TECHNO-ECONOMIC ASSESSMENT STUDY FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT

PHASE II: PROJECT DEFINITION OPTIONS

Volume 4: IMPLEMENTATION STUDIES

Chapter 1: Implementation schedule and construction method

August 2014

Report No. P.002378 RP 44 rev. C

C	14/08/2014	Final Version	VLI	LCO	LBO
B	31/03/2014	Final	VLI	NSA	NSA
A	12/11/2013	First Revision	VLI	LCO/NSA	NSA
0	10/04/2013	First Emission	F.Ferranti	A.Lara/L.Corti	N.Sans
Revision	**Date**	**Subject of revision**	**Drafted**	**Checked**	**Approved**

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1 INTRODUCTION

In the framework of the task T2-14 of the Contract for consultants' service between OSHPC "Barki Tojik" and the Consortium "Coyne et Bellier" (Tractebel Engineering S.A.) - ELC-Electroconsult – IPA Energy, the implementation schedule for the three Dam alternatives (with the full supply level at respectively 1290 masl, 1255 masl and 1220 masl) is elaborated.

This report deals with the tentative construction schedule of the 3 above alternatives, assesses the overall construction period and the critical activities and presents recommendations.

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3 BRIEF DESCRIPTION OF THE MAIN COMPONENTS OF THE ROGUN HYDROPOWER PROJECT

3.1 General

Rogun HPP project is located in Tajikistan, about 120 km on the East of the capital Dushanbe, on the Vakhsh River, upstream the Nurek Reservoir. The site coordinates are 38.67°N – 69.77°E.

Rogun HPP construction project started in 1981, just after the completion of Nurek dam but was stopped nearly 90's for about 10 years. At present only minor maintenance and rehabilitation works are ongoing.

The Rogun project consists of an embankment dam, an indoor Power House equipped with six Francis turbines, which during the final configuration of the plant will be fed by six independent headrace tunnels, penstocks and manifolds, while during the temporary configuration (called Early Generation phase) two turbines with a temporary arrangement (temporary generators) are envisaged. During this phase, the generating Units will be fed by a temporary headrace tunnel located downstream from a temporary intake set at elevation 1035 masl, close to the River Diversion Tunnels. The manifolds as well as the tailrace channels (collectors) for the early generation phase will be maintained even in the final configuration phase. It is worthwhile mentioning that the outlet of the tailrace channels will release the water into the two diversion tunnels.

A complex system of underground tunnels is required for the access and the construction of the powerhouse, the relevant electromechanical equipment and auxiliary systems installations. In addition, a consistent number of outlet devices are envisaged for the flood management River Diversion and Reservoir, as well as several transportation facilities.

The consultant reviewed the Design made by HPI and proposes some modifications, especially with respect to the outlet devices necessary for the flood management. In any case the layout proposed by the Consultant tries to use the structures already executed for time and costs saving.

The Consultant has analyzed three alternatives with FSL 1290, FSL 1255 and 1220, which differ from each other mainly for:

- Dam crest elevations;
- Installed capacity;
- Outlet structures for floods management.

The layout of the power waterways system as well as the switchyard does not change significantly considering a certain FSL alternative rather than the other two.

For each FSL alternative three installed capacities have been considered in the frame of the Consultancy service (i.e. Reservoir operation study etc), as follows:

	FSL = 1220 masl	FSL = 1255 masl	FSL = 1290 masl
High installed capacity	2 800 MW	3 200 MW	3 600 MW
Medium installed capacity	2 400 MW	2 800 MW	3 200 MW
Low installed capacity	2 000 MW	2 400 MW	2800 MW

Figure 3-1: Installed capacities

For a given FSL alternative, a variation in the installed capacity does not affect the relevant implementation schedule; therefore only three implementation schedules are studied (one for each FSL alternative) by the Consultant.

Since the implementation schedules of the three FSL alternatives are very similar to each other (the main differences lay in the duration of the construction), in the present report reference is made mainly to the alternative FSL 1290, while a comparison with the remaining two FSL alternatives is presented. In any case, in the annex 3 the Gantt chart of the three alternatives is given.

3.2 Cofferdams and Embankment Dams

For each of the 3 alternatives the following embankments dams are present:

- Pre-cofferdam and cofferdam, the pre-cofferdam having crest elevation at 1000 masl is included in the body of the cofferdam, which has the crest at elevation 1050 masl. In the cofferdam a polymeric membrane is present in order to ensure the watertightness of the embankment.
- Stage 1 Dam. It is a concrete asphalt core embankment dam with the crest elevation equal to 1110 masl for the alternative FSL 1290, 1090 masl for FSL 1255 and 1075 masl for FSL 1220. It shall be pointed out that the cofferdam body is included in the Stage 1 Dam body.
- Main dam with a central core and three different crest elevations depending on the considered alternative: 1300, 1265 and 1230 masl.

A complete description of the Dams is given in ([12]), while the relevant drawings for each alternative are given in the Volume 3 Chapter 4. Here below a picture of the Dams cross section for the case FSL 1290 is given.

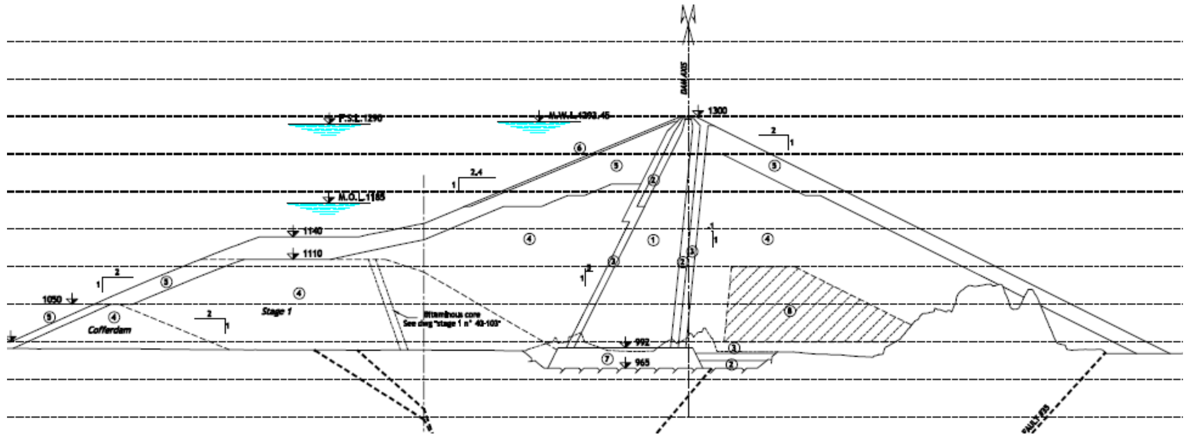


Figure 3-2: FSL 1290 Cross section of the Dam

3.3 Diversion tunnels, middle & high level outlets and spillways

As explained in [4], during the River Diversion phase the diversion tunnels DT1, DT2 and DT3 will be used for diverting the Vakhsh River.

DT1 and DT2 tunnels are already excavated and lined even if important rehabilitation works are needed. On the contrary DT3 is not yet realized and, as DT1 and DT2, it shall be operative before the river diversion date [4].

During the construction of the Dams and during the operation of the Rogun plant the following hydraulic devices, in addition to DT1, DT2 and DT3 are envisaged for the flood management:

- Middle level outlets MLO1 and MLO2 having the inlet elevation at respectively 1085 masl and 1140 masl. MLO2 is foreseen only in the alternative FSL 1290 while MLO1 is foreseen for the three alternatives.

- High level spillways HLTS1, HLTS2 and HLTS3, which working operation levels and numbers are different depending on the selected alternative, as illustrated in reference [4]. Two high level tunnel spillways are envisaged for alternative FSL 1290, three for FSL 1255 and only one for FSL 1220.

- Gated Surface spillway channels which working operation levels and the number of bays is different depending on the selected alternative, as illustrated in reference [18]. This spillway is not necessary for the flood management during construction.

The above listed structures are not constructed yet and they shall be ready to be operated before the reservoir water levels, during the first impounding phase, reach the inlet of each structure.

4 BRIEF DESCRIPTION OF THE ACTUAL PROGRESS OF THE MOST IMPORTANT EXISTING STRUCTURES

As written above, the project layout proposed by the Consultant is aimed to use as much as possible the structures already built, even if remedial works need to be carried out for several of them.

It is Consultant's opinion that the rehabilitation of the existing underground structures would speed up the delivery of the plant and would permit a cost saving, in comparison with the construction of new structures having an equivalent role.

The exhaustive assessment of the structures already built is carried out in PHASE I of the consultant services and it is detailed in report [17].

In any case, it is worthwhile mentioning the following main structures already realized, since they will be recalled in the next chapters and their description would enable a better understanding of the rehabilitation and completion works to be performed:

- **PH Cavern** The overall dimensions are: width 21 m, height 69 m and length 220 m; according to the information available to the Consultant the PH is mostly excavated down to elevation 966 ma.s.l., while the remaining part to be excavated reaches approximately elevation 947 ma.s.l (excluding the pits which house the draft tube bends, and reach elevation 932 masl). In the Units 6 & 5 area the excavation reached el. 958.50.

  The temporary supports as well as the concrete lining are already installed for the part already excavated. Some damages caused by local instability can be observed on the exposed concrete surfaces, in addition important convergences of the power house side walls were recorded during the excavation, especially in correspondence of the part of the cavern located in the siltstone area (western of the cavern) [20]. This led to the need to analyze in detail the stability and to define the supporting system for the excavation of the further phases (see Phase I report).

Figure 4-1 : Power house cavern

The Powerhouse sector in correspondence of the Assembly Bay area is almost completed. The concrete structure of the workshop is already poured.

Figure 4-2 : Power house cavern on the left: View taken from the erection bay, on the right the installed overhead travelling crane

The crane beams for the overhead travelling crane are also constructed and the Powerhouse is presently equipped with a 160 tons capacity crane, but some additional stabilization/strengthening works on the crane beams are needed.

- **Transformers cavern** the overall dimensions are: width 19 m, height 42 m and length 212 m. The cavern is excavated approximately up to elevation 983 masl, while the deepest point of the remaining part to be excavated reaches elevation 966 masl. It is worthwhile recalling that no signs of global instability have been detected during the site inspection held in June 2011.

Figure 4-3 : Transformer hall cavern, upstream wall, view from Unit n 6

- **Cables galleries** The Cables Galleries are two parallel tunnels of about 700 m length located near the Powerhouse Access tunnel T4, on the left bank. The main geometrical data, relevant the typical transversal section, are:
  - Excavation width: 5.8 m
  - Excavation height: from 7.7 to 8.2 m
  - Lining thickness: from 0.5 m to 0.6 m

According to the current information available to the Consultant, the maintenance works for these two tunnels has been already done, during the site visit held in June 2011 grouting works were in progress as well as minor rehabilitation works.

Figure 4-4 : Cable galleries, view from the transformer hall

- **Temporary headrace tunnel – Penstock** The Stage 1 Headrace Tunnel is characterized by a D-shaped cross section of approximately 8 m width and 7.5 m height; the thickness of the lining is approximately 0.5 – 0.6 m. The tunnel length is about 373 m; this distance includes the steel lined stretch in correspondence of the main and emergency gates structure. The two penstocks are about 105 m long each.

Intake construction is at the foundation level and approximately 15 m of tunnel excavation and lining in correspondence of the inlet shall be realized. The steel lining has been installed in correspondence of the gates structure. Some rehabilitation works were carried out on the concrete lining in the gates chamber.

The penstock stretch excavation has been accomplished while the lining installation has not been completed yet as well as the erection of the mechanical components.

In addition some rehabilitation works might be envisaged.

- **Diversion tunnel DT1 and DT2** As stated in previous paragraphs, DT1 and DT2 tunnels are already realized; according to the information currently available to the Consultant the gates are already erected and tested, but consistent rehabilitation civil works need to be done (drainage holes, dowels and dywidag bolts installation, additional concrete lining, impermeabilization grouting. For time saving it is foreseen to realize the rehabilitation works of DT1 and DT2 in parallel.

Figure 4-5 : DT1 tunnel, repaired sections in correspondence of the collapsed area–fault 35

Figure 4-6 : DT2 tunnel, on the left collapsed area downstream of the gate section; on the right cracks on the crown in the stretch between the gates chamber and collapsed area

It is worthwhile recalling that during the first period of operation of the diversion tunnels some collapse took place: the topic is discussed in the Phase I report.

5 CONSTRUCTION FACILITIES

The infrastructure of the former site installation still exists ([17]) but needs to be rehabilitated. Main access road to the site and service roads within the site areas need to be enlarged and/or rehabilitated for the transportation of heavy machinery and equipment as well as for intensive traffic of dumpers and trucks.

In addition, further service and permanent roads as well as transportation tunnels shall be constructed, while in the existing tunnels rehabilitation works shall be implemented. More details concerning the corrective measures to be implemented for these structures are dealt with in [17].

The main roads are shown in the drawing report (Volume 3, Chapter 4), while the most important transportation tunnels are listed hereafter.

1. PERMANENT TRANSPORTATION TUNNELS

- T_2: access to gates chambers, to the saline gallery (which will not be used) and to the Dam Curtain Gallery;
- T_4: tunnel T_4 is the main access tunnel to the Power House;
- T_6: tunnel T_6 is connected to the tunnel T_4 and it represents the access tunnel to the Transformer Cavern;
- T_8: tunnel T_8 is the main access tunnel to the Diversion Gates Chambers;
- T_{10}: this tunnel is providing access to the left bank from dam D/S shoulder
- T_{18}: tunnel T_{18} is the access tunnel to the penstock shaft upper Chamber
- T_{39}: this tunnel connects the upstream and the downstream of the Dam on the right bank and provides access to the new discharge facilities and to the dam D/S shoulder
- T_{50}: tunnel T_{50} access to gates shaft yard for alt. FSL 1290
- T_{50A}: tunnel T_{50A} access to dam crest from left bank for alt. FSL 1255 and FSL 1220
- $T_{3'}$: tunnel $T_{3'}$ is the extension of Tunnel T_3 below described

2. TEMPORARY TRANSPORTATION TUNNELS

The transportation tunnels that have to be considered as temporary structures are:

- T_3: transportation tunnel T_3 is the main access tunnel to the works area during the construction period
- T_{5A} - T_7 - T_{7A}: tunnels T_{5A}, T_7, T_{7A} are branches of Tunnel T_3 and they will be abandoned once the reservoir impounding is completed
- T_{10A} this tunnel will be used for the construction of the dam body
- P_{28}: tunnel P_{28} provides access to the lower penstock shaft bend
- T_{22}: tunnel T_{22}, on the left bank, is the access to the Stage 1 dam crest
- $T_{37'}$: tunnel $T_{37'}$ is the extension of Tunnel T_3
- T_{37A}: tunnel T_{37A} is the extension of Tunnel T_3
- T_{3a}: provides access to T_3 after first impounding stage
- Conveyor tunnels

These tunnels should be plugged as the level of the reservoir raises.

