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ACRONYMNS AND ABBREVIATIONS

BS         British Standard
CP         Code of Practice
DRF        Dakawa Rice Farm
GES        Government Electrical Specification
MCC        motor control center
TANESCO    Tanzania Electric Supply Company
UWAWAKUDA  Farmers’ cooperative at Dakawa
1. INTRODUCTION

1.1 GENERAL DESCRIPTION OF PROJECT
CDM International Inc. (CDM Smith), through a contract with the U.S. Agency for International Development (USAID) in Dar es Salaam, Tanzania, has been tasked with evaluating the existing pump station at the Dakawa irrigation scheme, developing designs and construction contract documents for the rehabilitation of the pump station, and overseeing procurement of equipment and the construction and commissioning of the completed works. This work is being carried out as part of CDM Smith’s contract with USAID, No. EDH-I-00-08-00023-00. The pump station provides water from the Wami River to irrigate approximately 2,000 hectares of farmland at the Dakawa Rice Farm (DRF) that is owned and operated by the farmers’ cooperative, the Dakawa Irrigators Cooperative Union (UWAWAKUDA Ltd.).

This design and construction project will consist of the rehabilitation of an existing Pump Station including new pumps and piping, new monorail hoist for pump installation and removal, new intake trash rack, improvements to the sluice gate operators, new electrical transformers and switchgear, new Operations Building, new perimeter security fence and gates, and rehabilitation of the existing access road.

This Design Criteria Report establishes the initial criteria adopted for the project, upon which detailed designs will be based. Detailed specifications will be developed for each work component, expanding on the criteria included below.

1.2 IRRIGATION SCHEME
The 2,000-ha irrigation area that is served by the Dakawa pump station lies directly northeast of Dakawa, a village along the main road Morogoro-Dodoma (B 129) some 48 km north of Morogoro. The irrigation supply infrastructure comprises a pump station and a 7.3-km main canal that provides water to six secondary canals.

Water for irrigating the DRF is supplied by the Wami River. A water abstraction permit has been issued by the Ministry of Water to the cooperative union, UWAWAKUDA, and limits the extraction of water by the union to 432,000,000 liters/day (5 m³/sec for a 24-hour day) for the period March, April, May, June, July, September, October, and November. This rate of flow may be the limiting factor in sizing future pumping or canal delivery systems.

The Wami River currently has sufficient supply and the water levels are high enough to serve the Dakawa pump station from approximately March to July each year; the timing depending on rainfall within the catchment area. This supply is sufficient for the cooperative to farm a main season of rice.

1.3 PUMP STATION
The existing pump station was constructed in 1981 by Jos. Hansen and Soehne in Hamburg (Germany). The installation includes six horizontal centrifugal pumps and motors, piping system, electric switchgear, and transformers. The structure includes a below-grade pump room to house the six pumps, an intake well where the six pumps draw suction, and an electrical room for pump motor transformers and switchgear. An intake canal carries water from the Wami River to the pump intake well. Each pump draws water from the intake well and discharges it to the main irrigation canal headworks structure through individual pipes.

There are six main pumps, which are horizontal mounted, electric motor driven, and housed in a sub-basement pump room substructure. Only four of the six pumps are currently operable. The pumps deliver an estimated 1.0 to 1.4 m³/sec per pump, but this has not been verified as there is no flow measurement equipment at the station.
Three-phase power is delivered to the site from a 33-kV transmission line operated by the Tanzania Electric Supply Company (TANESCO), the local electric utility company. Transformers and all switchgear are owned by UWAWAKUDA.

An existing 700+-/- meter long dirt access road connects the village of Dakawa to the pump station site. It is in poor condition and covered with deep potholes. The road traverses a low, flat area that is flooded during the rainy season. The existing site perimeter security fence is in poor condition.

The recommended option for the Dakawa pump station is to completely replace the existing end suction centrifugal pumps and motors with axial flow pumps with integral submersible motors, installed directly into the intake well, and with new electrical motor control centers (MCCs) and switchgear, electrical transformers, and power cabling.

This option would entail complete removal of the existing pumps, motors, suction piping and valves, electrical switchgear, and transformers, and would require structural and piping changes to the station. The existing pump house superstructure would be removed and disposed of properly. Existing mechanical and electrical equipment would be removed and turned over to UWAWAKUDA. TANESCO will provide power to the new transformers via the existing 33-kV transmission line.

