			7.5
900	945			8.4
1000	1048			9.3
1100	1152			10.2
1200	1255			11.1
1400	1462			12.9
1500	1565			13.9
1600	1668			14.8
1800	1875			16.6
2000	2082			18.4

Internal Protection:

Pipes should be internally lined with a sulphate resistant blast furnace slag cement mortar applied by a centrifugal process in accordance with the International Standard for example ISO 4179:2005 and the European Standard EN 545:2010, with the following thicknesses:

DN	Thicknesses (mm)	
	Nominal	Tolerance
60-300	4	-1.5
350-600	5	-2
700-1200	6	-2.5

External Protection:

Pipes should be externally protected with suitable coating with an alloy of zinc and aluminium with or without other metals (85%Zn-15%Al) coating followed by a finishing layer. Always mention standards to be referred during the later physical verification of materials used during civil works.

The mixture of zinc and aluminium shall contain zinc at minimum 85% and aluminium at 15% and the mean mass of alloy zinc and aluminium coating shall not be less than 400 g/m² applied on the bare metal of the external surface of the pipe.

The finishing layer shall uniformly cover the whole surface of the metallic zinc aluminium alloy layer and be free from such defects as bare patches or lack of adhesion. The uniformity of the finishing layer shall be checked by visual inspection.

Joints:

Flexible Joints: Flexible Joint shall be of spigot socket automatic push-on joint type (Tyton and/or Standard or equivalent), mechanical type (for collars or couplings only).

The joint shall be suitable for angular deflection.

Joints may permit angular deflection to accommodate ground movements and negotiate large radius bends. The angle deflection shall be as per the table below:

5 ° for DN 80 to 300

4° for DN 350 to 400

3 ° for DN 500 to 1000

1 ° 30 for DN 1200 to 2000

Higher angular deflection shall be accepted.

The material used for the rubber gaskets shall be an EPDM elastomer, in accordance with ISO 4633:2002 and duly certified as suitable for potable water up to 50°C.

Flanged Joints: Flanged ended pipes and fittings shall be used when connecting to valves or other special fittings.

The flanges shall be raised face and integrally cast rotatable flanges may be used for fittings up to DN 600 mm.

The dimensions and the drilling of the flanges shall be in accordance with the International Standard ISO 7005-2 or the European Standard EN 1092 -2. The pressure rating of the flanges shall be as given in the particular specifications. Flanged joints shall be supplied complete with gaskets and bolts.

Rubber gasket shall be EPDM elastomer in accordance with the International Standard ISO 4633: 2002 and duly certified as suitable for potable water up to 50°C. The gasket shall be reinforced and suitable for a minimum pressure rating of 10 bars and higher.

Anchored Joints: Ductile iron pipes and fittings may be anchored to be used where pipelines have to cross through existing ducts, in areas with restricted accessibility, when the use of concrete anchor blocks is prohibited or impossible, or when the pipes must be pulled during the installation and for mains on steep slopes (> 25%).

Anchored joint shall be designed to resist to the axial thrust forces but maintaining flexibility and angular deflection as mentioned in Table below. Anchored joints shall be designed to withstand the greater of the pressure or the service pressure + surge pressure or the site test pressure.

The socket ends of all pipes and fittings shall consist of two chambers: a sealing chamber for the gasket and a locking chamber for the restraining locks. The spigot ends of all pipes and fittings shall induce a factory applied welding bead to fit inside the restrained socket. No bolts, nuts, and glands shall be used as part of the socket

locking joint. The locking mechanism shall be a resultant of the direct contact between the welding bead and the corresponding number of locking segments as shown in Table below. The locking segments shall be of ductile iron.

Marking: All pipes and fittings shall be legibly and durably marked and shall bear at least the following information:

- The Manufacturing Unit.
- The identification of the year of manufacture.
- The identification as ductile iron.
- The DN.
- The PN rating of flanges when applicable.
- The reference to the standard.
- The C class designation of centrifugally cast pipes.

The first five markings given above shall be cast-on or cold stamped; the other markings can be applied by any method, e.g. painted on the casting or attached to the packaging.

Gaskets and Sealing: The material used for the rubber gaskets shall be an EPDM elastomer, in accordance with ISO 4633:2002 and duly certified as suitable for potable water up to 50°C, by one of the national regulations.

Sufficient lubricant as recommended by the pipe manufacturer shall be provided for pipe installation plus ten percent as surplus material. Lubricant containers shall be adequate for extended storage and the pipe manufacturer shall supply instructions for storage limitations and environment.

Factory Testing: Inspection for external appearance, shape and dimensions shall be carried out on each pipe and fitting. All pipes and fittings shall be sound and free from surface defects.

Each pipe centrifugally cast shall be subjected to the hydrostatic pressure test as specified in EN 545-2010. Hydrostatic pressure tests shall be performed before the pipes are coated or lined. Each fittings and accessory not centrifugally cast shall be subjected to a leak tightness carried out with water or air as specified in EN 545-2010.

Any pipe or fitting that leaks or does not withstand the test pressure shall be rejected.

Mechanical tests for hardness, tensile strength, and elongation shall be performed on pipes selected at random out of castings grouped in lots. Each lot shall comprise 200 pipes successively cast.

(ii) Steel Pipes and Fittings

The pipes made out of steel and their connections must correspond to the national standards. The use of the pipes and connections out of steel is limited to piping of the works of collecting, treatment, supply, under pressure, and storage for the assembly in the open air. When they are welded tubes, the welding of sheets must be regular over the entire length of the tubes; the edges, cutting or projection, as much internally as externally, must be removed. The tubes are welded uninterrupted, either longitudinally, or helical.

The tubes must be subjected to a test of water pressure in the factory. These tests should be carried out systematically and the supplier must provide the certificate of these tests.

(iii) Plastic Pipes (HDPE and uPVC)

uPVC pipes have the advantage of easy handling and installation and also high corrosion resistance. However, the pipes suffer some loss in strength when exposed to direct sunlight, and care should therefore be taken to keep them sheltered when they are in the open. This has to be specified in the tender documents and respective storage is to be foreseen.

uPVC pipes are also easily damaged by careless handling and transportation. The pipes are manufactured in several classes to satisfy different design and operational pressures and they are generally most suitable for use in small size pipelines of diameters not exceeding 160 mm. These pipes have a disadvantage that unauthorized tapping from uPVC pipelines is quite easy.

Polyethylene is very suitable for small-diameter pipelines because it can be supplied in rolls. This flexibility reduces the numbers of the joints and bends required. PE pipes are supplied as “High Density” (HDPE) or “Medium Density” (MDPE). HDPE is preferable although it is supplied at a higher cost. Polyethylene does not deteriorate when exposed to direct sunlight. However, they are not

suitable in rocky ground as they are susceptible to damage. The pressure ratings for HDPE pipes should be strictly adhered to as they show a high rate of pipe bursts. These pipes like uPVC have a disadvantage that unauthorized tapping from polyethylene pipelines is quite easy.

The pressure ratings for different uPVC and HDPE pipe diameters are presented in the table below.