6 CONSTRUCTION MATERIAL ON SITE

A detailed description of the quarries is given in [3]. It is worth mentioning quarry n.15, located on the left bank approximately 7 km upstream of the Dam. This quarry is one of the most important since it is the source material for rock fill shell material and concrete aggregate both and for filter and transition materials for the dam. It shall be considered in the Construction Schedule that approximately 31.4 Mm3 of raw materials have to be extracted from this quarry before the reservoir water level reaches elevation 1045 masl. The time estimated for this task is approximately 4 years.

The conveyor system is the selected way to transport the shell and the filter materials to the dam body. A description of the conveyor is given in [2], while hereafter only the more important data will be provided.

Part of the conveyor has been already installed during the past years, but it cannot be used as it is and the re-installation of the overall conveyor system is required.

Figure 6-1 : Remains of the conveyor stretches already installed

The conveyor belt is foreseen to deliver the gravel extracted from the Quarry N.15 to the dam site. The layout of the conveyor belt is portrayed in the picture given hereafter.

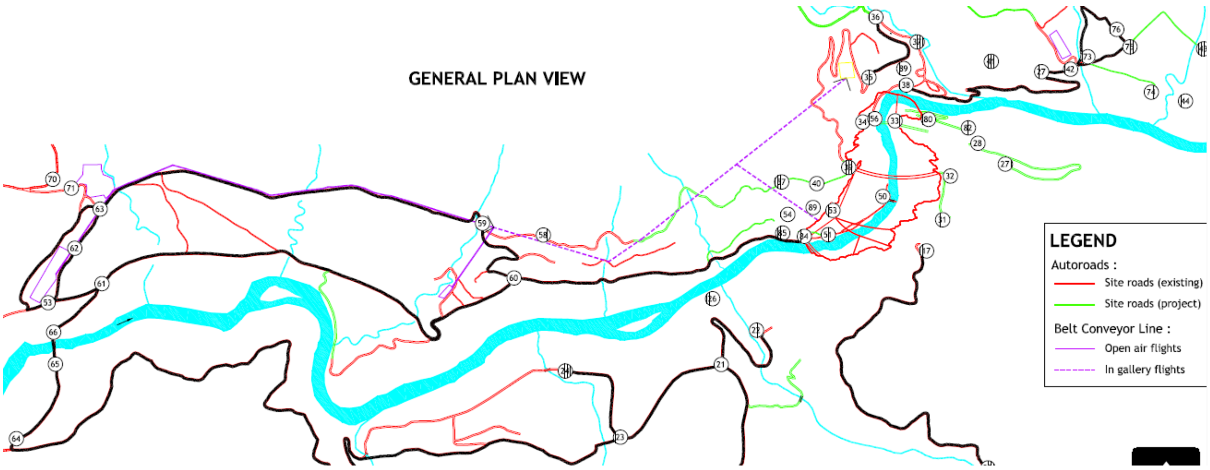


Figure 6-2 : General plan view, in violet the conveyor line, with dotted line the stretch in tunnels, with the continuous line the open line

The required average delivery rate for meeting the required placing rate in the embankment can be estimated approximately in 4’000 t/hour, the belt shall deliver mainly pebble.

The outlet of the conveyor line is foreseen at elevation 1100 masl, from where the material will be reloaded and transported to the elevation in progress.

A reasonable scheduling for the conveyor implementation is the following:

- Order 6 months
- Delivering 12 months
- Erection and commissioning 6 months

Since a part of the conveyor line will be placed in tunnel, it shall be ready before the delivery of the conveyor will take place.

Considering the foreseen schedule the conveyor will be able to provide gravel for part of the Stage 1 and for the Main Dam, until the reservoir water level will reach the elevation 1200 masl, since from this elevation it will be flooded.

7 SPECIAL FEATURES

This paragraph deals with some special features of the project: the mitigation measures for the Ionakhsh Fault and the stabilization measures against the potential instability along the geological discontinuities ("S4" or similar) located on the left abutment.

In the Ionakhsh Fault, which cuts the Rogun dam site in a roughly NE-SW direction in the upstream part of the site presence of salt (evaporities) is detected. The salt wedge is subjected to dissolution as well as to diapirism. In order to evaluate and mitigate potential consequences of a loss of equilibrium between those two opposed effects the following works are envisaged:

- Grout curtain cup (the stretches to be grouted range between the elevation 940 and 960 masl, since the top of the salt wedge is detected at elevation 950 masl)

- Drill hole pattern to be performed downstream of the salt wedge (hydraulic curtain)

These works shall be completed after the completion of the cofferdam and before the placing of the embankment of the Stage 1 Dam.

The overall length of the foundation zone to be treated is equal to approximately 350m in the river bed.

It is assumed that for performing these tasks 8 months are necessary.

It shall be pointed out that the proposed mitigation works are envisaged according to the information current available on the salt wedge. According to [9], further tests and studies shall be carried out; hence a modification of the mitigation works might occur in the next Phase of the design.

The presence of the discontinuities "S4" which plunge at 40deg, having a dip direction of 0deg, spaced about of 40m are the reason of concerns for the stability of an extended part of the reservoir slope located just upstream of the left abutment, in addition the stability of the permanent intake might be compromise in case of instability. Owing to this, important stabilization works shall be envisaged. Considering the geological/geotechnical information currently available to the Consultant, shear key galleries are detected as a suitable solution, but at this consultancy phase it is not possible either to define in detail these stabilization measures or to affirm that other solution might be adopted.

In any case the above mentioned stabilization works do not play a key role in the frame of the implementation schedule since they do not fall in the critical path of the project of the 3 alternatives.

8 TENTATIVE IMPLEMENTATION SCHEDULE

8.1 General

As stated before the layouts of the three alternatives are very similar. The main differences with the layout lie in the crest elevation of the Stage1 Dam and the main dam as well as the number of diversion devices and its elevation. FSL1290 is presented in detail, while for the other two the summary of the main results are presented for comparison.

For the energy production two main phases are envisaged:

- **Early generation phase**: it is foreseen during the construction of the power plant and it is realized by means of UNIT 5 and 6 equipped with temporary generators. The Commissioning is made when the reservoir water level reaches 1100 masl. The Stage 1 Dam shall guarantee this reservoir elevation for the commissioning date.

- **Final generation phase**: in this phase the UNIT 5 and 6 are equipped with the permanent generators, while the turbines and the generators of unit 1, 2, 3 and 4 will be placed directly with EM equipment in the final configuration.

8.2 Milestones

The following main milestones are taken into account in implementing the construction program:

1. OSHPC BARKI TOJIK TEAS validation and GoT decision to proceed with the Project. As per current schedule, this validation is expected in June 2014.

2. Signature of a pre-contract for civil works with local contractor or a Consortium.

3. Signature of the main contract for civil works, selecting an International Contractor or Consortium. It is assumed that the financial closure is obtained by the time of signature.

4. Signature of the contract for the electromechanical equipment with the Ukraine supplier for the Units 5, 6.

5. Signature of the main contract for the electromechanical (which is foreseen for the Units 1, 2, 3 and 4) and HSS equipment after the selection of an international Supplier.

6. River Diversion date.

7. Commissioning of the UNIT 5 and 6 foreseen in the frame of the Early generation phase.

8. Commissioning of the UNIT 1, 2, 3 and 4.

8.3 Main activities that it is recommended to commence in the frame of the pre-contract

The Rogun project is a challenging and complex project which lasts a considerable number of years. In order to reduce as much as possible the overall construction time of the project, the following reasonable even if challenging assumptions are formulated:

a) Several site/rehabilitation activities (listed hereafter) necessary for the resuming of the project shall commence at the date of the TEAS validation by Client / Funding Agency.

b) During the tendering period for selecting the main Contractor/Consortium, the construction of several structures (here below listed) will be already started by local Contractors.

The main activities that shall commence at the resuming of the project are divided as follows:

- Financing process
- Tender process

  The following timeframe can be reasonably conceived:

  - Detailed design and Preparation of Technical specifications in parallel with Condition of contract, overall duration 9 months. This time includes the preparation of pre-qualification documents and pre-qualification process of prospective bidders.
  - Tender process, with duration of 6 months. This includes bid preparation by the pre-qualified bidders (including site visit, and one pre-bid conference for clarification of the tender documents and site conditions).
  - Evaluation of the bids, negotiation with the selected bidder and award of Contract, with duration of 6 months.
  - Contractor mobilization, with a duration of 12 months (3 Months overlapping with the Pre-Contract contract, 9 Months at the beginning of the Main Contract)

- Construction activities
  - River diversion works;
  - Dam works;
  - Early generation works;
  - Facilities (Construction and rehabilitation).

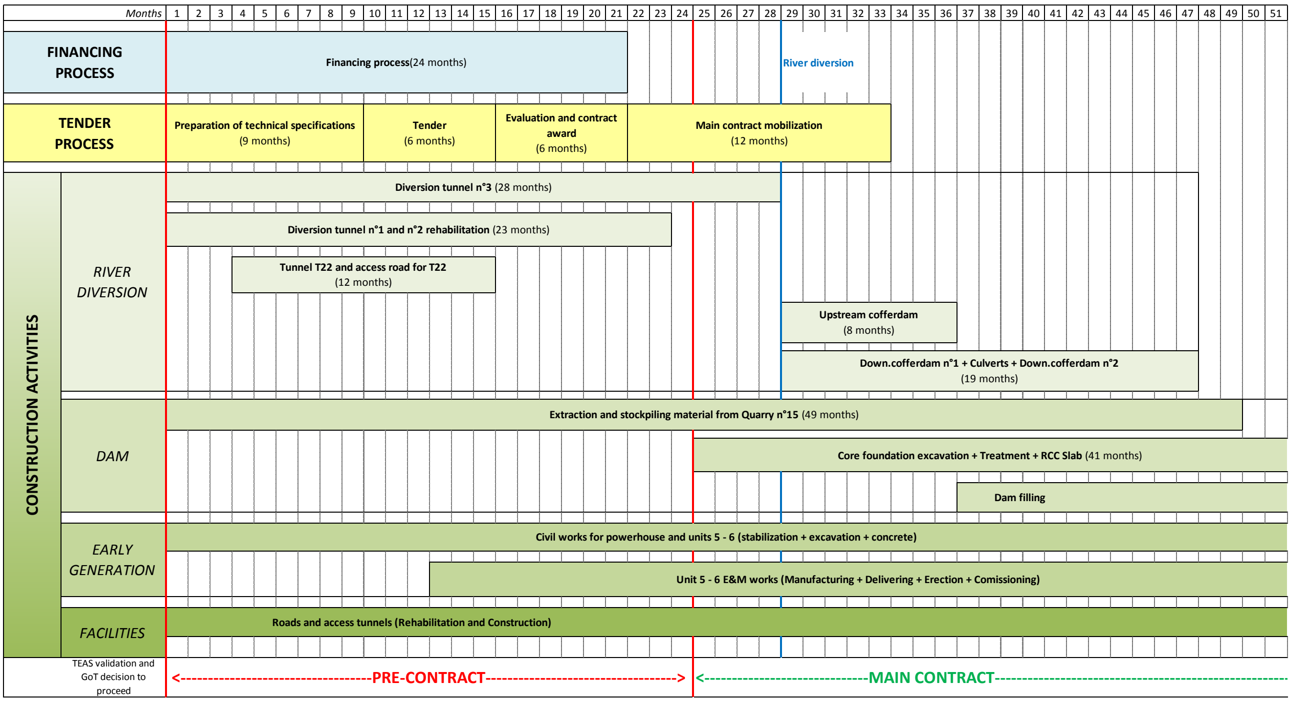


Figure 8-1: Pre-Contract definition

The figure above shows the main activities considered for pre-contract and interference with main contract. The pre-contract is more commonly encountered in the Construction of HPP, and presents several advantages:

- Direct negotiation for the Pre-contract activities will avoid the lengthy process of tendering under International Competitive Bidding for activities that can be performed by local contractors already acquainted with the site conditions and having previous experience on Rogun project.

- The works assigned to Local Contractors/Consortium are less complex than the works currently envisaged in the Consultant's implementation schedule for the main contract.

- The interferences between Local Contractors in charge of the pre-contract and the Main Contractor are limited, clearly defined and result in an easier management of the Main Contract for all parties involved. Taking over by the Main Contractor of the works performed by the contractors in charge of the pre-contract facilities will be required. The Main contractor will be required to examine and certify that the works performed on side under the pre-contract are fit for purpose and can be integrated in the overall project layout under its full responsibility.

This sequence of works is the most effective to ensure resuming of activities at the earliest in a progressive manner. Considering the Importance of the Project and the long duration of the construction of the Project (that with the assumptions formulated by the Consultant is respectively 10, 11.8 and 13.6 years for the Alternative FSL 1220, 1255 and 1290, from the beginning of pre-contract to the end of the dam construction), it is in the Consultant's opinion all the efforts aimed to reduce the Construction time of the Project shall be done, included the presence of this Pre-Contract for the initial phase of the construction.

Hence before these 24 months the Main Contractor/Contractors will not be fully operative and ready for the commencement of the main activities. It is therefore suggested to commence/terminate the following activities by local contractors/Consortium before the River Diversion date. As much as possible the activities started in the pre-contract must be terminated by the same contractors.