1.4 PUMP STATION OPERATION
The six proposed axial flow submersible pumps will be started manually by the operator. Design conditions allow for the operation of five pumps continuously with the sixth pump as standby. Duty time on all pumps should be balanced so that all pumps see approximately the same number of running hours per month.

When each pump starts, water will be lifted up a riser pipe then flow to the canal headworks structure through individual 600-mm pipes from each pump riser pipe.

Pumps will normally be stopped manually depending on the demands of the irrigation scheme, but a low water level shutoff will be provided to stop all pumps when the intake well water level drops to a predetermined level (normally coinciding with low river levels or caused by a blocked trash rack). Pump motors will also be specified with high motor winding temperature shutdown and seal leakage shutdown, with warning alarms.

1.5 TOPOGRAPHIC SURVEYS AND SITE PLANS
A topographic survey of the pump station site and access road has been completed and plans have been developed for the pump station site. This survey and the accompanying bench marks have been used for the new facilities design and will be used during construction of the new facilities.

Site plans will indicate the locations of the new Operations Building, perimeter security fence, and access road horizontal and vertical alignment.

2. CIVIL/SITE WORKS

2.1 SITE EXCAVATION, BACKFILLING AND GRADING
Civil works will include construction of a new Operations Building, new concrete electrical transformer pads, new concrete electrical duct banks, perimeter fence posts, and rehabilitation of existing access road, and all associated site excavation, backfilling and grading. Work will be designed according to standard materials and methods specifications and standard details.
All materials used in the works shall be new and of approved quality and in full compliance with appropriate specifications. All materials specified in the works for which a Tanzanian Bureau of Standards Specification has been published shall fully conform to the latest edition. All materials specified in the works for which Tanzanian Bureau of Standards Specification has not been published shall conform to the relevant British Standard Specification for such materials.

2.2 ACCESS ROAD REHABILITATION
The existing access road and pump station service road shall be rehabilitated according to the Tanzanian Ministry of Works, Standard Specification for Road Works, 2000 ed. The access road will be designed to a minimum width of 6 meters from edge to edge of carriage way and raised to a level to prevent frequent flooding and ponding of water. The surface will be sloped to drain water from the center. Side embankment slopes will be sloped 1:3. The road will not be designed to prevent flooding in the event of heavy rains and external floods. Drainage culverts will be replaced as needed. Material for resurfacing shall be G45 gavel as defined by the Standards.

The service road inside the pump station site shall be resurfaced and graded with G45 gravel.

2.3 PERIMETER SECURITY FENCE AND ACCESS GATES
The perimeter security fence will be 50-mm square galvanized wire mesh, 2 meters in height above grade, and supported by vertical concrete posts every 3 meters. Posts shall be designed with 450-mm square x 450-mm high concrete bases constructed below grade. Strained posts at bend shall be braced to additional concrete bases.

Each access gate shall be designed as a double gate with a total clear distance between hinge posts of 6 meters. Each gate left shall be 3-meters wide. Gates shall be 2 meters in height above grade. Gate posts shall be designed so that gates clear the finish grade surface by 20 cm. Swing area of gate leafs shall be graded to provide 20-cm clearance when opening.

2.4 SITE SECURITY LIGHTING
Site security lighting shall be provided at two locations around the pump station site. Each unit shall be pole-mounted 5 meters above the finish grade at the location. One pole shall be located between the Operations Building and the intake well, and one at the north side of the pump station intake well. Power wiring shall be routed from the main electrical panel at the Operations Building underground in the most direct route to each light pole and light. Lighting units shall be sodium vapor lamps.

3. OPERATIONS BUILDING

3.1 DESIGN CONCEPT
The Operations Building will be a 63-m² single story concrete frame and concrete block building with wood truss roof and metal roofing. The building will house one office, one storage room, one electrical room and one toilet. The building will be designed with a concrete foundation and concrete floor slab with infill concrete block. Doors and windows with security locks will be included. A double-access door will be included for the electrical room. Exterior and interior will be painted. Lighting, electrical receptacles, and ceiling fans will be included. A new septic system will be included on site to serve the building toilet.
Room Sizes | Area (m²)
---|---
Office | 9
Storage Room | 10
Toilet | 5
Electrical Room | 23

### 3.3 CONCRETE AND REINFORCING STEEL

Structural concrete for foundations and building columns will be designed in accordance with BS 5328 using ordinary Portland cement.