Table 2: Pressure rating for uPVC and HDPE pipes

Outside Diameter	Pressure Rating				
(mm)	PN 2.5	PN 4	PN 6	PN 10	PN 16
	Inside Diameter (mm)				
20				16.0	14.4
25			21.0	20.4	18.0
32			28.0	26.2	23.2
40		36.0	35.4	32.6	29.0
50		46.0	44.2	40.8	36.2
63	59.8	58.2	55.8	51.4	45.8
75	71.2	69.2	66.4	61.4	54.4
90	85.6	83	79.8	73.6	65.4
110	104.6	101.6	97.4	90.0	79.8
125	118.8	115.4	110.8	102.2	90.8
140	133.0	129.2	124	114.6	101.6
160	152.0	147.6	141.8	130.8	116.2

Table 3: External dimension for uPVC and HDPE pipes

Type	Size (diameter in mm)
uPVC	63; 90; 110; 160; 200; 250; 315; 400
HDPE	20;25;32;40;50; 63; 75; 90; 110; 125, 140;160;200;250;300;400

The use of plastic pipes is highly recommended where calculations allow, as they are manufactured in Rwanda or in the region and therefore are cheaper and easy to operate and maintain during WSS operation. The use of local materials is also in line with the “made in Rwanda” policy.

Plastic pipes with pressure rating below PN 10 are not recommended in water supply. You can find also plastic pipe with pressure rating of PN 25 but they are generally available on commend.

(iv) Transportation and Delivery of Water Pipes

Cast iron or steel pipes will be delivered in bundles or ringed boots, so as to facilitate the handling operations, with packing adapted to the transport conditions and the needs for protection. The pipes in cast iron and steel should be delivered with a plastic stopper at each end of the pipes.

Handling and storage on site should be carried out in accordance with the recommendations of the suppliers. Thus the cast iron pipes could be stored (by complying with the rules of packing) in the open air; the steel pipes should be protected from the sun, as well as the PVC and HDPE pipes.

(v) Opening of the Trenches

The minimum depth of trenches is given by the pipe diameter, location and the pipe material. Minimum pipe cover should not be less than by 60 cm. The trench should be wide enough and straight (as much as possible). The bases of the trench excavations should be drawn up perfectly well and purge the stones met.

Before laying pipes, the base of the trench should be prepared so that the pipes rest over all their entire length on the ground without stones. At fitting, niches should be carried out. In case of rocky or stony undergrounds, the bottom should be covered with at least 20 cm loose soil or better with fine sand.

(vi) Flanges and Cutting Through of the Flanges

All the technical provisions concerning the flanges, machining, diameter, characteristic of the joint, surfaces contact, should be in conformity with the stipulations of applicable standards and codes. Flanges should be delivered complete, i.e. with nuts and bolts and sealing packing. The supports like all the pipe fittings and valves and fittings shall be able to stand the pressures which they have to undergo., in particular at the time of the tests on the construction site. All the accessories of flanges (nuts and bolts) should be also designed to withstand the pressures. The bolts should be galvanized with threading and diameters in conformity with the standards. The suppliers are to ensure, before forwarding, of the complete coherence of the deliveries: qualities of the provided equipment and cutting through templates in particular, to ensure the coherence of the supplies of the drains batches and valves and fittings and for the coherence of the parts of the same batch.

(vii)Nuts and Bolts

All the nuts and bolts should be provided with the delivered equipment and according to the standards specific to the particular equipment. Bolts and nuts must be protected against corrosion; stainless in the material of manufacture by surface protection (zincing, cadmium-coating etc).

(viii) Blank Flanges

Normal blank flanges: The closure of the ends of the drains should be carried out with blank flanges (circular parts) made of the same material as the pipes required and drilled as indicated above at the flanges.

The supply should also include the sealing packing and the bolts necessary for the assembly. The blank flanges should be protected against corrosion. Blank flanges with central embossing should be tapped.

(ix) Valves

Gate Valves

The lower part of the passage of water is perfectly straight and smooth (no groove to receive the valve shutter is allowed). The valve shutter should be made of cast iron with vulcanized synthetic rubber mould. The seat of the shutter should be out of synthetic rubber. The body of the gate valves should be made of cast iron. The elevated gate valves or those under manholes should all be operated by turning a wheel. The valves buried under the ground should be equipped with a mouth key, secured by a pit covered at the top at the roadside and to operate by turning long pieces of tubes.

Butterfly Valves

This is an eccentric element rubber seal. The mechanism of the butterfly valve is provided by a housing of cast iron including a control lever, a bronze nut and a stainless steel gear controlled by a lever. The buried butterfly valves should be equipped with a mouth with a complete key while those installed above the ground should be provided with a steering wheel.

Taps and Saddles for Connections

The taps and valves of water adaption or stoppage for the connections should be made of bronze or cast iron and bronzes. They are generally equipped with a mouth with key with gate vault. They should be equipped with parts of connection corresponding to the nature of the control of the connection. The service clips in load should be with glasses or embossing out of steel, cast iron, PVC or PE following the quality of the pipe. The service clips saddles must be provided with their connecting and seal holding bolts. They must be protected from corrosion.

Non-Return Valves

In principle, the simple devices of no return are made of cast iron, with articulation made of bronze, brass or stainless steel, and rods in suspensions of the leaf made of malleable pig iron, nodular or graphite cast iron or steel, and lining made of synthetic rubber. They should be provided with a dismountable cast iron lid fixed using bolts and with pins and giving access to the leaf.

For special uses or in the case of intensive service, the non-return valves can be of the type with rubber membrane instead of a shutter with leaf or, of the type with polyurethane disc shutter supported on stainless steel springs but, should form part of those of the last generation being that ensures a quiet usage without shock and a with reasonable longevity. For raw water, the valve sandwich types made of stainless steel with shutter with angular displacement and embedded tonic joint on the seat are recommended.

The valve, whose articulation is flexible and made of flexible iron framework, metal or not, moulded elastomer are prohibited because of their low resistance during their service time.

Air Vents

The air vents must perform the three following operations automatically:

- Air release during the filling of the pipes
- Air intake during draining of pipes
- Air escape whenever an air pocket tends to be created.

The operation of these gargets does not have to cause water hammers in the pipes and must consequently be provided with the with safety units, as well as taps or valves necessary, incorporated or not which isolate it from the principal control. The air vent should be of the type

of one or two balls. The body of the garget should be made of cast iron and the floats should be covered with rubber.

4.2.1.12.5 Water Reservoirs

The selection of storage reservoir materials largely depends on whether the reservoir is to be placed on the ground or to be elevated on a support structure. Ground storage reservoirs are normally made of reinforced concrete or stone masonry. Elevated storage reservoirs are normally made out of galvanized pressed steel panels and placed on steel support structures. All other factors being equal, the most economical storage reservoir shape is “circular”, followed by “square” and lastly “rectangular”. Usually, the depth of water in a storage reservoir should not exceed 5 m.

Reservoir sites should be selected such that they are on stable ground, not threatened by landslides or erosion. Level ground sites are preferable because they simplify excavation work. The design of storage reservoir foundations must be based on proper evaluations of ground bearing capacities.

It is recommended that reservoirs are provided in standard capacities of 10, 25, 50, 100, 150, 200, 300, 500, 800 and 1,200 m3.

The size of the outlet is also determined by the demand requirements and should be located at least 200 mm above the reservoir bottom. This creates a dead volume which allows for the settlement of sediments. It should also have a shut – off valve adjacent to the reservoir. Pipe sizes inferior to DN 80 are not recommended for the reservoir outlet and they should be made preferably out of ductile iron. Plastic pipes are not allowed in this case.