The following activities must start during the pre-contract:

Key Structures / Activities to be implemented for the River Diversion

1. Diversion tunnels DT1 and DT2 strengthening works
2. Diversion tunnel DT3 construction (including the relevant access tunnel and roads)
3. Tunnel T22 (tunnel for providing the access to the Cofferdam and then to Stage 1 crest)
4. Access roads to T22 tunnel

Key Structures / Activities to be implemented for the Early Generation

1. Power house cavern stabilization measures (including crane beam stabilization)
2. Power house cavern excavation UNIT 5 and UNIT 6
3. Draft tubes excavation (UNIT 5 and UNIT 6)
4. Transformer hall excavation completion in Units 6 and 5 area
5. Drainage gallery at draft tubes elevation and the relevant access tunnel P37
6. Tunnel T18 (access tunnel to the upper permanent penstock upper chamber)
7. Access tunnel to the lower penstock bends and to manifolds P28
8. Temporary intake
9. Temporary penstocks
10. Concreting of tunnels, powerhouse and transformer hall at units 6 and 5
11. Erection of electromechanical equipment

Key Structures / Activities to be implemented for the dam construction

1. Conveyor tunnels (the part to be completed has an overall length of about of 1800m)
2. Excavation in the Riverbed at the DT outlets
3. Quarrying extraction from quarry N. 15 (about of 20 Mm3) that will be flooded when the reservoir water elevation reaches 1050 m asl (Cofferdam crest elevation).
4. Construction of roads:
    - 31 – 32 (access to RB dam crest)
    - 38 - 37 – 36 – 35 – 39 (access to LB dam crest)
    - 39 – 40 –57 – 58 (access to quarry)
5. Construction of Tunnels:
    - T39
    - T-50
    - T-10A
    - T5

6. Remedial works or completion of Tunnels:
    - T3 and T3'
    - T37 and T37'
    - T2
    - T4
    - T8
    - T6
    - Cables Galleries N1 and N2

Key Facilities to be implemented for the project

1. Rehabilitation of all existing roads including Rogun town access road
2. Batching plants rehabilitation
3. Aggregate plants rehabilitation
4. Rogun town building rehabilitation
5. Fresh water system rehabilitation
6. Sewer system rehabilitation
7. Telecommunication system
8. Removal of scrap materials and equipment located in construction site n.1 (it is the construction site located on the right bank, approximately 2km U/S of the main Dam)

A large number of activities shall start before the River diversion date to avoid accumulating delays for the early generation phase and for the Main dam completion.

It shall be pointed out that most of these activities are foreseen to commence before the Detailed Design / Tender Design will be available. In the implementation schedule, six months allowance has been given for detailed design either before the activity can start or in parallel for some structures.

Contract separation / Packaging definition

Regarding the repartition of batches for the contractors, the Consultant advises the following:

- Package 1: Dam and diversion structures (Civil works and HSS equipment)
- Package 2: Powerhouse and Underground works (Waterways: civil works and HSS equipment)
- Package 3: E&M (Electro - Mechanical Equipment)
- Package 4: TL/SS (Transmission lines and Substation bays)
- Package 5: Roads, Resettlement and Infrastructures Replacement

8.4 Description of the construction schedule

Two main sub-schedules can be envisaged for each of the three alternatives presented in this study:

- a sub-schedule for the construction of the Dams and Generation Facilites
- a sub-schedule for the Early generation phase

These sub-schedules are strictly connected to each other and for both critical paths are found.

The critical path is the most important path in the construction schedule since a variation in the duration of the activities which fall inside it, can prevent the fulfilling of the duration initially established for the project completion and / or the respect of the target dates envisaged.

8.5 Rates of progress of the main activities of the Schedule of Activities

The rates of progress adopted and a brief description of the main activities of the construction schedule are discussed here below.

To reach the above rates of progress the production rate on site are based on:

- Embankment works:
  - Core: 9 months per year, with 3 months of stoppage because of weather conditions (rain, snow and frost)
  - Shells and U/s – D/s protection: 11 months per year out of 12 months because of frost.
- Open works:
  - Aggregate processing 11 months per year because of frost
  - Open air concrete 11 months per year because of frost
- 25 working days per month
- 18 working hours per day

<u>Excavation and concreting of the underground structures:</u>

TUNNELS and CAVERNS

The excavation of all the underground structures will be done with the drill and blast technique.

The rate of progress in the tunnel is assumed equal from 15 m/week. For each tunnel it will be considered that the excavation will be done from two fronts and the excavation of the access to the gates chambers (if any) will be realized in parallel to the excavation of the main tunnel.

The average rate of progress in the power house excavation is assumed to be approximately 3,000 m3/months, in consideration of the reduced working space corresponding to each unit.

For the case of the Diversion Tunnel 3, in view of its importance for the River Diversion, a specific implementation schedule has been prepared, based on the information provided by the Client in respect to the present progress of the works and on the outcomes of the site visit performed by the PoE/WB representatives:

- The upstream adit TT1 has been already constructed, reaching the tunnel upstream stretch at some 330 and 400 m from the inlet portal;

- The downstream adit TT2, which would reach the tunnel in correspondence of the upstream and downstream ends of the sector gates chamber, as well as at an intermediate position, is mostly excavated: only the branches from the main adit alignment are still to be constructed.

- Some stretches of the top heading summing up to about 400 m have been excavated in the tunnel upstream reach.

The above outlined situation has been represented in the sketch which is appended to the report, called “Progress of DT3 construction assumed by the TEAS Consultant for the preparation of the Implementation Schedule”.

Therefore, starting from the above information, the implementation schedule which is attached to the document at hand has been prepared, taking into account the Diversion Tunnel N 3 features proposed in the TEAS studies, as shown in the drawings 40111 “Diversion Tunnels - General Plan” and 40121 “DT3 Tunnel – Profile, Intake, Gates Chamber and Sections”, also attached to this report. The following rates have been considered:

Average tunnel excavation: 12.5 m/week when the adit through which excavation is performed is used for one heading only, 10 m/week if the adit is used for two headings.
For the tunnel upstream reach, where poor rock quality was reported having been found, the excavation completion rates were lowered to 6 m/week (top heading) and 9 m/week (benching).

Lining of Tunnel Current Section: 12.5 m/week.

As for the special structures envisaged along the tunnel, they have been considered separately from the tunnel current activities.

The following times have been taken into account for excavating and constructing those structures:

- some 7 months excavation for the upstream gates chamber (160 m long including transitions);
- some 10 months excavation for the downstream gates chamber (200 m long including transitions);
- some 1.5 to 2 additional months for each of the two faults crossings.

As for the concreting, the following times have been considered:

- some 5 months for the upstream gates chamber;
- some 6 months for the downstream gates chamber;
- some 2 additional months for each of the two fault crossing special structures.

After that, and considering that the gates caverns have been already constructed, the electromechanical equipment has to be installed.

Mobilization and access roads construction (3 months) have been considered to take place before the TEAS validation.

In consideration of the above, a total time of 28 months has been evaluated for the construction of DT3.

SHAFT

The shafts will be done excavated using the raise boring technique. From the top of the shaft a drilling rig will drill a pilot hole to the lower chamber. A reaming bit is then attached to the drill and the bit is pulled up (up-reaming). In the current study it is foreseen that after the raised boring operation the enlargement to the final diameter will be done by drill and blast excavation. For this activity an average rate of 16 m/month is considered.

Concrete Lining for tunnels

For the lining of the tunnel 15 m/week are assumed, while for the concreting of the inlets and outlets 6 months are estimated to be necessary. In addition it is assumed that they will be realized in parallel. For the concreting of each the gates chambers 6 months are envisaged.

The concrete lining of the spillway shaft is done with an advancing rate of 1.5 m/day.

EMBANKMENT

An optimization of the placement rates has been performed following the Paris meeting in September 2013 with GoT. These placement rates have been approved by GoT, WB and PoE following the Paris meeting in October 2013.

The dam is divised in 4 phases to define mean placement rates for each (as shown in the Figure 8-2):

- Cofferdam
- Stage 1 dam
- Phase B (Main dam body)
- Phase C (Top of the main dam)

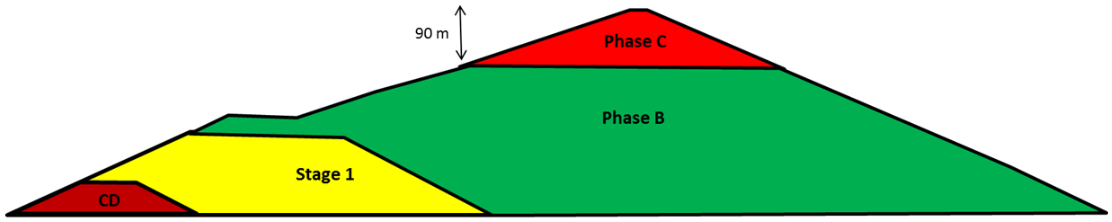


Figure 8-2: Dam phasing

The following placement rates have been taken into account:

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	300 000	300 000	300 000
Stage 1	600 000	550 000	500 000
Phase B	800 000	750 000	700 000

Figure 8-3: Placement rates – Mean per working month [Mm3/month)

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	275 000	275 000	275 000
Stage 1	550 000	504 200	458 300
Phase B	733 300	687 500	641 700
Phase C	320 800	275 000	229 200

Figure 8-4: Placement rates – Mean per month [Mm3/month)

A specific note is presented in Appendix 2, giving more details about the calculations performed.

8.6 Critical paths for the early generation phase

The critical path for the early generation phase is given by the following construction activities:

- *Power House Cavern stabilization works Power House Cavern excavation of UNIT 6*
- *Concreting and Installation of UNIT 6*
- *Power House Cavern excavation of UNIT 5*
- *Concreting and Installation of UNIT 5*

The description of each construction phase is given hereafter:

Power House Cavern stabilization

The breakdown of the main activities required for this task foresees:

- **Detailed Design** Since at the PH stabilization beginning date the tender design will still be in progress, a design for the PH stabilization is needed. The assumed time for this task is 6 months.

- **Mobilization** It is assumed that 3 months are required for providing the local contractor mobilization.

- **Power House Cavern walls support** It is the first work to carry out before proceeding with the Power House excavation. The two power house cavern sides, having an overall surface of about of 15,000 m2, need to be stabilized.
  The assessment of the PH cavern as well as of the stabilization measures have been

completed by June 2013. The conclusions drawn from the modeling work performed by the Consultant led to propose the following set of stabilization measures:

- Installation of rock anchors (80 tons design load tendons) on both the downstream and upstream sidewalls, between the rock dowels already in place above the present excavation level, with the same characteristics as those already installed in the MH cavern, excluding the zone where the MPSP system below described is adopted. Their length is estimated to be 35 m approximately, with a pattern of 2.5 x 2.5 m.
  These stabilization measures will be adopted also for stabilizing the cavern while progressing with the excavation below the present level.

- Stabilization of the highly de-stressed rock mass in the pillar between the MH and TH caverns by installing steel piles (micro-piles) with properly spaced valves, to allow for consolidation grouting at predetermined pressure levels. In this case the Multiple Packer Sleeved Pipe (MPSP) system developed in the early 1990 by Rodio would be adopted. This system is to be implemented along a length of about 115 m starting from the western side of the cavern, corresponding to the Units 5 and 6 area, mostly in siltstone rock, with a pattern of 2.5 x 2.5 m, and extending further to Unit 4, up to the end of the contact between siltstone and sandstone.

It is hence estimated an overall duration of 19 months, where are even included the installation and the removal of the scaffoldings. This duration implies the contemporary presence of two working teams for each sidewall between the MH and the TH for the implementation of the MPSP system and one team at the opposite walls for the installation of the tendons, both at the powerhouse and at the transformers cavern. Concurrently with the walls stabilization measures, also stabilization/strengthening works for making the existing crane concrete beams capable to support the permanent cranes for the erection of the first two Units 6 and 5 have to be carried out. Once duly stabilized and strengthened the cranes beams will be used also for other units. Other works may be necessary, but in the Consultant opinion they are minor compared to the tendons installation operation.

Power House Cavern excavation for UNIT 6.

A volume of about of 10'000m3 needs to be excavated.

The following excavation phases are envisaged for the units:

1. Excavation of the horizontal stretch of the draft tube (from the drainage gallery to the draft tube elbow below the unit)

2. Pit excavation with outlet in correspondence of the draft tube elbow, this shaft will be used to evacuate the excavated material

3. Excavation of the area corresponding to the UNIT and enlargement of the pit to the dimension of the draft tube

It shall be pointed out that the drainage gallery at elevation 932 masl shall be built before the completion of step n.1.

Once the excavation of Unit 6 is complete and stabilization measures have been implemented, the erection of the hydromechanical equipment and stepped concreting of unit 6 will take place.

The steps above described are repeated for the subsequent unit 5. The relevant activities would start after some 11 months from the beginning of unit 6 erection.

The supporting and the monitoring of the walls of the Power House will proceed according and close to the progress of the excavations.

The time for implementing the PH excavation activity for each of the first two units is estimated in 8 months.

It is foreseen to proceed with the excavation of each unit at time in order to limit, as much as possible, convergences of the PH wall which could take place during the UNITS excavation. Only the last two units 2 & 1, which are to be excavated in sandstone, will be excavated at the same time.