Steel reinforcing bars shall be designed according to the following:

- Mild steel bar reinforcement shall be hot rolled grade 250 complying with the requirements of BS 4449.
- Cold worked steel bar reinforcement shall comply with the requirements of BS 4461.
- Steel fabric reinforcement shall comply with the requirements of BS 4483. The wires shall be welded at all intersections.
- Hot rolled deformed high tensile bars having a guaranteed minimum yield stress of 410 N/mm² and other physical properties complying with BS 4449.

Concrete materials for concrete shall be designed according to the following:

- Aggregates for concrete shall consist of naturally occurring material complying with the requirements of BS 882 and 1201.
- Ordinary Portland cement shall normally be used (and shall comply with the requirements of BS 12).

The following concrete cover shall be detailed for all steel reinforcement:

- Internal | 20 mm
- Below ground | 20 mm
- External above ground | 20 mm
- Columns | 40 mm to main steel

The following designates the required concrete finishes:

- Above grade formed concrete work will be designated as F3 finish, fair faced concrete.
- All other formed work will be F1 finish.
- All floor surface concrete will be designated U3 finish with hard smooth steel trowelled finish.

### 3.4 WINDOWS AND DOORS

The building shall be equipped with both single-leaf steel doors with steel frames, and double-leaf steel doors with steel frames. Windows shall be designed with aluminum frames and sashes and be operable. All doors and windows shall be fitted with suitable security locks.
Metal door frames are to be steel to comply with BS 1245 of profile to suit the wall thickness. All hardware shall be designated as stainless steel.

Aluminum windows are to be designed, manufactured and fixed in accordance with the relevant British Standards summarized below.

- **BS DD4**: Grading of Windows
- **BS 1470**: Wrought aluminum and aluminum alloys
- **BS 1474**: Wrought aluminum and aluminum alloys
- **BS 4315**: (part 1) window and structural gasket-glazing systems
- **BS 4842**: Finishes to aluminum
- **BS 4873**: Aluminum alloy windows
- **CP 3CH.V**: Loading
- **CP 153**: Code for windows and roof lights

### 3.5 FINISHES
All walls and ceilings shall be designated to be plastered and painted. Floors shall be trowelled to a hard finish during curing and sealed with a non-skid concrete floor sealer. Steel doors and frames shall be designated to be painted with epoxy exterior paint.

### 3.6 BUILDING UTILITIES
#### 3.6.1 PLUMBING
All components of the system shall be designed according to the British Standards or British Standard Codes of Practice (CP).

The Operations Building will be designed with a complete plumbing system. The cold water potable water system will include a wash basin, lavatory, wash hose station, and gravity water storage tank. No domestic water heater will be provided.

The sanitary plumbing system will include gravity drains and vents for the wash basin, lavatory, floor drain, cleanouts, below-grade sanitary sewer piping from the toilet room to an on-site septic tank, leach field, and all associated piping.

The potable water system shall be designed according to the following:

- PVC pipes for cold water services shall comply with the requirements of BS 3505 and all fittings shall comply with BS 4346.
- PVC pipes and fittings shall be solvent welded using the pipe manufacturers approved cement.

The sanitary sewer system shall be designed according to the following:

- PVC soil pipe work and fittings shall comply with the requirements of BS 4514.

#### 3.6.2 ELECTRICAL
All components of the system will be designed according to the British Standards or British Standard Codes of Practice.

The Operations Building will be designed with a complete electrical system serving each room of the building. All rooms will be fitted with appropriate 240-V receptacles, light switches, electric fans, and overhead lighting. The building will have one circuit
breaker panel with sufficient separate circuits to handle all anticipated electrical loads and according to the appropriate standards. A minimum of one circuit will be provided per room. Electric fans shall be on one separate circuit.

The wiring will be carried out in PVC-insulated cables in PVC conduit throughout, but galvanized steel conduit may be offered for multiple cable runs.

General lighting and power distribution boards will comply with BS 3817, BS 214.

The main switchboard will be cubicle-type wall-mounted comprising circuit breakers and metering cubicles.

The lighting panel will include circuit breakers, conduit and wiring for two yard lights.