The drain (washout) facilitates cleaning of the reservoir should be located at the bottom of the tank. Cleaning should be done by shutting the main line valve and opening the discharge line.

The reservoir should be constructed with a slope towards the drain line to simplify cleaning. Reservoirs should have an overflow line that can support the maximum anticipated overflow (pump or spring capacity).

The overflow pipes should be at least 50% larger than the inlet pipes and should be well screened and covered. It should be possible to observe the overflow so that the inlets can be controlled.

Manholes and covers should be installed to provide an entrance during cleaning, maintenance and repair. They should be raised higher than the roof level to prevent entry of contaminated surface water. The manhole covers prevent entry of sun rays that encourage algae growth. They should be lockable.

Water level indicators should be used to indicate the water level inside the reservoirs. A depth gauge using a float and wire should be used and specified in the bill of quantities.

The type of control valves used depends on the type of operation used by the system. The flow into the reservoir may be stopped manually or automatically by a float valve, pressure switch or any other device. Electric float valves are recommended for reservoirs receiving direct water from pump. Double orifice valves allow release of air when water is flowing. Single orifice valves allow the release of air accumulated at specific points to be released when water starts flowing.

Large reservoirs should be equipped with internal and external ladders and should have external walkways and handrails, especially if they are elevated. They should be appropriately partitioned if the reservoirs exceed 500 m3.

(i) Reinforcement Works

Reinforcement steel shall be of good quality (no corrosion, etc.). International standards shall be applied in placing the reinforcement steel (horizontal and vertical layers); The connections of horizontal and vertical layers shall be done properly; Spacer blocks shall be used to ensure a sufficient cover of concrete and avoid exposure of the steel to air and corrosion; The starter bars to connect e.g. walls to the foundations shall be sufficiently long to ensure stability; Make sure the spacing of the reinforcement bars allow for proper concrete compacting.

Note: any weakness in reinforcement works will have impact on the stability of the reinforced concrete.

(ii) Formwork

Make sure that suitable formwork used; The formwork shall be installed properly to bear the pressure of the concrete. Formwork shall be made in timber or steel.

Note: improperly fixed formwork will cause deformation of the structure and hence reduced stability.

(iii) Concrete Works

Aggregates and materials used shall be of acceptable quality; cast concrete shall be properly compacted; cracks or irregularities in the finished concrete structures shall be avoided; connections between foundations and walls shall be properly done (water stop, etc.); the thickness of the concrete cover on top of the reinforcement layer shall be sufficient.

Note: Minor concrete quality and improper concrete casting practices will cause cracks in the civil structure, decreased stability, leakages, etc

(iv) Protection of Structures

In case of excavations at sloped sites, retaining walls shall be foreseen. The retaining wall shall be in reinforced concrete or stone masonry. Retaining wall of high exceeding 2m shall be avoided.

4.2.1.12.6 Public Water Taps

The location for a public water tap should be based on the local demand within a walking distance not exceeding 30 minutes round trip, including queuing, for fetching water as national norm to be complied with.

Types and sizes of the tap should depend on number of users and life style. Kiosks should be used in commercial centres, while a simple tap stand is sufficient where the population is scattered.

4.2.1.12.7 Electromechanical Equipment

The DTED study should evaluate how to connect electromechanical equipment to the power grid. Drawings prepared should indicate the connection lines to power, access roads to site (for big projects) and provide technical specifications of existing nearby power lines and specify what are the required specifications of the equipment to be installed (LV line, MV line, capacity of power transformer, etc.).

Initial cost as well as operation and maintenance must be considered when proposing the selection of the water pump to be used. Pump oversizing should be avoided to minimize unnecessary power consumption by considering all parameters such as water flow, longitudinal profile and size of the transmission pipe.

4.2.1.12.8 Planning of Works Implementation

The consultant shall produce a planning of upgrading works with detailed feasibility charts/graphs reflecting and based to the types and quantities of site equipment's related to the project conditions. These shall be presented in the aforementioned alternatives

He/she will determine an accurate time period for the execution of the proposed construction of ''To do: *Insert the name of the system*''. The consultant shall, according to the above fixed time period calculated with parameters, evaluate and assess the necessary types and the corresponding quantities/number of construction equipment's. To this end, he/she will provide a planning for an efficient site equipment use to be in time with the project condition.

4.2.2 Environmental and Social Impact Assessment

The Environmental and Social Impact Assessment is usually performed at the preliminary design phase. The ESIA to be submitted to RDB should include the following:

- A project brief of the project should be submitted to RDB for approval
- Descriptions of the institutional and legal framework, regulations and standards should be considered
- Analysis of all stakeholders, public, private; if a concept was drafted on how to engage the stakeholders (consultations, interviews, etc.) A baseline
- Definition describing geographical, climatic, social, economic, etc should be provided
- Primary & secondary users as well as beneficiaries of the project should be identified
- All environmental impacts (positive & negative) and risks related to the project should be identified
- A respective plan should be provided on how to mitigate or minimise the environmental impacts and risks identified
- All social impacts (positive & negative) and risks related to the project should be identified such as loss of agricultural land/crops, employment, economic growth, quality of life, etc.
- A respective plan should be provided on how to mitigate or minimise the social impacts and if risks are identified (especially for resettlement, expropriation, compensation)
- An ESMP draft that reflects all identified impacts and risks should be provided

- Sufficient meetings and consultations should be organised during preparation of the feasibility study and ESIA.

Note: The ESIA should be approved by RDB and the respective certificate for the project should be issued

4.2.3 Financial Feasibility

The analysis of the financial feasibility is usually performed at preliminary design phase.

4.2.3.1 Investment Cost/Capital Expenditures (CAPEX)

The consultant must conduct evaluation of investment costs for selected technical option, estimation made should be reasonable based on current market either local, regional and international (depending on origin of materials to be procured).

4.2.3.2 Operation and Maintenance cost/ Operation Expenditure (OPEX)

The consultant should conduct the evaluation of the operation and maintenance costs of the selected technical option. He/she should conduct a comparison between OPEX versus CAPEX to come up with the most balanced technical solution (e.g. energy efficient pumps less expensive during operation but more expensive at the time of purchase).

4.2.3.3 Life Cycle Costs

The consultant should analyse the whole project life cycle to come up with the most cost-effective technical option. He/she will consider initial investment, owning, operating, maintaining, and residual value at the end of the project / end of design life. Lifespan of the project will depend on the type and project complexity.

4.2.3.4 Management Model

The consultant should propose the project management mode and how the system should operate, what will be the estimated investment costs and how will the service be contracted.

4.2.3.5 Financial Risk Analysis

The consultant should assess investment and operation risk of the project.

4.3 Proposed Criteria, Sub-Criteria for the Evaluation of Full Technical Proposals for a WSS project

(i) General experience of the firm in the field: The consultant firm must be having at least a general experience of more than 10 years.
(ii) Relevant experience in similar services: The consultant must be having done at least 3 projects related to the elaboration of feasibility and detailed study of construction of WTP & water distribution network with similar size and complexity.
(iii) Quality of the methodology and work plan proposed responding to the Terms of Reference:
   a) Work plan and coherence between the chronogram of activities and key experts
      - Work plan
      - Coherence between the chronogram of activities and key experts
   b) Methodology
      - Comprehension of the mission
      - Organization and staffing and activities management
      - Implication of communities' beneficiaries and Water and Sanitation stakeholders.