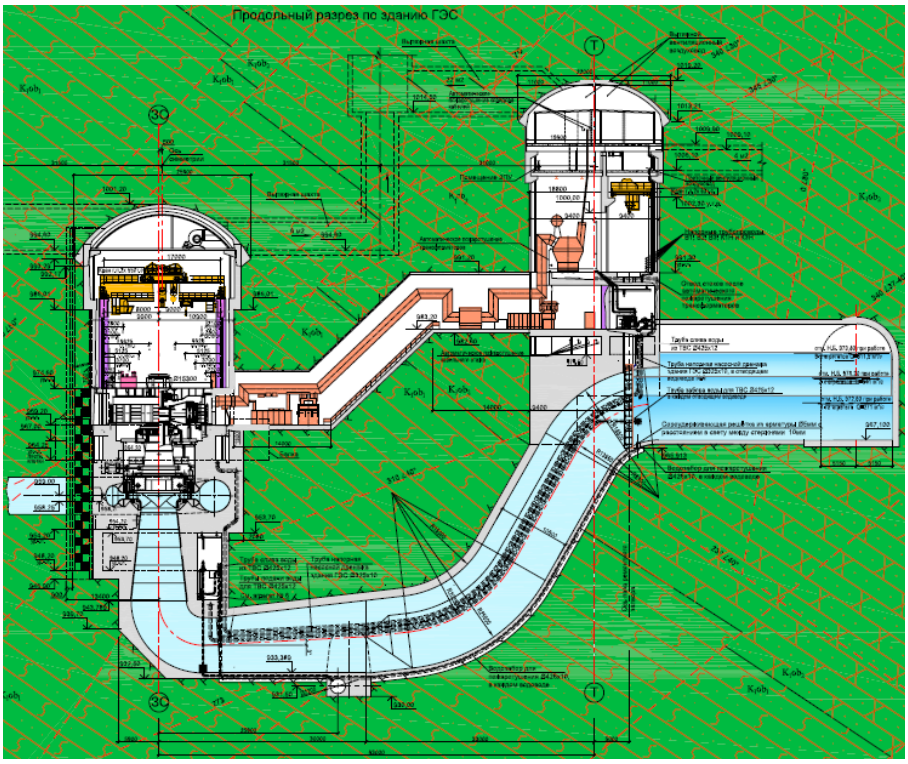


Figure 8-5 : Power house cross section [13]

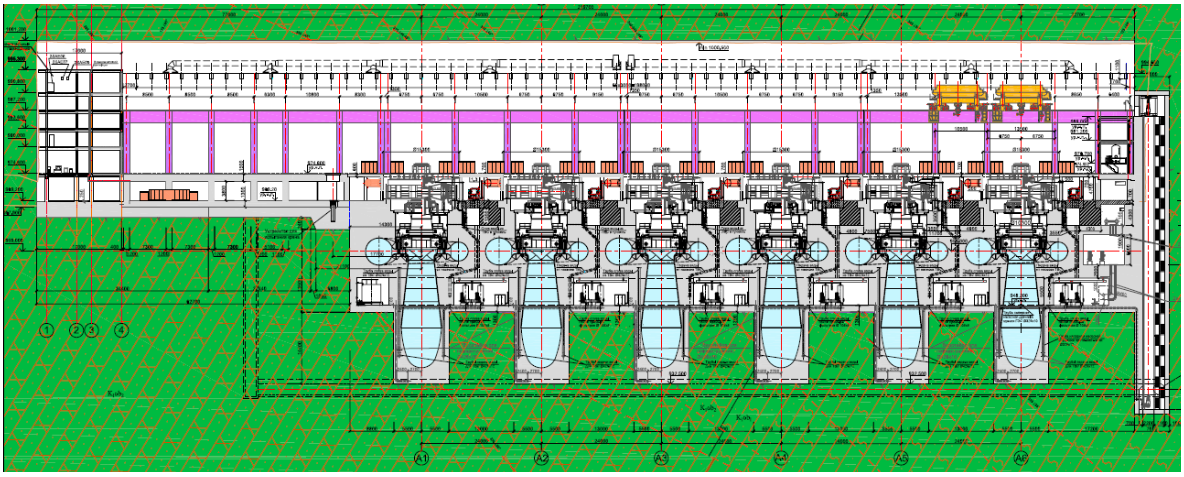


Figure 8-6 : Power house longitudinal profile [13]

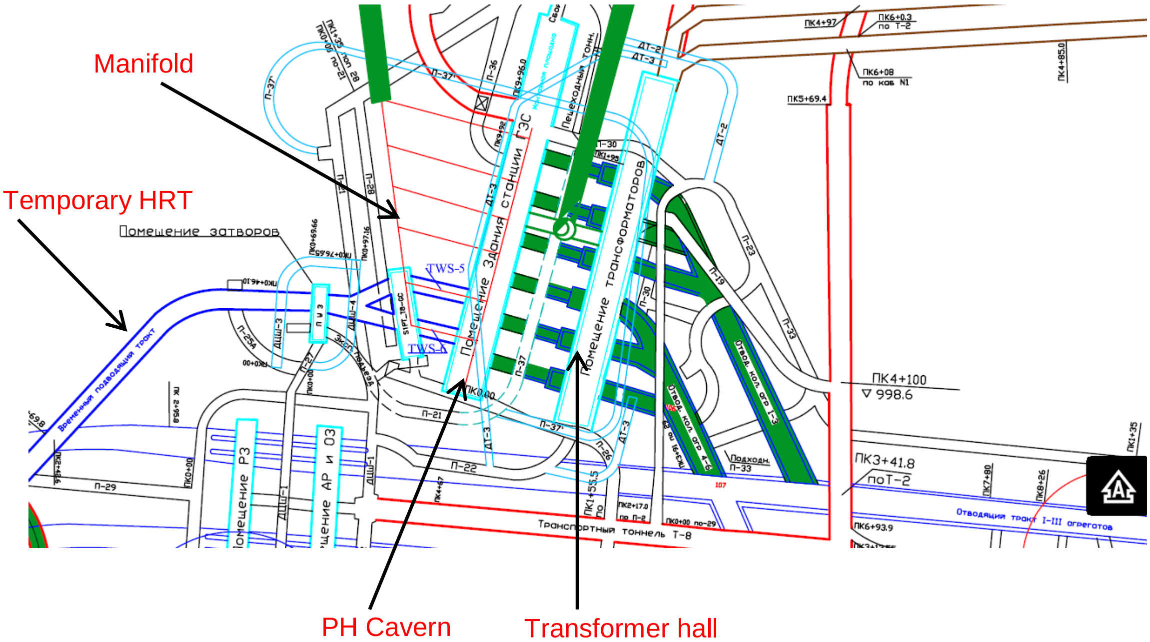


Figure 8-7 : Power house, extracted from the drawings Underground complex 2, HPI 2009

- **Units 6 and 5 Installation** It should be pointed out that unit 6 is located at the opposite of the erection Bay in the Power House. To operate U6 and U5 the control building which is located in the Erection Bay should be constructed. Consequently, concrete works will proceed in U6 as well as in the Control Building simultaneously. For this exercise high hook velocity lifting equipment will be necessary. It has been anticipated that the temporary overhead travelling cranes will be used for the concrete works together with concrete pumps. In addition the permanent overhead travelling cranes are necessary for the installation of the turbines shaft and the rotors. Those cranes and relevant rails shall be installed at the early stages of the construction of the Power House.

  For performing this activity the assumption of 18.5 months is made.

  It is recommended to proceed with the concreting of the UNIT 6 as soon as the excavation of the UNIT 6 is completed. The same recommendations are done for the UNIT 5.

The dry and the wet tests of both units with a global duration of 5 months will follow the erection of the second unit 5. It is mandatory that the permanent overhead travelling cranes shall be ready at the moment of the erection of the heaviest parts of the unit.

It is also mandatory that the following structures are functioning and the following activities already performed for providing the Early Generation of UNITS 6 and 5:

- Cabling erection
- Transformers for UNIT 6 and 5
- Switchyard
- Transmission line
- Stage 1 Dam up to elevation 1110 masl

8.7 Critical paths for the main dam

The critical path for the main dam is given by the following construction activities:

- *Construction / Rehabilitation of transport facilities*
- *Core foundation abutment excavation*
- *Core foundation excavation below elevation 1000 masl*
- *RCC slab located under the core*
- *Core / Embankment filling*

Here after a breakdown of the main activity required for these tasks is given.

- *Construction / Rehabilitation of the key transport facilities*
- *Core foundation abutment excavation:* the core abutment excavation has a total volume of about of 1.8 hm3. In addition, the slopes of the core abutments are very steep making the excavation difficult to perform. The construction of the temporary roads will be difficult as well. For the higher part of the abutments excavation rock climbers should be foreseen. The time for performing this task considering both abutments excavated in parallel is 30 months.
- *Core foundation excavation below elevation 1000 masl:* the core excavation has a volume of about of 0.53 hm3 and requires approximately 5 months.
- *RCC slab locate under the core*: the grouting galleries will be embedded into concrete slab, which has an overall volume of about of 0.35 hm3 and requires 7 months to be realized.
- *Embankment filling* the placement of the embankment of the main DAM (where are not considered both the Cofferdam and the Stage 1) takes an overall time of 135 months. Hence the average placing rate for the dam is about of 0.5 hm3/months.

8.8 Synthesis of the main results of the implementation schedules of the three envisaged layout

This paragraph deals with the summary of the construction planning for the three alternatives.

The timing necessary to reach the main milestones considered in the implementation schedule and the most important dates (i.e. cofferdam completion, Stage 1 completion, etc.) are given for the three alternatives. The time is counted starting from the TEAS validation date.

KEY DATES in months counted from the TEAS validation and GoT decision to proceed with the Project

	Alternative 1290 m asl	Alternative 1255 m asl	Alternative 1220 m asl
TEAS Validation and GoT decision to proceed	0	0	0
River diversion date	28	28	28
End of cofferdam construction	36	36	36
End of stage 1 dam construction	58	53	49
Commissioning of U6 Temp.	73	73	82
Commissioning of U5 Temp.	75	75	84
End of Erection U4	85	85	85
End of Erection U3	98	98	98
End of Erection U2	112	112	112
End of Erection U1	112	112	112
Minimum reservoir level reached	112	94	80
Temp. U5 and U6 shut down	117	114	
Commissioning of U4	115	101	101
Commissioning of U3	117	114	114
Commissioning of U2	119	116	116
Commissioning of U1	121	118	118
Commissioning of U6	123	120	
Commissioning of U5	127	122	
End of dam construction	163	142	120

Table 8-1 : Summary of the main project milestones of the 3 envisaged alternatives

Here below it is given the table which deals with the duration of the pre-contract and the main contract foreseen for the civil works for the three alternatives:

KEY DATES in months counted from the TEAS validation and GoT decision to proceed with the Project

	Alternative 1290 m asl	Alternative 1255 m asl	Alternative 1220 m asl
Pre-contract duration	24	24	24
Main contract duration	139	118	96

Table 8-2 Civil works: pre-contract and main contract duration for the 3 envisaged alternatives

It shall be stressed that the above given values include the overlapping which takes place between the pre-contract and Main Contract.

9 CONCLUSIONS AND RECOMMENDATIONS

This report deals with the Project implementation schedule of the three alternatives worked out by the Consultant, where three full supply reservoirs are foreseen with levels at elevation 1290, 1255 and 1220.

The detailed analyses of these three Project Implementation Schedules are based on the data made available by Client and/or obtained during the site visits made by the Consultant and on some assumptions derived from the Consultant’s experience in previous large scale hydro projects. The level of details reached by the present study is adequate within the frame of the Technical and Economic Assessment of the Project carried out by the Consultant.

In the present study, alternative FSL 1290 is detailed, while for the other two alternatives, being very similar to the first one, only the main results are given and compared with alternative FSL 1290.

Two critical paths are found in each alternative: one for the dam and one for the early generation phase. These critical paths are detailed in the present report and their links with the key activities are given as well.

The main results are summarized as follows:

- The **river diversion** starting date is controlled by the construction of diversion tunnel DT3, which was not foreseen in the Alternative proposed by HPI in 2009. The construction of this DT3 tunnel (28 Months) allows the river diversion in two wet seasons, i.e. in October 2016. The material placement for cofferdam construction can be anticipated during the four months of the wet season (cf. Appendix 1 - River closure optimization of cofferdam construction).

- The **Early generation dates** (Commissioning of UNITS 5 and 6) foreseen by HPI cannot be confirmed under the current assumptions and with the actual status of the Works. This is not only due to the longer time needed for the River Diversion but also due to the PH cavern stabilization works as recommended in Phase I report.

- In order to reduce the overall duration of the Construction of the Project, it has been anticipated to have some permanent works as well as rehabilitation works of roads and site installation carried out under a Pre-Contract agreement with local Contractor during the tendering period of the Main Civil Contract.

- In order to accelerate and facilitate the procurement and the installation of the EM equipment of the Early Generation phase, the EM works have been split in two separate Contracts. The first one related to the Early Generation stage is directly negotiated with the former supplier of Units 5 and 6 and consists of the delivery and the installation of the components of Units 5 and 6 and of the relevant auxiliary facilities which have not yet been delivered to site since the early Nineties.

  The second one is subjected to an International Tender and consists of the Supply, Delivery and Installation of the complete equipment of Units 1, 2, 3 and 4 together with the relevant auxiliary facilities.

- A detailed analysis of the dam construction has been prepared by the Consultant in order to derive placement rates for the dam fill in accordance with standard practice in rockfill projects of such a magnitude (cf. Appendix 2 – Optimization of placement rates for Rogun dam).

The implementation schedules of the 3 alternatives presented in this report have been used to derive the disbursement curve of each alternative that is incorporated in the Financial and Economic Analyses of the project alternatives.

As a final remark, the present study allows to depict well the critical paths of the Project (paragraph 9) and to assess the main constraints, construction sequences and interferences envisaged for the design and implementation phase. Due to the importance of these aspects for the realization of the Project, to the very challenging nature of the Project and of its tight scheduling, the Consultant recommends to put into place all efforts to carefully select experienced and highly qualified Main Contractor/Contractors (and eventually Sub-Contractors) as well as Designers and Owner Engineers.

ANNEX 1 – RIVER CLOSURE OPTIMIZATION OF COFFERDAM CONSTRUCTION

TECHNO-ECONOMIC ASSESSMENT STUDY FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT

PHASE II: PROJECT DEFINITION OPTIONS

Volume 4: IMPLEMENTATION STUDIES

Chapter 1: Implementation schedule and construction method

Annex 1: Schedule Optimization

March 2014

A	13/11/2013	First Emission	VLI	ALA	NSA

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

The aim of this note is the optimization of the river closure in order to reduce the placement rate required for cofferdam construction The volume of the cofferdam, 2.4 Mm3, must be placed between October and May (8 Months) corresponding to the period of low water levels. This induces a placement rate of 0.3 Mm3/Month: a high rate considering the others activities which have to be performed at this initial stage of construction.

In order to reduce this placement rate, a hydraulic study has been made to evaluate the possible volume which can be placed in advance during the period of high water levels. This volume depends on the contraction and the water elevation induced by narrowing the river cross section.

2 REFERENCES

1. **TEAS.** *Phase II Report. Volume 3, Chapter 3, Appendix 3: Flood Managment During Construction.* 2013.