The building electrical system will be designed according to the following:

- Government Electrical Specification No. 1 (GES No. 1) and No. 2 (GES No. 2)
- Electrical Power Act and the Rules made thereunder
- The current edition of the Regulations for the Electrical Equipment of Buildings issued by the Institution of Electrical Engineers of Great Britain with any Tanzanian amendments
- Tanzanian Electricity Board Bylaws

4. MECHANICAL/ELECTRICAL WORKS

4.1 DESIGN CONCEPT

Six axial flow pumps with integral submersible motors will be installed directly into the existing intake well. Power will be supplied by new electrical MCCs and switchgear, electrical transformers, and power cabling. The six proposed axial flow submersible pumps will be started manually by the operator. Design conditions allow for the operation of five pumps continuously with the sixth pump as standby. Duty time on all pumps should be balanced so that all pumps see approximately the same number of running hours per month.

When each pump starts, water will be lifted up a riser pipe then flow to the canal headworks structure through individual 600-mm pipes from each pump riser pipe.

4.2 PUMPING CRITERIA

Each pump is designed to operate separately and discharge to a single discharge pipe directly to the existing canal headworks structure. Each pump will be selected and sized to pump 1.0 m³/sec when the river level is at its lowest point. At higher river levels the pump will pump at a slightly greater rate. Pump must be specified to operate within the acceptable range as determined by the manufacturer.

Normally five of the six pumps will deliver the pump station’s design capacity, according to the existing permit that has been granted. Pumps will be designed to start manually by the operator.

Pumps will normally be stopped manually depending on the demands of the irrigation scheme, but a low water level shutoff will be provided to stop all pumps when the intake well water level drops to a predetermined level (normally coinciding with low river levels or caused by a blocked trash rack). Pump motors will also be specified with high motor winding temperature shutdown and seal leakage shutdown, with warning alarms.
4.3 PUMPING EQUIPMENT
The design pumping equipment will be axial flow pumps with submersible motors. These pumps are designed to operate while submerged in water and are self priming. The motor is close-coupled to the pump and each unit will be installed in a steel riser pipe fitted with a retaining flange at the bottom to support the pump.

The riser pipe will be installed and supported within the intake well and will be extended to above the top of the intake well top level. A 600-mm discharge pipe will be welded to the riser pipe, then connected to the existing 600-mm discharge pipe at the pump station. The pumps will be installed from the top of the riser using a manual overhead hoist attached to a monorail.

Air and vacuum valves will be installed in the top plate of the riser pipe to evacuate air during pump startup and allow air back into the riser during shutdown. The 600-mm discharge pipe will be designed to be above the highest water surface either in the river and intake well or in the canal. No valves will be required in the discharge pipe. When the pump stops water in the riser pipe flows back down to the intake well. Water cannot flow from the canal to the intake well because the highest level of the discharge pipe is above the canal water surface.

4.4 ELECTRICAL EQUIPMENT
New electrical transformers will be specified for the six new pumps. Power for the station will be from the existing TANESCO 33-kV line adjacent to the station. The system will include two 33kV/400-V, 500-kVA step-down transformers (each serving three pumps). A new MCC for six pumps and six sets of switchgear will be installed into the Operations Building electrical room. Load break and bypass switches will be specified as well as two 140kVAR power factor correction units.

All power wiring will be installed in conduits, within concrete duct banks. Duct banks will be installed from the step-down transformers to the electrical room equipment, and from the electrical room to the intake well where the pumps will be located. Six individual isolation (disconnect) switches will be installed at the location of each of the six pumps, at the intake well.

4.5 MONORAIL AND OVERHEAD TRAVELING HOIST
A steel frame and monorail will be installed on the existing intake well for the purpose of installing and removing six pumps. The monorail will be equipped with a 3-ton manual chain hoist capable of lifting one pump from the riser pipe. The monorail will be extended beyond the end of the intake well by 5 meters to allow for truck loading and unloading from the monorail and hoist. The height of the hook of the chain hoist (and therefore the height of the monorail structural frame) shall be determined by the pump manufacturer to allow for lifting the entire pump clear of the top of the riser pipe with 0.5-m clearance. The frame and monorail shall be designed to support the weight of one pump and associated equipment, and the support structure itself. A detailed truss design will be completed.