4.3.1 Profiles of Key Experts for a WSS Project

The following table summarises the minimum requirement for the qualification of key experts to be deployed during the study elaboration. It should be emphasized that proposed experts must conduct the study for the successful tenderer. The team composition / position and qualifications must be adopted according to the project size and complexity

Table 4: Key staff and their respective profiles

Key experts	**Description and profiles**
Team Leader	He /she shall have at least Bachelor's Degree (BSc) in Civil Engineering or Water Supply Engineering with 12 years of general experience and at least 5 years of experience as team leader in the related field of expertise and he /she must have a proven work experience in similar assignments. Having a specific experience in similar works for at least 3 projects of such magnitude. He/she will be responsible for coordinating the team of experts and the successful implementation of the study
Civil Engineer	He /she shall have at least Bachelor's Degree in Civil Engineering with 10 years of General Experience and 5 years related experience in the field of expertise and he /she must have a proven work experience in similar assignments. Having a specific experience in similar works for at least 2 projects of such magnitude.
Water Supply Engineer	He /she must have at least BSc. in water supply engineering with general experience of 10 years and 5 years of experience in water treatment plants design, hydraulics, and high-pressure pipe calculations. Having a specific experience in similar works for at least 2 projects of such magnitude.

Hydrologist	He /she must have at least Master's Degree in hydrology with general experience of 10 years and 5 years related experience in the field of expertise and he /she must have a proven work experience in soil investigations. Having a specific experience in similar works for at least 2 projects of such magnitude
Electromechanical Engineer	He /she shall have at least BSc Degree of Electromechanical or Electrical Engineering with general experience of 10 years and 5 years related experience in the field of expertise and demonstrated experience in electro-mechanical installation and electrification of water treatment plants. Having a specific experience in similar works for at least 3 projects of such magnitude.
Environmental Expert	He /she shall have a minimum of a master's degree in Environment Engineering with general experience of 12 years and 8 years related experience in the field of expertise and he /she must have adequate experience in conducting a comprehensive Environmental impact assessment and analysis, as well as being able to identify in advance the shortcomings, which might hinder the smooth implementation of the project and the best ways to mitigate the problems. Having a specific experience in similar works for at least 3 projects of such magnitude. The expert should have the following experience: • Experience in development and conducting ESIAs assignments; at least one of these assignments has been done as a team leader • Fully conversant with the REMA's EIA guidelines and delivery methodologies -including ESMP • The Environmental Expert shall be registered by the Rwanda Association of Professional Environmental Practitioners (RAPEP) and recognized as lead expert in the field of ESIA / ESMP • Three years EIA experience in the Road sector will be a great asset. • Over the last three years, at least one relevant experience in developing countries, preferably in Eastern and/or Central Africa
Socio-Economist	He /she shall have a minimum of a master's degree in Sociology or Economy with general experience of 10 years and 5 years related experience in the field of expertise and he must have adequate experience in conducting a social and economic impact assessment of water supply projects. Having a specific experience in similar works for at least 3 projects of such magnitude.
Water Treatment Expert	He /she must have at least Master's in water treatment/water supply engineering with general experience of 10 years and 5 years related experience in the field water treatment process and he /she must have a proven work experience in similar assignments. Having a specific experience in similar works for at least 3 projects of such magnitude.

Quantity Surveyor	He /she must have at least BSc. In quantity surveying with general experience of 5 years and 3 years related experience in the field of expertise and he /she must have a proven work experience in similar assignments.
Topographic Surveyor	He /she must have at least BSc. in topography with general experience of 10 years and 6 years related experience in the field of expertise and he /she must have a proven work experience in similar assignments. Having a specific experience in similar works for at least 3 projects of such magnitude.

The consultant can propose other non-key staff to accomplish the assignment (these ones will not be evaluated).

4.3.2 Personnel Time Inputs for a WSS Project

The tentative experts months on the field to conduct the work described in the previous sections are presented in the following table.

Table 5: Defined the expert's input by position

Key expert **The team composition / position must be adopted according to the requirements**	**Person-month required for feasibility study, technical design, and preparation of tender document** **The months must be adopted according to the requirement**
Team leader	6
Civil Engineer	5
Water Supply Engineer	5
Hydrologist	2
Electromechanical Engineer	2
Environmental Expert	2
Socio-economist	2
Water Treatment Engineer	3
Quantity Surveyor	3
Topographic Surveyor	1
Geotechnical Engineer	1
Total	**32**

4.4 Study Reporting Schedule for a WSS Project

4.4.1 General

The design of a water supply scheme involves preparation and presentation of among others design reports. The reports serve the following main functions:

(i) To record and present all information concerning a project in a clear and concise manner for future reference, and for the information of planners and other parties interested in the project
(ii) To present the basic data, information, design criteria, assumptions and conclusions regarding the project, to enable planners and other parties interested in the project, to make appropriate decisions and supervise the implementation of the project.

4.4.2 Introduction

The form and content of a design report will largely, depend on the nature and complexity and size of the project. Large and complex projects require reporting during the design stages:

(i) Inception Report
(ii) Feasibility Study Report
(iii) Preliminary Design Report
(iv) Detailed Design Report
(v) Tender documents
(vi) Engineer's Estimate

For small and uncomplicated schemes, one detailed design report may be sufficient. The contents of each report are presented separately in this section and should be adjusted to suite the requirements for a particular project.

4.4.3 Inception Report

The Inception report presents the following:

(i) The mobilization and establishment status of the Consultant;
(ii) The specific staffing plan;
(iii) The updated work plan the Consultant proposes to follow in carrying out the assignment, based on the Consultants initial findings;
(iv) Review of Methodology;
(v) Details of any constraints or inputs required from the employer; and
(vi) Such remarks as are deemed appropriate including the works done so far.

The Consultant shall carry out a comprehensive literature review immediately after signing the contract and will present his/her findings in the inception report. Literature review shall cover scholarly articles, books and other sources (e.g. dissertations, conference proceedings, policy statements, manuals, procedures, strategy papers, and existing laws) relevant to design/construction and related areas of research, or theory. The Consultant shall then provide a description, summary, and critical evaluation of each work. The purpose of the literature review is to offer an overview of significant literature published on the topic/project.

4.4.4 Feasibility Study Report for the WSS Project

A feasibility Study (economic and conceptual design) is a requirement after the project identification process. There are usually a number of alternative technical solutions to be considered from which the most economically viable alternative is determined. During the feasibility study it is established whether for the best alternative solution chosen:

(i) The project conforms with the country's development objectives and priorities
(ii) The relevant policy framework is compatible with the achievement of the projects' objectives
(iii) The project is technically sound and that it is the best of the available technical alternatives
(iv) The project is administratively workable
(v) There is adequate demand for the projects output
(vi) The project is economically justified and financially viable
(vii) The project is compatible with the customs and traditions of the beneficiaries
(viii) The project is environmentally (ecologically and socially) sound; and that
(ix) The project is compatible with urban/regional master plans.

This feasibility study report should include:

(i) General arrangement and layout of proposed project
(ii) Performance characteristics of the proposed project elements and components
(iii) Preliminary cost estimates based on life cycle approach
(iv) Plan for phased implementation
(v) Implementation schedule
(vi) Environmental, socio-economic impact of the proposed development; and
(vii) Recommendation of the best alternatives for detailed design.