2. **Hager, Willi H. et Schleiss, Anton J.** *Traité de Génie-Civil, EPFL: Volume 15. Constructions hydrauliques : Ecoulements stationnaires. .* 2009.

3. **Chow, Ven Te.** *Open Channels Hydraulics.* 1959.

4. **Khaldre, S.V Izbash and Kh.Yu.** *Hydraulic of River Channel Closure.* s.l. : The Butterworth Group, 1959.

3 METHODOLOGY

The river closure with cofferdam and diversion tunnels DT1 and DT2 are represented in Figure 3-1.

Figure 3-1: Plan View (Google earth).

The cofferdam crest level (1) is 1050 m asl, and the total volume is about 2.4 Mm^3.

The cofferdam construction has to be finished before May. The construction starts in October (beginning of low water level season), therefore 8 Months are available leading to a placement rate of 0.3 Mm^3/Month. This rate is very high according to the various works necessary in the dam site at this stage. Consequently, it has to be reduced by anticipating the river closure before October (during the high water level season).

In this way, the level 10xx (2) (corresponding to the level of anticipating closure) has to be determined.

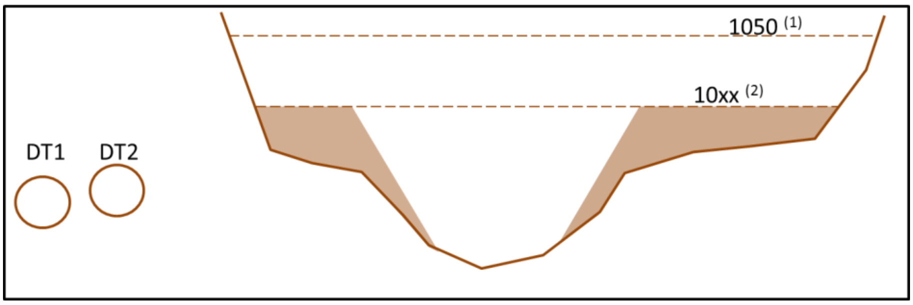


Figure 3-2: River Cross Section.

The total discharge is the sum of discharge through the diversion tunnels DT1 and DT2, and the discharge through the cofferdam cross section. The cofferdam cross section depends on the factor m (contraction ratio).

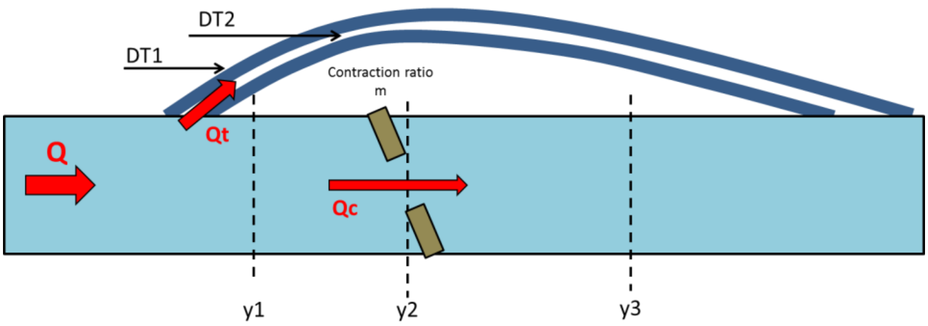


Figure 3-3: Flow Representation - Plan view.

$$Q = Qt + Qc$$

$$Qt = QDt1 + QDt2$$

With:

- Q: Total discharge, [m^3/s]
- Qt: Discharge trough diversion tunnels DT1 and DT2, [m^3/s]
- Qc : Discharge trough cofferdam section, [m^3/s]
- m: Contraction ration such as $m = 1 - Ah/Ai$, [-]
- Ai: Initial section, without contraction, [m²]

- Ah : Hydraulic section contracted, [m²]

The contraction of hydraulic section induces an increase of the water level upstream of the cofferdam. This raise limits the anticipation of construction, because the water level must be lower than the level 10xx of contraction. Moreover, an important increase could flood prematurely the areas upstream, and disturbs the works.

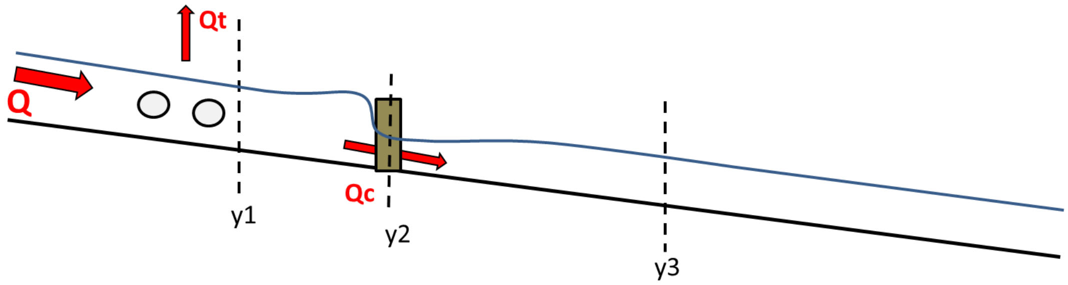


Figure 3-4: Flow Representation - Longitudinal section.

The return period flow considered for the cofferdam is 100 years, corresponding to a discharge of 3900 m3/s. For the calculation a discharge $Qc = 4000\, m3/s$ is considered (this criteria is conservative).

Therefore, the methodology consists in two steps of calculation:

- Determine the water elevation upstream to the cofferdam for each contraction. For that, the head losses have been evaluated in order to calculate the upstream water level with a downstream water level equal to the normal water level.

- Calculate the volume of material for each contraction, in order to evaluate the reduction of the placement rate during the 8 months of low water level. A three-dimensional model (Rhino 3D Software) has permitted to calculate precisely the volumes of materials, considering the complex geometry of the cofferdam (cf. figure below)

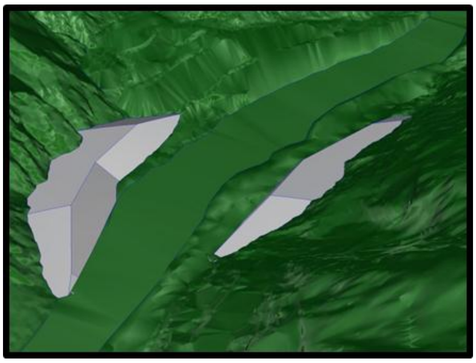


Figure 3-5: Three-dimensional model (Rhino 3D)

4 CALCULATION

4.1 Hydraulic study

4.1.1 Methodology and definitions

The first step of calculation consists in determining the water elevation for each contraction. The methodology is detailed in Figure 4-1.

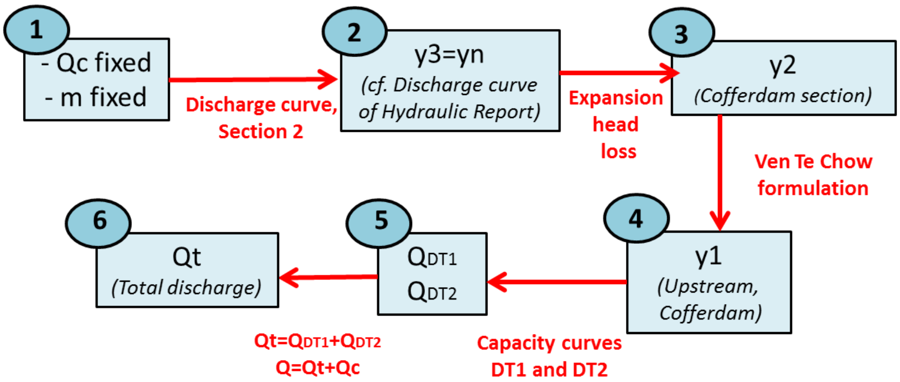


Figure 4-1: Hydraulic study methodology.

A discharge Qc and a contraction ratio m fixed induce a water level upstream and a total discharge Q.

The formulas used for the hydraulic calculation are:

- **Discharge curve:** (cf. (1), paragraph 2.1)

  The Water Elevation H [m a.s.l] is formulated as a function of Q:

$$H = 982.1 + 1.24 * Qc^{0.26} \rightarrow H = GWL + y3.$$

  With:

  - y3: Water depth for a discharge Qc, [m]
  - GWL: Ground Water Level in section 2. GWL=982.1 m asl.

- **Expansion head loss**: (cf. (2), page 38).

  The expansion after cofferdam contraction induces a head loss ΔHe formulated as:

$$\Delta He = \xi e * \frac{V^2}{2 * g}$$

  With:

  - ξe: Head loss coefficient referring to expansion loss, [-].
  - V: velocity in contracted section S2, [m/s]

- g=9.81 m.s-2

- **Ven Te Chow formulation:** (cf. (3), pages 475 to 493).

The water elevation Δh [m] induced by the contraction is formulated as:

$$\Delta h = \frac{V2^2}{2 * g * C} - \alpha 1 * \frac{V1^2}{2 * \mathrm{g}}$$

With:

- V2: Velocity in contracted section S2, [m/s]
- α1: Kinetic coefficient, considered equal to 1.1
- V1: velocity upstream to the cofferdam, section S1, [m/s]
- C: over-all coefficient of discharge, [-]

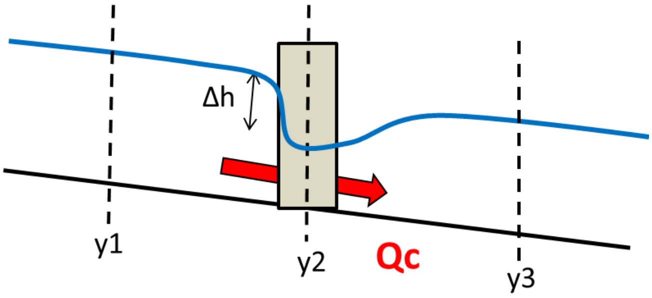


Figure 4-2: Definition of Δh.

Discharge Coefficient C

The calculation of discharge coefficient depends on various coefficients described in Figure 4-3. These coefficients are function of the contraction ratio m and the geometry of the contraction. The contraction considered is Type III with and angle $\phi = 30°$ between the cofferdam axis and the transversal axis of the hydraulic section.

$$C = C' K_F K_r K_W K_\phi K_y K_x K_e K_t K_j$$

Figure 4-3: Discharge Coefficient C, (3).

Some coefficients do not interfere with the calculation performed and therefore are considered equal to 1. The resulting formula is:

$$C = C' * K\phi * Kx$$

With :

- C' : Coefficient of discharge (standard value), [-]

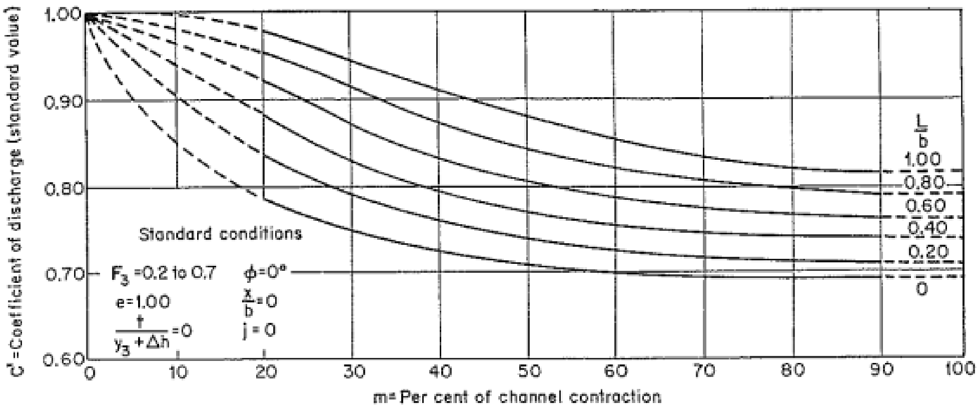


Figure 4-4: Discharge coeffcient C', (3).

- $K\phi$: Coeffcient function of the angle between the cofferdam axis and the transversal axis of the hydraulic section, [-]

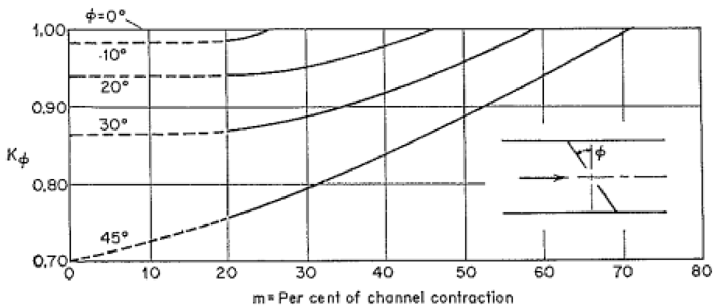


Figure 4-5: Kϕ coefficient, (3).

- Kx : Coeffcient function of the ratio x/L. Kx has been considered constant and equal to 1.05, [-]

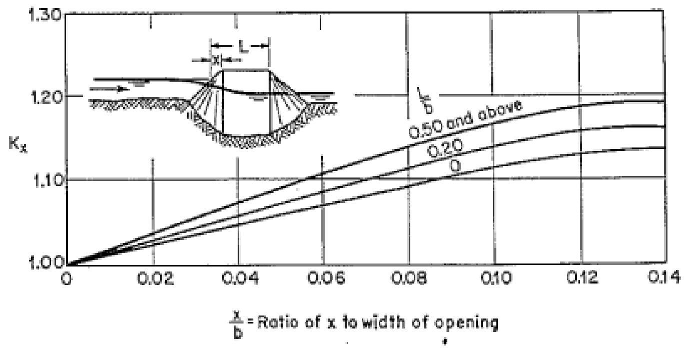


Figure 4-6: Kx coeffcient, (3).

Figure 4-7 summarizes the calculation of C', $K\phi$, Kx, and the global coefficient of discharge C.