4.4.5 Preliminary Design Report for the WSS Project

The consultant shall prepare and submit a report on preliminary design to the client for approval, which shall contain the project design brief and outline design drawings.

The report shall also include:

(i) A geotechnical report
(ii) An Environmental and Social Impact Assessment Report
(iii) EIA certificate issued by RDB and
(iv) Topographic Survey Report.

A geotechnical report may be required. This report shall present:

(i) The soil conditions and characteristics of the site;
(ii) Field test results: the geology of the area and field investigations: drilling bore holes, standard penetration tests, undisturbed samples, determination of ground water results;
(iii) Laboratory tests: sieve analysis, Atterberg limits, moisture content, shear strength, specific gravity, consolidation, chlorides, sulphates, PH values, CBR, etc.

An Environmental and Social Impact Assessment Report will be required. The report shall summarize:

(i) The effect of the project investment on the environment and recommend appropriate solutions to forestall any disagreeable effects resulting from the investment
(ii) The positive and negative impacts of the project
(iii) Environmental Management Plan to mitigate adverse environmental effects that that project may have
(iv) Community's role in the project in so far as the project influences their lives, especially for women, children and the elderly, and quantify the benefits which would accrue to them during and after the construction of the project; and
(v) Approval from the National Environmental Management Authority.

Topographic and Cadastral Survey Report may be required. This report will:

(i) Confirm the boundaries of the plot
(ii) Size of the plot
(iii) Existing ground profiles
(iv) Position of existing buildings and features and the location of existing services; and
(v) Where adjustments to the boundaries are found necessary, the Consultant shall recommend the appropriate action.

4.4.6 Detailed Technical and Engineering Design Report for the WSS Project

This report shall include detailed Engineering Report on all investigations, technical, economic, environmental and social investigations, structural design and calculations.

The detailed designs would be expected to include:

(i) Statistical analysis of data collected for the population and demand projections, hydrological data and hydrogeological, meteorological data etc
(ii) Minimum cost lay-outs for different components of the project, i.e. treatment plants, hydraulic and structural work
(iii) Structural and stability computations of different structures
(iv) Calculations for pumps, motors, power generators and other machinery and equipment
(v) Engineering analysis for deciding the most economic size of delivery mains; and
(vi) Hydraulic computations for the distribution system.

Detailed Drawings would include:

(i) Index plan showing overall layout of project
(ii) Schematic diagram showing levels of relevant components of the project (may not necessarily be to scale)
(iii) Detailed plans and sections in scale for the headwords, treatment plants, clear water storage tank, pumping station, etc., in a scale 1 :20 to 1: 100 depending on the details and size of work
(iv) Detailed structural plans for structures, intake treatment plant, clear water reservoir etc., in a scale of 1: 20
(v) Index plan of the. distribution system normally in an appropriate scale
(vi) Longitudinal sections of the delivery main and details of appurtenances in scales:
    a) Horizontal scale 1: 500 to 1: 5000 depending on distance and details
    b) Vertical scale 1:20 to 1:100 depending on the terrain surface undulations.

4.4.7 Preparation of Tender Documents for Works for the WSS Project

Tender documents form the basis on which a civil engineering Contractor will prepare his tender and carry out and complete the contract works. These documents should detail all the requirements of the project in a comprehensive and unambiguous way. These documents also identify all the rights and duties of the main parties to the contract. Collectively they constitute a binding contract, where by the contractor undertakes to construct works in accordance with the details supplied by the Engineer and the Employer agrees to pay the Contractor in stages during the execution of the works in the manner prescribed in the contract.

The consultant will prepare the tender documents by using the latest version of the Standard Bidding Document of RPPA, which must include at least the following documents:

(i) The invitation to tender
(ii) Instructions to Bidders
(iii) The General Conditions related to civil works
(iv) The Special Conditions
(v) The Technical Specifications and Performances indicators
(vi) Part of unit of prices breakdown from confidential cost estimate
(vii) The various drawings and implementation files for the preparation of bids and proper implementation of works
(viii) The model of submission
(ix) The model of bid security
(x) The form of progress of the work
(xi) Models of guarantee (performance bond, advance)
(xii) The quantitative picture of the materials to be imported
(xiii) The contract will be unit price-based.

Before the expiration of contract, the Consultant will present and publish the final reports of studies. The detailed final report, the (Abbreviated) Resettlement Action Plan (ARAP or RAP), and the tender documents.

The Consultant will also provide all electronic documents (source files, PDF files), and other documents such as editable version of the drawings, excel files of the traffic analysis, signed laboratory tests results).

4.4.8 Conclusions and Recommendations

This should cover conclusions and recommendations about the project as a summary.

5 Section 4: DETAILED TECHNICAL AND ENGINEERING DESIGN OF A BUILDING PROJECT

ABBREVIATIONS

Abbreviation	Description
BoQ	Bill of Quantity
EIA	Environmental Impact Assessment
KfW	KfW Development Bank
LODA	Local Administrative Entities Development Agency
PPE	Personal Protection Equipment
RDB	Rwanda Development Board

5.1 Introduction to the Guidelines for DTED for Buildings

Building design is the process of taking a client's requirements for a new building or changes to an existing building and translating them into an agreed design that a contractor is then able to construct.

As the standard of regulations has increased, building components have become more complex, and the technical requirements of clients have become more demanding, so the design process has become more challenging. As a consequence, other than the very smallest projects, building design will generally involve a number of different designers and other consultants.

This guideline on the elaboration of terms of reference for building construction projects will enable LODA and District engineers to elaborate appropriate ToRs to be used in recruitment of consultants to conduct DTED for building projects and to validate design reports.

These guidelines cover the entire building design process, from the inception stage through site investigations and materials analysis, architectural design and structural design, to the final preparation of drawings and detailed specifications.

Wherever you need to complete or update, this is characterised by a "to do" marked in green.

Furthermore, there are explanatory part that are marked in light green and are starting with "Explanation" as shown in the example below.

Explanation:	This is for further explanation and should be deleted once the document is finalized

5.1.1 Information Sheet of Building Project

1	Country	Rwanda
2	Consultancy services	To do: Describe the service in summarized form
3	Road Name	To do: Insert District Name
4	Location of the project	To do: Insert location map
5	Recipient	To do: Insert District Name
6	Executing Agency	To do: Fill the information below Insert District Name P.o. Box:

		E-mail: Tel :
7	Funding Agency	To do: Fill the information below Insert Name P.o. Box: E-mail: Tel :
8	Project Description	The Government of the Republic of Rwanda, represented by the (insert the name of the District) is recruiting a consultant who will conduct consultancy services to conduct Feasibility and Detailed technical study of (To do: Insert bridge name). The services include reconnaissance of the building project, the topographic survey, architectural design following climate resilience principals, the geotechnical study site, structural design, Technical drawings, the study of Environmental and Social Impact Assessment and preparation of the Bill of quantities and tender documents for the execution of works of the above mentioned project. The services will be reported in three report: d) **Inception report** shall contain the preliminary observations with the points that can affect the design of the building project, detailed work program, brief description of the working methods / methodology of the consultant in accordance with the Terms of Reference and identify any major issues/constraints and the staff mobilization plan. e) **The Feasibility study** shall contain the preliminary findings in topographic survey, architectural design following climate resilience principals, geotechnical investigations, the preliminary designs for at least two alternatives including their costs. The report shall include any possible alternatives and the environmental, socio-economic profile assessment of the project. The report shall include the comparison of the alternatives and argue recommendations for choosing the appropriate alternative. The findings from this report shall lead to the development of the details design and detailed Bill of Quantities and ESIA. **f) The final report** shall contain the details designs of the building, the Tender Documents and ESIA. The language of the reports is English or French
9	Estimated Duration	Total duration of the services: (to do: Fill months of study implementation).....Months

10	Consultancy Services Required and Phase of Selection	The Procurement of Consultancy Services will be carried out in accordance with the Procurement Law of Rwanda. Consultancy services for carrying out the building studies will be determined on the basis of Short-listing. The selection procedure to determine the short-listed firms for implementing the study shall be based on technical quality with price consideration (QCBS: Quality Cost Based Selection).

5.1.2 Introduction to the Building Project

Building design is the process of taking a client's requirements for a new building or changes to an existing building and translating them into an agreed design that a contractor is then able to construct.

Wherever you need to complete or update, this is characterised by a "to do" marked in green.

Furthermore, there are explanatory part that are marked in light green and are starting with "Explanation" as shown in the example below.

Explanation:	This is for further explanation and should be deleted once the document is finalized

5.1.2.1 Description of the Building Project

The District of (to do: insert the name of district) intends to carry out the Consultancy services for the design of (to do: insert name of the building) located in (to do: insert the name of district).

(to do: insert the name of building) bridge is located on (to do: insert the name of the area) in (to do: insert the name of district) district. The building will be designed to host (to do: insert the number of staff). The number of project beneficiaries is estimated to (to do: indicate the estimated number of beneficiaries).

5.1.3 Objective of the Services Required for the DTED for a Building Project

The main objective of the services is the complete study and preparation of tender documents which will lead to the construction of the (to do: insert the name of the building).

5.1.4 Scopes of services for the DTED for a Building Project

The consultant shall provide and guarantee the highest quality of detailed engineering for civil woks design, topographic survey, geotechnical investigation, detailed engineering design, technical specifications, unit prices analysis and cost estimates, construction drawings, environmental and social impact assessments.

The consultant shall carry out but not limited to:

i) Topographic survey for the project including the following to prepare the topographic map and all other necessary data for the detailed engineering design;
   - Establishment of horizontal and vertical control points (benchmarks)
   - Topographic profile survey covering the crossing area with contour lines,
   - Surface water runoff survey

j) Carry out subsoil investigation including boring and laboratory tests and other necessary tests, provide sub-soil investigation maps. The consultant shall make detailed soil investigation

k) Carry out hydrological survey by collecting available historical data from relevant authority. The catchment areas, run-off coefficient depending on the terrain type, existing vegetation, land use and geological type, hydraulic slope and design flood discharge for appropriate return periods shall be determined for the design of drainage to convey rainwater

l) Identify existing public utilities (if any) and propose possible relocation site with the utility relocation maps. Also provide cost estimates for relocation of utilities,

m) Carry out the environmental and social impact assessment according to existing and current regulatory framework i.e. policies, lows, regulations and guidelines as published by REMA, RDB and other relevant legal and institutional framework

n) Carry out detailed designs including detailed plans and construction drawings, detailed cost estimates, associated contract documentation to include detailed specifications, bill of qualities (BoQ) with detailed breakdown and description of unit rates, and implementation schedule for project

o) Elaborate the tender documents for the execution works

p) Present the maintenance plan of the proposed building.

5.1.5 Expected Outputs for the DTED for a Building Project

The expected output of the study are:

a) Assessment and recommendation of the required intervention for the improvement of the service, safety, environmental protection, erosion control and building protection

b) Detailed Engineering Study for the building construction works;

c) Cost estimates of the project and the BoQ

d) Updated environmental and social economic impact;

e) Development of Environmental and Social Management Plan (ESMP);

f) Preparation of tender documents.

5.2 Feasibility Study and Preliminary Design Stage for the Building Project

Explanation:	For the Feasibility Study please also refer to LODA's feasibility study guidelines of 2020

5.2.1 Technical Dimension of the Building Project

5.2.1.1 Inception Report

This shall contain the preliminary observations with the points that can affect the design of the building project: detailed work program; brief description of the updated working methods; methodology of the consultant in accordance with the Terms of Reference and identify any major issues; constraints and the staff mobilization plan.

Explanation:	The inception report should be presented to District staff in a meeting and open issues should be discussed and decided on.

5.2.1.2 Building Design Feasibility Study

The Feasibility study shall contain the preliminary findings in building location and surveying operation, architectural design following climate resilience principals, soil investigation, socio-economical assessment, environmental impact assessment, preliminary building structural design, technical documents and bills of quantities.

The report shall include any possible alternatives and include the economic analysis and comparison of the alternatives and argue recommendations for choosing the appropriate alternative.

Explanation:	The feasibility study is the Avant-Project Sommaire (APS) and shows the advantages and disadvantages, analysis possible environmental and social risk to be mitigated later, shows technical options for the building and provides a first rough cost estimate for each option

5.2.1.2.1 Building Location and Survey Map

In selecting the location for a building we always avoid high risk zones. The primary aims of field surveying are:

- To measure the horizontal distance between points
- To measure the vertical elevation between points
- To find out the relative direction of lines by measuring angles with reference to any arbitrary direction
- To find out absolute direction by measuring horizontal angles with reference to a fixed direction.

The consultant will prepare the topographic map, sections and all other necessary data for the detailed engineering design.

5.2.1.2.2 Architectural design

The minimum content of architectural plans is as follows:

- Site plan,

- Floor plans,
- Elevation views,
- Cross section drawings and details

Additional plans:

- Mechanical and electrical plans,
- Plumbing and sanitation installations
- Structural plans

To consider the concept of Green building:

Promotes energy and water efficiency
Takes advantage of the ambient (upland) climate,
Reduces the need for air-conditioning usage
Maximizes natural ventilation
Maximizes the use of sustainable and locally manufactured buildings materials
Provides superior Indoor Environmental Quality (IEQ) to building occupants, protects environment and promotes biodiversity.

5.2.1.2.3 Soil Investigation

The weight of the buildings will be carried by the soils supporting the foundations. In order to design appropriate foundations the consultant has to determine the nature and location of the different soil types occurring at the site of the building, to depths containing soil layer sufficiently strong to support the building without significant deformation.

This information is obtained by analysing samples taken from a grid of bore-holes or test pits covering the whole of the proposed site, and by testing the samples for density, shear strength, plasticity and penetration, in order to provide quantitative data for foundation design.

The level and nature of the ground water also affect the foundation design and the engineer must take into account the impact of building construction on the ground water and hence the stability of nearby works and slopes.

Minimum soil tests:

- Soil identification tests;
- Shear tests;
- Dynamic cone penetrometer test

5.2.1.2.4 Building Structural Design

Structural design is the methodical investigation of the stability, strength and rigidity of structures. The basic objective in building structural analysis and design will be to produce a structure capable of resisting all applied loads without failure during its intended life.

Building Structural plans are to be prepared after the structural design.