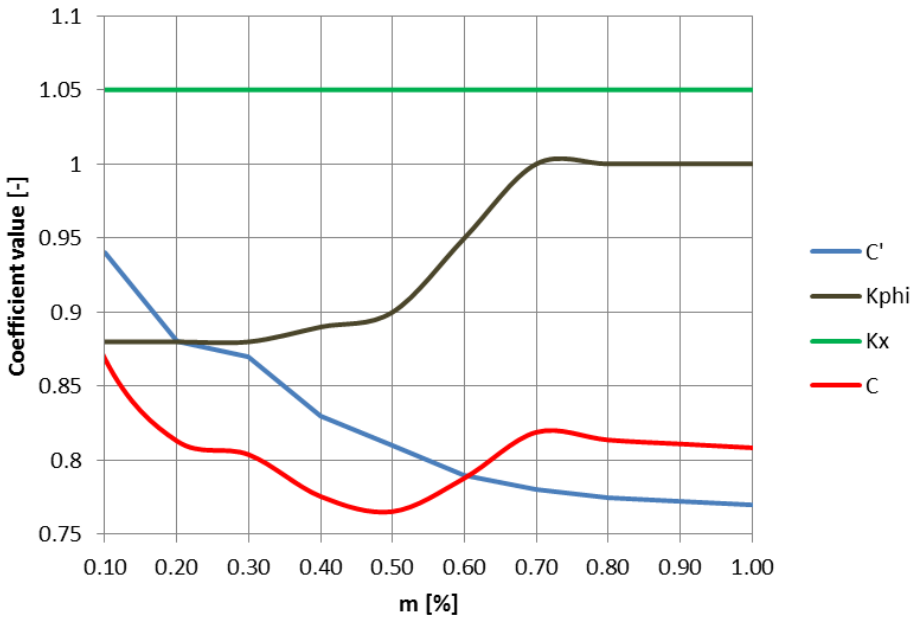


Figure 4-7: Discharge coeffcients C, C', Kϕ and Kx.

- **Discharge capacity curves of DT1 and DT2**

The discharge capacity QDti [m^3/s] of each diversion tunnel DTi is formulated as the minimum value of discharge between orifice and spillway formulation:

$$QDTi = MIN(k * (H - Ho)^{a})$$

The parameters h, Ho and a are explicated in Table 4-1.

Table 4-1: Parameters for Discharge Capacity Curves of Diversion Tunnels DT1 and DT2

	Q, Orifice			Q, Spillway		
	k	Ho	a	k	Ho	a
DT1	215.0	992.82	0.5	13.5	990.00	1.5
DT2	285.0	995.19	0.5	19.0	1002.00	1.5

4.1.2 Results of hydraulic study

It is shown in Figure 4-8 that the upstream water level is not influenced for the contraction ratio m lower than 0.4, i.e. it is possible to place materials in advance in the river and then to contract the section up to m=0.4.

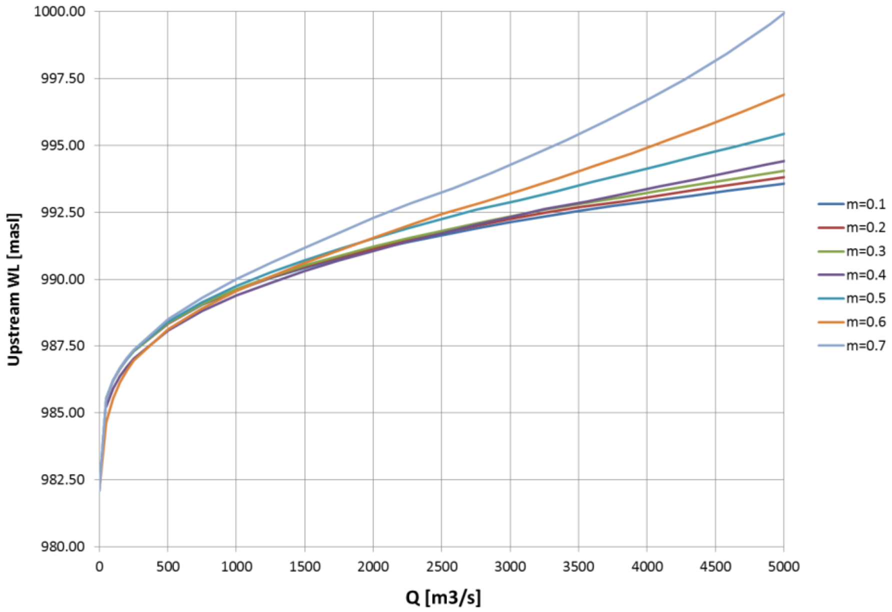


Figure 4-8: Upstream water level function of discharge and contraction.

The parameter m is useful using the Ven Te Chow formulation. However, it is not directly linked with the volume of material. Then the parameter A is defined as:

$$A = 1 - bc/bi$$

With:

- bi: bottom width of initial section, $bi = 125m$.
- bc: bottom width of contracted section, [m]

The simplified hydraulic cross section is defined in Figure 4-9.

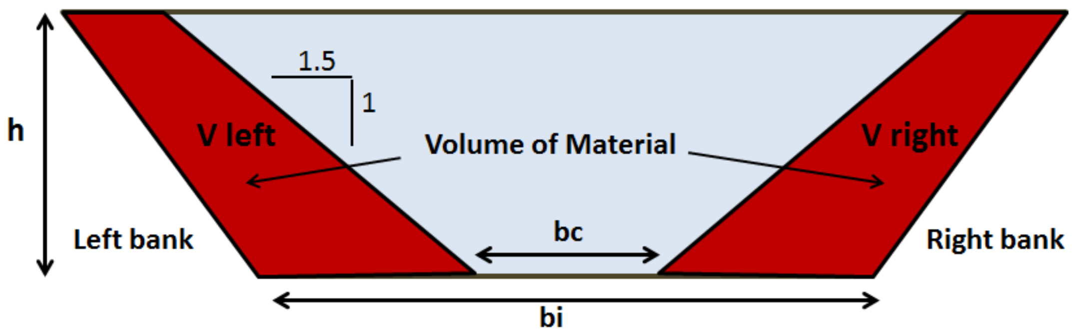


Figure 4-9: Hydraulic cross section.

With $Qc = 4000\,m3/s$, the water level is about 995 m asl up to A=0.4. For higher ratio A, the upstream water elevation increases greatly.

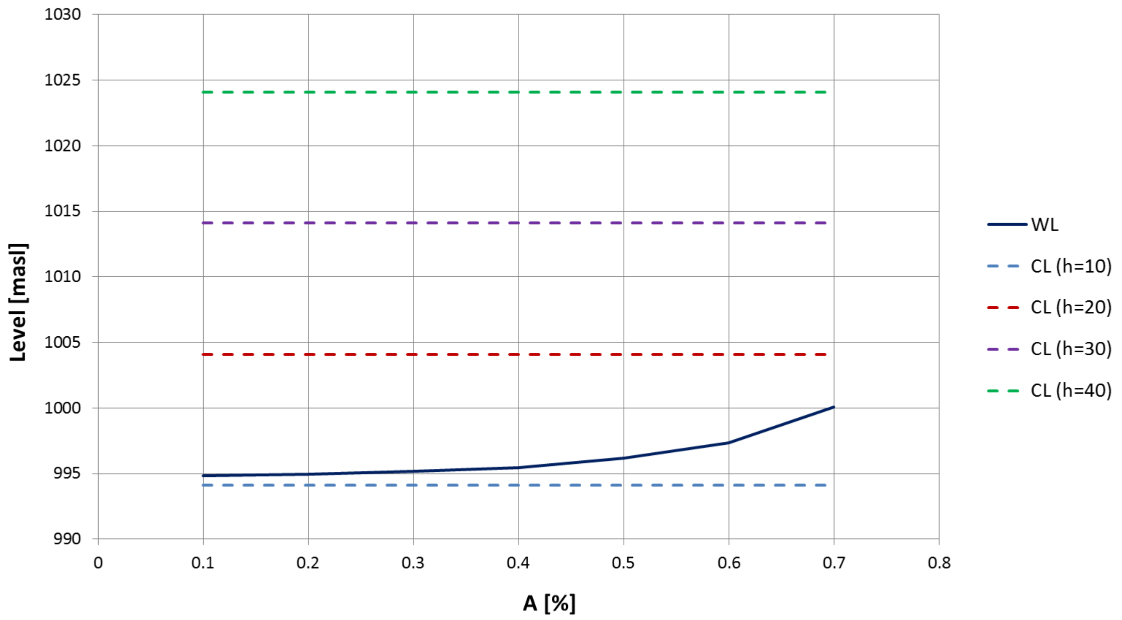


Figure 4-10: Water Level (WL) and Crest level (CL) function of ratio A. Qc=4000 m^3/s.

The total discharge $Q = Qc + Qt$ depends also of the contraction. Figure 4-11 shows the values for Qc=4000 m3/s and A variable between 0.1 and 0.7. In effect, for a discharge Qc fixed, the total discharge raises with the contraction ratio A.

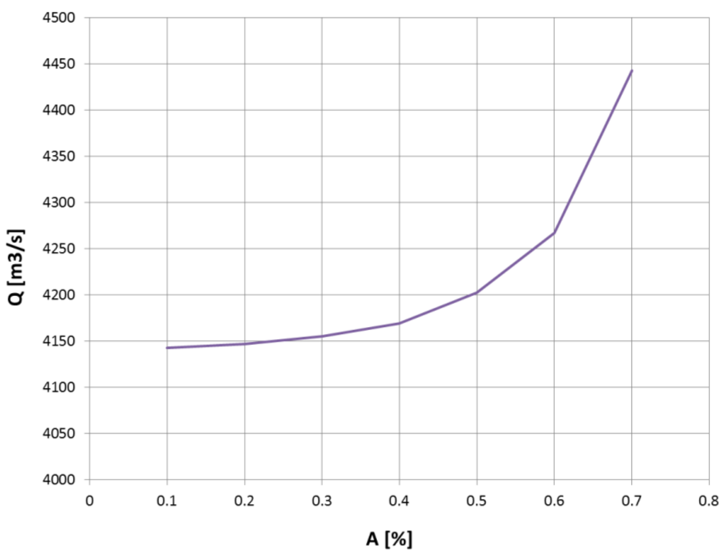


Figure 4-11: Total discharge Q function of ratio A. Q=4000 m^3/s.

Moreover, the velocity in the cofferdam cross section increases also with the contraction ratio A. For A=0.4, the velocity V_2=4.5 m/s. In order to avoid the transport of material by the flow, the size of materials has to be chosen adequately (a riprap protection placed in the riverbed can be useful to protect it against erosion).

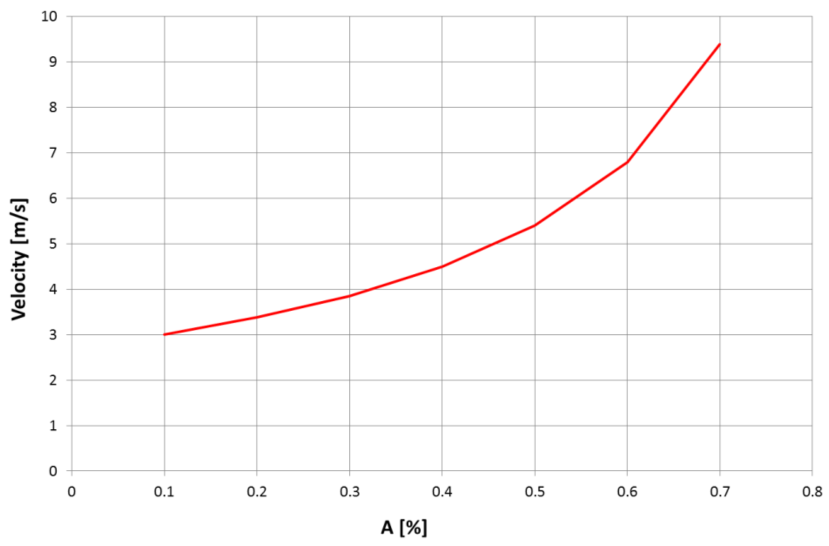


Figure 4-12: Velocity at Cofferdam section function of ratio A. Qc=4000 m^3/s.

To conclude, the first calculation step of shows that it is possible to reduce the hydraulic section up to the ratio A=0.4. The second calculation step is to determine the corresponding volume (presented in the next paragraph).

4.2 Material placement study

4.2.1 Definitions

The volume of material depends on the contraction level and the ratio A (defined in the previous paragraph). Figure 4-13 represents the cross section on the dam axis. The figure shows that an important volume can be placed in the right bank without influencing the hydraulic section.

The calculation has been performed with a three-dimensional model developed with Rhino software. The contraction has been simulated in the right bank and the left bank, in order to observe clearly where the placement rate reduction is the more efficient.

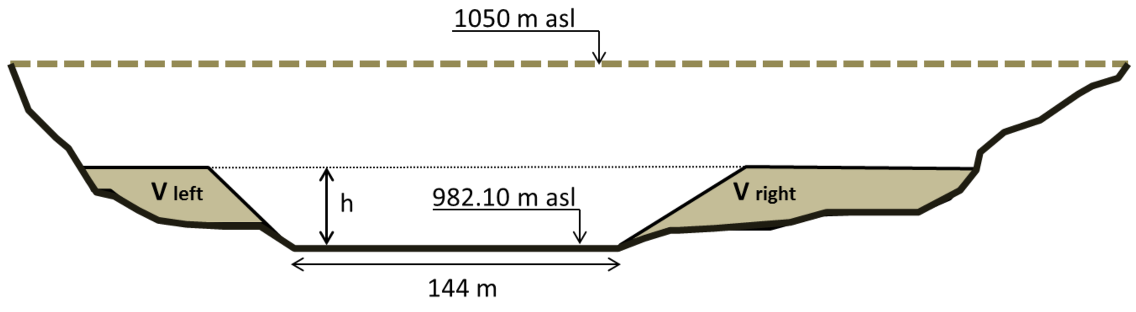


Figure 4-13: Typical Cross section of the river and reduction.

4.2.2 Results of material placement study

Figure 4-14 gives the total volume of cofferdam function of the elevation, and up to the crest elevation 1050 m asl. The total volume is about 2.4 Mm^3.