5.2.1.2.5 Environmental and Social Impact Assessment

The Environmental and Social Impact Assessment (ESIA) to be submitted to RDB should include at least the following:

- A project brief of the project should be submitted to RDB for approval
- Descriptions of the institutional and legal framework, regulations and standards should be considered
- Analysis of all stakeholders, public, private; if a concept was drafted on how to engage the stakeholders (consultations, interviews, etc.)
- Definition describing geographical, climatic, social, economic, etc should be provided
- Primary & secondary users as well as beneficiaries of the project should be identified
- All environmental impacts (positive & negative) and risks related to the project should be identified
- A respective plan should be provided on how to mitigate or minimise the environmental impacts and risks identified
- All social impacts (positive & negative) and risks related to the project should be identified such as loss of agricultural land/crops, employment, economic growth, quality of life, etc.
- A respective plan should be provided on how to mitigate or minimise the social impacts and if risks are identified (especially for resettlement, expropriation, compensation)
- An ESMP draft that reflects all identified impacts and risks should be provided

Sufficient meetings and consultations should be organised during preparation of the feasibility study and ESIA.

The ESIA should be approved by RDB and the respective certificate for the project should be issued.

5.2.1.3 Building Materials

It is assumed that the consultant is familiar with the structural use of steel, concrete and timber. The notes on building materials are intended only to:

- Specify properties of building materials to be used for building construction
- Clarify certain aspects of their use
- Draw attention to potential problems
- Provide a consolidated list of the numerous references.

5.2.1.3.1 Concrete

In general the designs are based on the use of Class: C25 or C30 concrete using 20mm coarse aggregate (30/20 concrete), the ordinary structural concrete is produced using ordinary Portland cement, Portland blast furnace cement, sulphate resisting Portland cement and Portland pulverised fuel ash cement.

Aggregates used in making concrete should conform with RSB standards or other standards used in Rwanda. Concrete for use with steel reinforcement is more likely to achieve the standard of compaction required if the maximum aggregate size is limited to 20mm.

Where there are significant amounts of sulphates in the soil or ground water, it is prudent to take precautions to prevent deterioration of the concrete, which is in contact with the ground. Breakdown of the concrete mass can result from reaction between sulphate and hydrates. Concrete made with less than 3.5 per cent tricalcium aluminate is considered resistant to sulphate attack.

The basic concept of making a dense, impermeable concrete with adequate cover to reinforcement is still best defence against the penetration of pollutants which attack the concrete mass or the steel reinforcement.

The total chloride content of the concrete mix should not exceed 0.3 per cent of the cement, or cement plus pozzolan mixture, when steel reinforcement is used, or 0.2 per cent when using sulphate resisting Portland cement in mass or reinforced concrete.
In order to avoid detrimental alkali-silica reaction, it is better to use aggregate known to be non-reactive. The alternative is to restrict the total sodium oxide content of the cement to less than 3.0kg per cubic metre of concrete.

Besides ensuring that the materials are of adequate quality, the single most important factor influencing both strength and durability of concrete is the water/cement ratio of the mix. When specifying concrete, the maximum free-water/cement ratio by weight should generally be limited to 0.5. In calculating the free water available in the concrete, it is important that any moisture on the surface of the aggregates is included. In marine situations or near the coast, the free-water/cement ratio should be no more than 0.42 to avoid premature deterioration due to corrosion of reinforcement or damage to mass concrete by salt scaling or sulphate attack. Careful mix design is necessary to ensure ease of placing concrete without violating the maximum free-water/ cement ratio.

Cover to reinforcement and curing of concrete must also be carefully specified and supervised on site if the structure is to have an adequate service life. The cover of 50mm shown to reinforcement in the standard designs is intended as a minimum for a structure in a moderate environment. In a severe environment, such as a marine situation in a hot climate, cover may need to be increased to 75mm or even 100mm to achieve the required lifespan. To ensure that the cover is as impermeable as possible, the concrete must be moist cured with clean non-saline water as soon as surface finishing is complete for exposed surfaces, or as soon as forms can be safely stripped from formed faces (3days for side forms, 14 days for structural supports or as advised by local engineers). This curing process should consist of covering the concrete with wet hessian and covering the hessian with polythene sheeting, which must be sealed around the edges to stop the hessian from drying out. The hessian and polythene should be kept in place until the concrete is at least 7 days old, if possible 14 days.

Special measures are necessary for concreting in hot weather and when there are drying winds and low humidity. Aggregates should be kept shaded, cool mix water should be used and the time between mixing and placing should be kept to a minimum.

5.2.1.3.2 Steel Reinforcements

Steel reinforcement for concrete shall consist of steel bars or steel wire fabric, except where otherwise shown. Steel bars shall consist of deformed and/or mild plain round steel bars in accordance with BS 4449 or equivalent valid standard in Rwanda.

The basic mechanical properties of the most used steel reinforcements are given in the following table:

Designation	Nominal grade	Characteristic strength, N/mm2	Minimum elongation
Mild steel	250	250	22
High yield steel	460	460	12

5.2.1.3.3 Required Minimum Laboratory Tests on Building materials

Concrete materials:

Sand

- Sieve analysis
- Sand Equivalent
- The absorption of fine aggregates
- chlorides content
- Reactive alkali content

Gravel

- Los Angeles Test
- The absorption of coarse aggregates
- chlorides content
- Reactive alkali content
- Sieve analysis
- The flakiness index

Cement

- Setting time
- Soundness
- Fineness

Concrete

Fresh concrete

- Slump test
- Compacting factor

Hardened concrete

- Compression test

Steel reinforcements

- Steel reinforcement Tensile test
- Bending test

Soil

- Sieve analysis
- Soil Waterberg limits
- CBR Test
- Shear test
- Modified Proctor test
- Density
- Moisture content
- Drilling (If required)

5.2.2 Detailed Technical Engineering Design Final Report

The Consultant shall implement the following activities but not limited to the final detailed technical design and engineering report:

5.2.2.1 Civil Works

- With reference to the preliminary assessment study (if available), carry out the topographical and cadastral surveys undertaken and update where necessary.
- Undertake soils, materials, geo-technical, stability and sub-surface analysis and investigations at the building sites, verify the availability of suitable and sufficient materials for construction and sample and test foundation design.
- Assess water catchment area, rainfall and run off characteristics, water table, temperature, climate and potential flooding risks to inform designs so as to avoid flooding. Carry out hydrological analysis to design required drainage.
- The horizontal alignment of all project access and circulation roads and parking areas should be in accordance with national standards. The vertical alignment should be designed to take into account the hydraulic and soil conditions.
- The pavement should be designed to carry the circulation of moving and resting trucks traffic over a 20-year design period of the proposed project. Other parameters to be considered during pavement design should include the results of the pavement evaluation, soils and materials tests and other engineering treatments dictated by available natural materials.
- All existing data and the results of the field investigations for soils, foundations, hydrology, etc. should be assessed and used as a basis for the design of drainage structures.
- Based on the topographic surveying and the designed pavements, the Consultant shall improve the horizontal and vertical alignments as necessary to comply with the approved design standards appropriate to the traffic and engineering characteristics of the facility. The Consultant shall use the designed alignments to perform volume computations for earthworks and pavement layers.
- The Consultant shall identify all possible accident black spots and incorporate their design, measures to improve any dangerous locations identified. Improved layout and visibility at

junctions, proper separation of pedestrians and cyclists from the vehicular traffic and the provision of pedestrian crossings, and parking areas shall be included in the design.