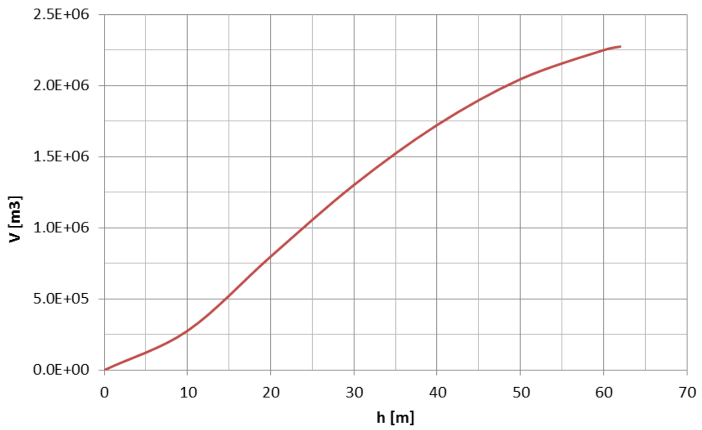


Figure 4-14: Volume of Cofferdam function height.

Figure 4-15 and Figure 4-16 correspond to the volume of material placed respectively in the left bank and the right bank, function of the contraction ratio A.

It is shown that a volume can be placed in advance, (especially in the right bank without contract the hydraulic section (A=0).

For a contraction ratio A=0.4, it is possible to place 0.8 Mm3 without influenced the water elevation.

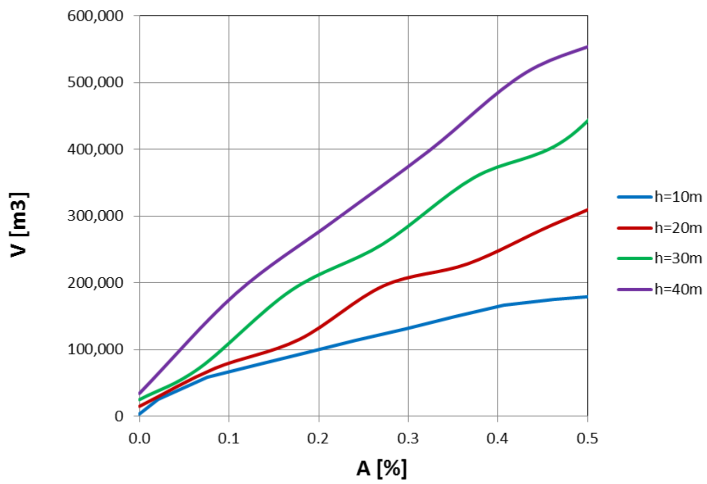


Figure 4-15: Volume of material in the Left Bank, function of ratio A.

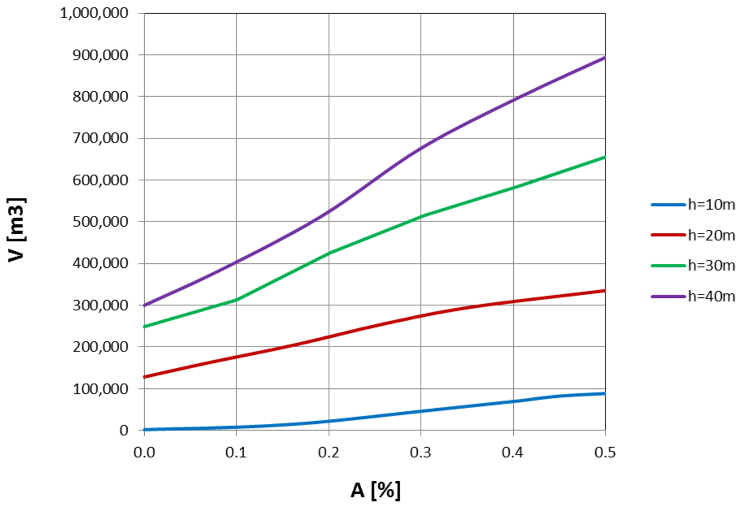


Figure 4-16: Volume of material in the Right Bank, function of ratio A

Figure 4-17, Figure 4-18 present briefly the methodology to contract the river section, by creating a protected area where the material placement is thereafter possible. This method is generally used for river diversion and must be studied in details for the next phase of the project.

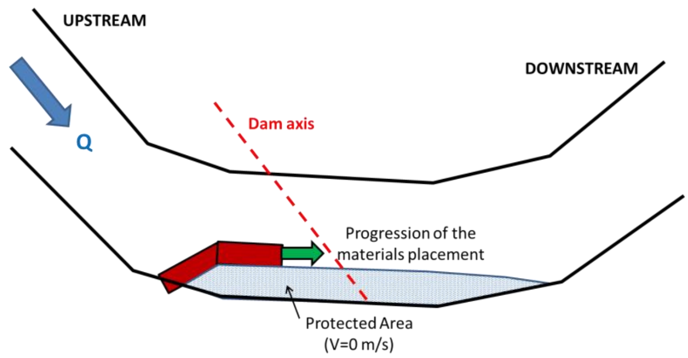


Figure 4-17: Plan view - Contraction methodology, first stage.

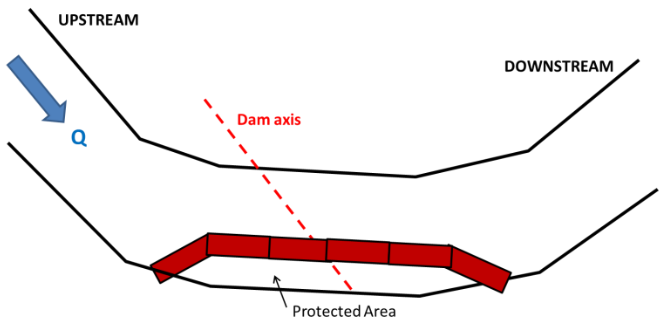


Figure 4-18: Plan view - Contraction methodology, second stage.

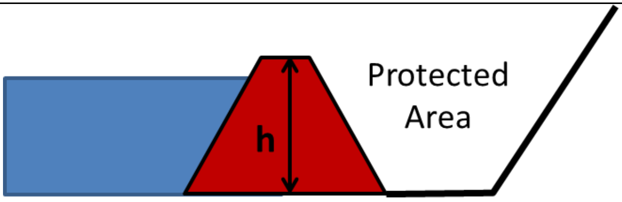


Figure 4-19: Cross section - Contraction methodology, second stage stage.

5 CONCLUSION

The anticipation of contraction for river diversion is a process often used for dam construction in order to reduce the placement rate during the low water elevation season

This note shows that it is possible to place a minimum of 0.8 Mm3 between May and October (4 months), and then place 1.6 Mm^3 between October and May (8 months) of the next year. Then the mean placement rate can be reduced from 0.3 Mm3/Month to 0.2 Mm^3/Month. The river closure has to be made from the right bank to the left bank, considering the important volume of material which can be placed without influencing the flow.

This gain on the placement rate is significant. The study shows that this methodology is possible and must be used for river closure in order to complete the works on time.

ANNEX 2 – OPTIMIZATION OF PLACEMENT RATES FOR ROGUN DAM

TECHNO-ECONOMIC ASSESSMENT STUDY
FOR ROGUN HYDROELECTRIC CONSTRUCTION PROJECT

PHASE II: PROJECT DEFINITION OPTIONS

Volume 4: IMPLEMENTATION STUDIES

Chapter 1: Implementation schedule and construction method

Annex 2: Placement Rates Optimization

August 2014

B	13/08/2014	Final version	VLI	LBO	LBO
A	13/11/2013	First Emission	VLI	ALA	NSA

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

Following the Paris meetings (September, 16-20), the aim of this note is the optimization of the implementation schedule and especially for placement rates assumed previously for Rogun dam construction.

The justification of the placement rates is organized in three parts:

- Analysis of the access roads, provided by the Client during the Paris meetings (September 16 to 20).
- Dam references, in order to show that this placement rate is credible.
- The approval/analysis of a specific expert in construction of rock fill dams

2 REMIND OF FIRST SUBMITTED VERSION (2013, MAY)

- **3 Schedules have been prepared**: one for each dam crest elevation (1300, 1255 and 1220 m a.s.l)
- **The starting date was:** June 2013
- **The river diversion was**: October 2017
- **2 critical paths were observed:**
  - ✓ Main dam:
    - Construction / Rehabilitation of transport facilities
    - Core foundation excavation (abutment, river bed)
    - RCC slab located under the core
    - Core / Embankment filling
  - ✓ Early generation:
    - Power House Cavern stabilization works
    - Power House Cavern excavation of UNIT 6
    - Concreting and Installation of UNIT 6
    - Power House Cavern excavation of UNIT 5
    - Concreting and Installation of UNIT 5

Note: River diversion and availability of DT3 is not on the critical path for commissioning of U5 and U6 for early generation.

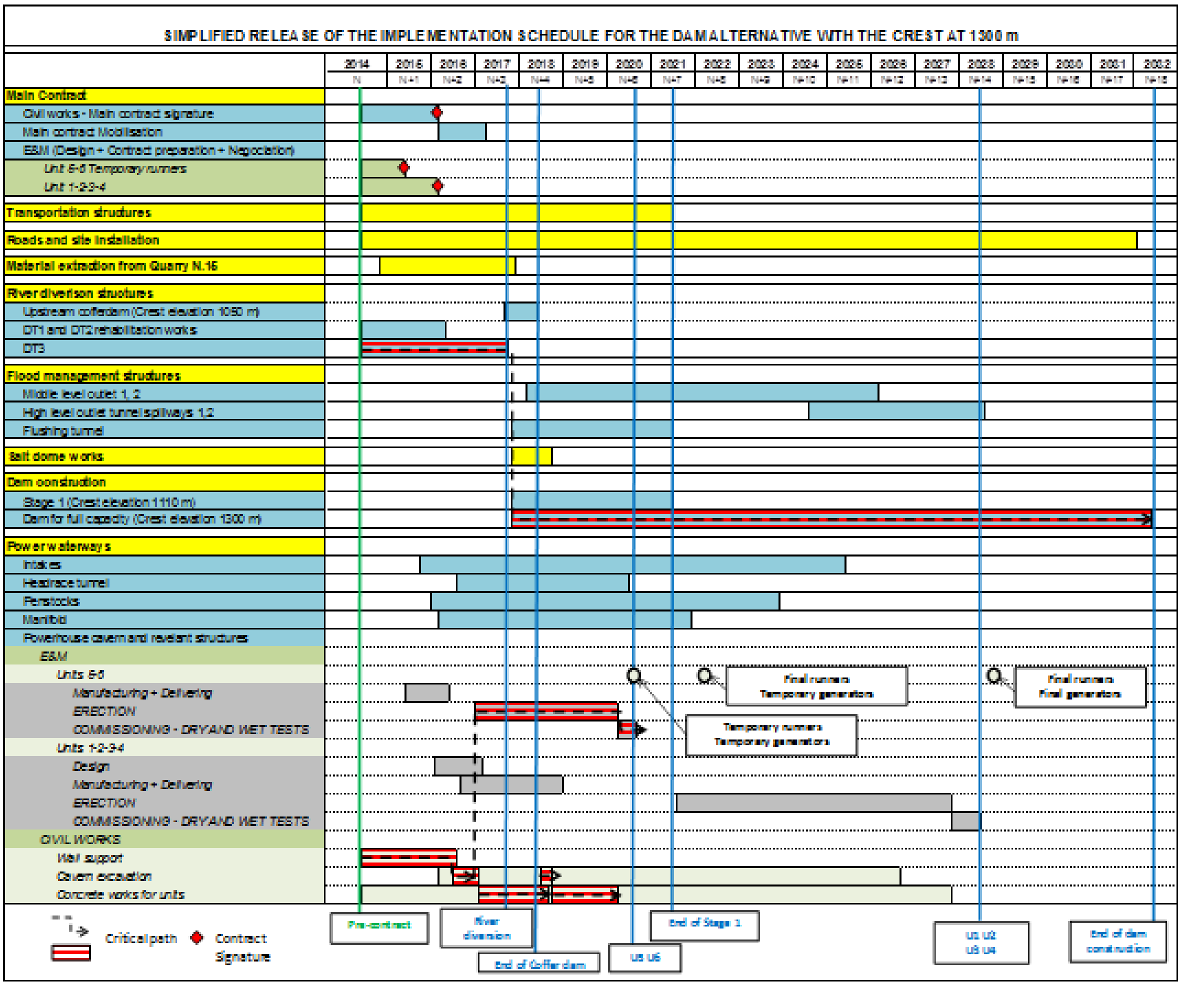


Figure 1: Simplified Schedule – First Version (2013, May)

The critical aspects to define placement rates are:

- ✓ The placing area for materials at each elevation
- ✓ The accesses to transport materials and equipment
- ✓ The climate/Conditions on site
- ✓ The equipment used on site

The rates of progress defined were:

- ✓ 11 working months per years for shells, U/s and D/s protection
- ✓ 9 working months for the Core
- ✓ 25 working days per month
- ✓ 18 working hours per day

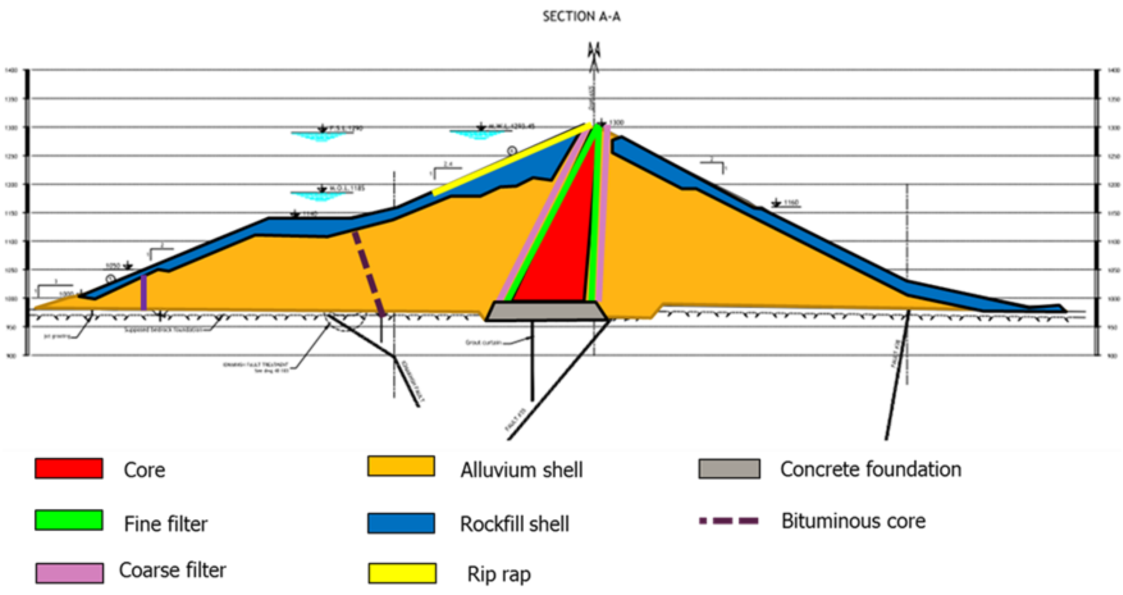


Figure 2: Cross section, material definition

	Material	FSL 1290	FSL 1255	FSL 1220
1	Alluvium shell	43.06	33.18	18.92
2	Rockfill shell	17.37	12.48	9.35
4	Core	6.99	5.10	3.71
5	Fine Filter	2.47	1.35	0.75
6	Coarse Filter	3.15	2.03	2.00
7	Rip rap	0.55	0.37	0.30