- The Consultant shall carry out traffic counts and origin and destination surveys.
- The Consultant shall develop Traffic Management Plans showing details of the location of bypass lanes, temporary structures, barriers, signs, signals and other physical features necessary to accommodate traffic flow during construction (if applicable).
- The Consultant shall prepare the following engineering drawings for the project using format and title sheets as required by the Client, with the originals becoming the property of the Client.
  Showing natural ground levels, horizontal and vertical details, running chainage, cross-section chainages, drains location, description and references to all drainage works, location of bench marks, location of the facilities, any other relevant information in the format approved by the
  Client.
    - Topographic Plans, scale 1:2000
    - Plans and Profile, scale 1:1000/1:100
- Verify the socio-economic information given in the feasibility study and related documents and where necessary update information and data on the following with respect to the site of the proposed project.
    - Community population and economic indicators at the sites
    - Health services availability and gaps
    - Water and electricity supply and waste management
    - Road and transport services and facilities
    - Communications services
    - Traffic count data and trends
    - Major environmental and Social concerns
    - Freight, cargo and passenger data, characteristics and trends.

5.2.2.2 Building Works

- The consultant shall work with all key stakeholders to identify their needs requirements and expectations in terms of space, facilities and services and prepare a stakeholder management plan.
- The Consultant shall carry out a condition assessment of all existing physical facilities (if applicable,) at the Border to determine if they can be retained and improved for or should be demolished. In this respect, the Consultant shall carryout a process and review audit of the current flow of services with a view to determining the relevance of the existing infrastructure and their suitability for conversion into a project facility.
- In order to assist in evaluating the required construction period and forward budget needs, the Consultant shall develop a Gant Chart of the project providing;
    - Major activities, their sequencing and duration,
    - Identified major milestones where meetings/ decisions need to be made
    - Duration of the entire project in the form of a bar chart,
    - Monthly cost of each activity, and
    - Anticipated monthly expenditure presented in form of an S-curve.



- In carrying out the analysis of the construction schedule, due account shall be taken of the climatic conditions of the areas concerned.

- Based on the preferred design concepts, the Consultant shall prepare to sufficient details the site plan general arrangement drawings showing the location of all identified facilities and the usage of available land/space as well future plans for expansion of services (if applicable).
- The site plan shall show the proposed buildings, access and circulation roads, parking, drainage, fencing, power and water supply, communications connections, landscape and other infrastructure. The site plan shall have details of the floor plans including the proposed layout, partitioning, fixed fittings, loose furniture, elevations, sections, perspectives of all structures.
- The designs shall describe the structural system (buildings); finishes (internal and external), including proposals for alternatives and the resulting impact on costs; internal fittings; sun shading and ventilation methods; electrical, mechanical and IT installations proposal, including linkages and connections to the existing systems (if available): Water supply and waste water management; Roads and Pavement details; Fire prevention proposals for the facilities; Cost estimates and cost control measures;
- The Consultant shall prepare scheme design drawings presented in scales of 1:100, 1:200 or other appropriate scales, showing in more detail (architectural and engineering) the site layout and the spatial arrangements and appearances of the proposed buildings, structures and infrastructures;
- The site plan should show the proposed water, drainage, electricity, communications and other services, the vehicular circulation and parking, pedestrian circulation, fencing, landscaping and other infrastructure;
- Draft technical construction and operation specifications (architectural and engineering) for the proposed project facilities;
- Schedules of the proposed finishes, fixtures, fixed and moveable fittings and furniture;
- Based on the above preliminary/schematic designs the consultant shall prepare preliminary cost estimates for the project facilities to guide subsequent decision processes and actions.
- At this stage the consultant shall provide an update on the project pointing out accomplished tasks and outstanding activities as well as additions/deletions necessary for driving the project to completion.
- The Consultant shall liaise with relevant local authorities on the scheme designs. At this stage the consultant shall also ensure that the scheme designs are in complete harmony with the designs on the counterpart and that it generally fulfils the principles of the project concept.

5.2.2.3 Costings

Preparation of detailed technical designs and tender documents for the project facilities works including confidential costs estimate. Calculations of project budgets and cost estimates should include an amount for contingencies broken down for each project component.

5.2.2.4 Tendering administration and contract documentation

The Consultant shall assist the client with managing the procurement process. The Consultant shall:

- Assist the client in coordinating the pre-bid site visits and meeting including provision of necessary clarifications to prospective bidders.
- Assist the client to evaluate bids and prepare evaluation reports (optional).
- Assist in dealing with queries and clarifications during the tender period.
- Assist the Client to negotiate with the selected bidders on any aspects of the construction contracts.
- Prepare the final construction contract documents and arrange for signing.
- Provide all other necessary information as may be required by the construction contract
- Arrange for the commissioning and commencement of the construction works.

5.2.2.5 Environmental and social impact assessment (ESIA)

The Consultant shall Conduct Preliminary Environmental and Social Impact Assessment and shall recommend appropriate mitigation measures/plans to minimize any negative impacts.

In undertaking Social Impact Assessment, the consultant shall establish the number and the cost of compensation for properties to be affected as per requirements of the project Compensation and Resettlement

The Consultant shall assess the likely impact of HIV/AIDS on the project and propose measures to mitigate the same in accordance with National HIV/AIDS policy and strategies. The Consultant shall also prepare an awareness programs which aims at educating the community.

5.2.2.6 Climate resilience analysis

The Consultant shall carry out the hydrological analysis to assess the impact of climate on the project infrastructure and drainage structure. The consultant shall pay attention to the hydrology of the project region and consider the incorporation of the climate change allowance into design of building and the drainage structures. He may also recommend on other interventions for climate proofing at the surroundings of the project infrastructures.

5.2.2.7 Documents Expected for the Preparation of Tenders

Explanation:	In most cases the standard bidding documents for small works of RPPA will be required for tendering. To prepare and allow Districts to fill in this template, the following documents are required at minimum.

The following documents are required at minimum:

- The book of particular technical clauses
- The works evaluation method
- A quality assurance file
- The framework of the unit price schedule

- The sub-detail of unit prices
- The bill of quantities framework
- All the drawings resulting from the detailed design studies essential for the establishing of execution plans
- The geotechnical soil survey report for the structure's foundations.

c) Implementation Schedule and Reporting

Explanation:	Reporting is an important aspect of the consultant responsibilities towards the Employer and shall allow the employer's officials in charge of the studies to closely follow and comment on the progress of the study.

To do: The maximum period for carrying out the study assignment should be indicated. This period does not include the validation times of reports by the client which will not exceed two weeks at each stage.

The schedule will clearly show:

- The duration of completion of all preliminary design studies
- The duration of all detailed pre-project studies
- As well as all the validation periods for the various studies by the client.

5.3 Minimum Key staff for Building Design and Construction

N°	Description	Minimum years of experience
1	Architect: Team leader	10
2	Geotechnical Engineer	10
3	Structural Engineer	10
4	Quantity surveyor	3
5	Environmental Expert	3
6	Senior Surveyor	3
7	Sociologist or Socio Economist	3
8	Electromechanical Engineer	3

5.4 Main References for Building Designs

Explanation:	Please familiarize yourself with the content of the documents listed below to have a better background on the requirements of road design

- Rwanda Building and Urban Planning Code of 2019
- Rwanda Building Control Regulations of 2009
- Les éléments de projets de construction, Ernest Neufert, 1983.