Figure 3: Quantities simulated

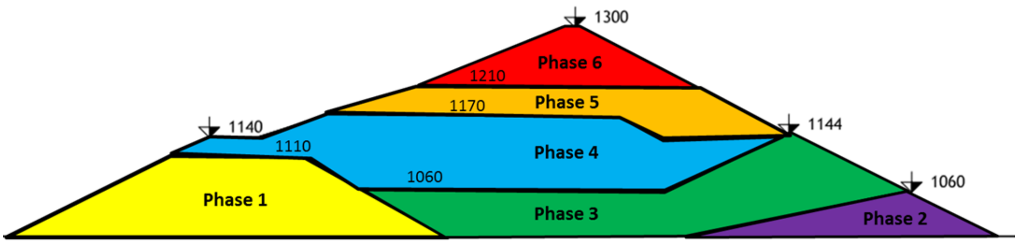


Figure 4: Dam Phasing (cf. Cost Estimate report)

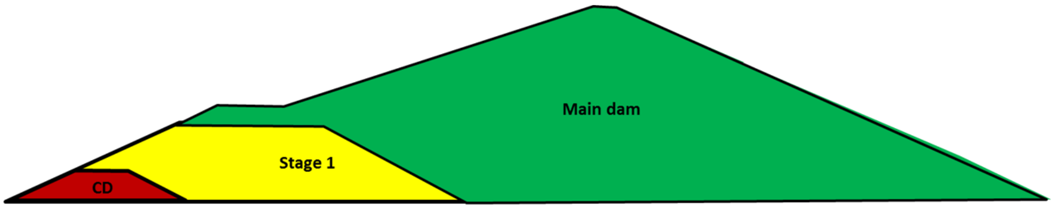


Figure 5: Dam Phasing used for Placement rate (2013, May)

A critical aspect observed from the implementation schedule is the dam construction. Initially, the mean placement rates (per month for one years) assumed by the Consultant were:

- Cofferdam: 290 000 m^3/Month
- Stage 1 dam: 300 000 m^3/Month
- Main dam: 455 000 m^3/Month

Mean placement rate per Month for 1 year
[m3/ month]

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	*290,000*	*290,000*	*290,000*
Stage 1	*300,000*	*300,000*	*300,000*
Main dam	*455,000*	*455,000*	*455,000*

Table 1: Mean Placement rate per month for one year (2013, May).

Mean placement rate per Working Month
[m3/ Working month]

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	*316,364*	*316,364*	*316,364*
Stage 1	*327,273*	*327,273*	*327,273*
Main dam	*496,364*	*496,364*	*496,364*

Table 2: Mean Placement rate per working month (2013, May).

It was proposed to revise this placement rate in order to reduce the duration of construction.

It is also important to remind that the placement rate assumed by the Consultant were in agreement with the rate assumed by HPI 2009 and the others previous studies. It was requested to study more in details possible ways to increase the placement rates in order to reduce the overall construction time of each alternative.

The keys dates are reminded in Table 3.

Table 3: Summary of the main project milestones of the 3 envisaged alternatives (2013, May).

KEY DATES in months counted from the TEAS validation

	ALT. Fsl 1290	ALT. Fsl 1255	ALT. Fsl 1220
TEAS validation	0	0	0
River Diversion date	40	40	40
End of cofferdam construction	48	48	48
Commissioning of UNIT 5 and 6 (Early gen. phase)*	73	73	73
End of stage 1 dam construction	85	76	67
Commissioning of the UNIT 3 and 4*	163	140	115
Commissioning of the UNIT 2 and 1*	167	144	119
End of dam construction	215	180	139

The optimization of schedule may have an important impact on the energy generation. The Figure 6 reminds the calculation made in the first version of Reservoir Operation. It is shown that the water share limitation can also limit the final unit installation and reservoir filling. This factor will be duly taken into account in the analysis.

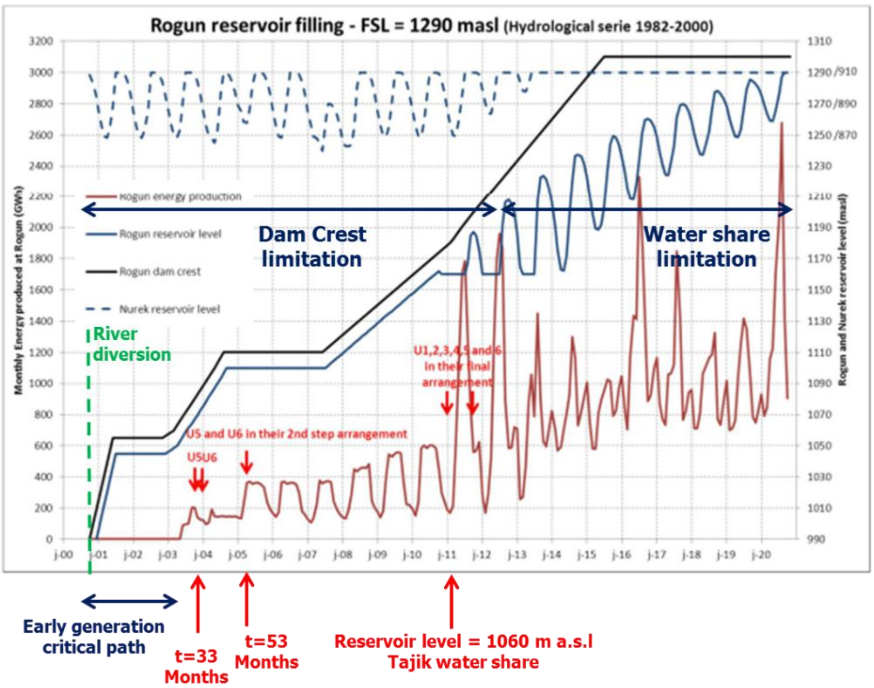


Figure 6: Energy generation (Alternative 1290m a.s.l).

3 CRITICAL ASPECTS TO DEFINE THE PLACEMENT RATE

Various parameters have to be taken into account to define the placement rate:

- The placing area which can limit the movement of the equipment on dam site
- The accesses are often the key of success to complete the works quickly, and therefore have to be adapted in terms of width, number, type and maintenance.
- The climate can stop the works during some months (rain, snow, …)
- The equipment has to be adapted to the placement rate assumed.

Regarding Rogun project, the climate in the region induces that the works can be performed during 9 months per year for the Core and 11 months per year for the rest of the dam embankment. The equipment has to be adapted in order to keep the placement rate assumed during the total duration of the works. The accesses are not critical to build the dam. The Contractor shall make all the effort to have sufficient adequate accesses in order to optimize the dam construction. Obviously it must be studied in details at next phase of the study in order to build new roads and tunnels if necessary.

Therefore the placing area remains the only one critical factor, which has been studied in this note to define the placement rate for the alternative 1290 in a first time, and deduce the placement rates for alternatives 1255 and 1220.

4 PLACEMENT RATE ANALYSIS

4.1 Steps of construction

The dam construction is divided in 6 steps, as shown in Figure 7. These steps correspond to the placement of materials and the works necessary to complete the dam (excavation, Fault treatment, Concrete foundations …).

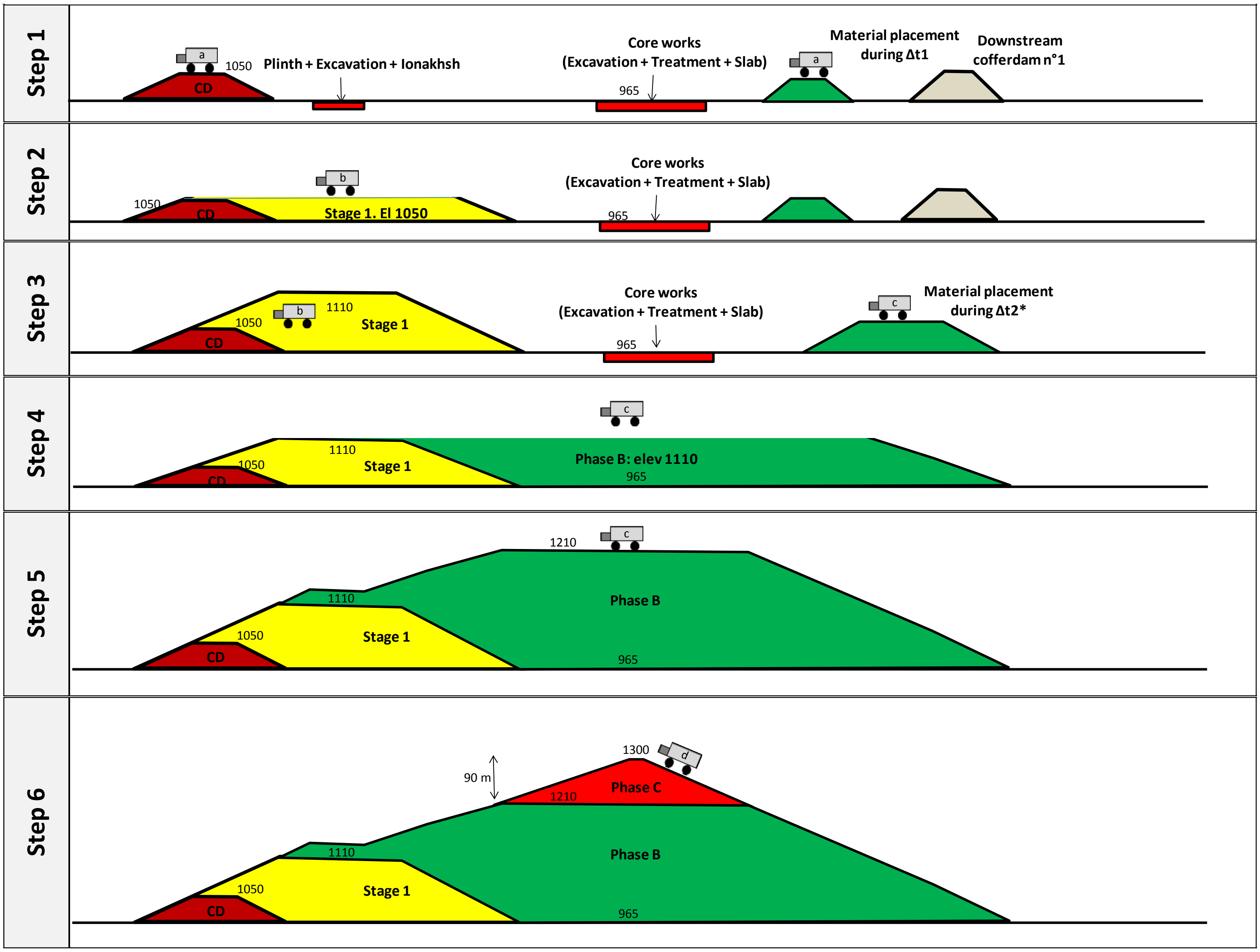


Figure 7: Step of Construction. Alternative 1290 m a.s.l.

The dam is divided in 4 phases to define mean placement rates for each (as shown in the Figure 8):

- Cofferdam
- Stage 1 dam
- Phase B (Main dam body)
- Phase C (Top of the main dam)

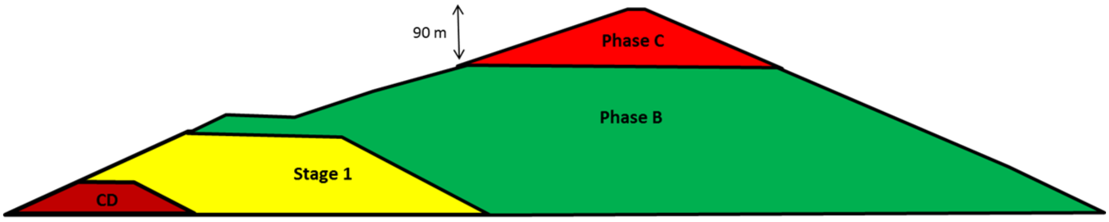


Figure 8: Dam phasing (September, 2013)

4.2 Placement rates

Cofferdam:

According to the river diversion scheme, 8 months (between October and June) are available to close the river. This time allowed induces a mean placement rate of 300,000 m3/Working month. However, an anticipation of the river closure during the previous 4 months will permit to reduce this placement rate to 220,000 m3/Working month, taking into account 11 Months of works (f. Appendix 2 “River Closure Optimization of Cofferdam Construction”).

The cofferdam is the same for all alternatives, therefore the same placement rate is considered.

Stage 1 dam:

Considering that belt conveyor is available at the beginning of stage 1 dam construction, a placement rate of 600,000 has been considered (this was not considered in the initial version). The volume for the highest alternative is about 10 Mm3.

The stage 1 dam has the same width but different crest level for each alternative (respectively 1110, 1090 and 1075 m a.s.l). As a preliminary approach, it has been considered a difference of 50,000 m3/Working month between each alternative.

Top of main dam (Phase C):

The top of the main dam is more complex due to the various layers which have to be built in a limited area (cf. Figure 9). Therefore the placement rate will decrease up to a very low value at the crest level.

It is considered that Phase C started 90 meters below the crest level. The mean placement rate for the highest alternative is fixed at 350,000 m3/Working month. A difference of 50,000 m3/Working month between each alternative has been considered in the calculation.

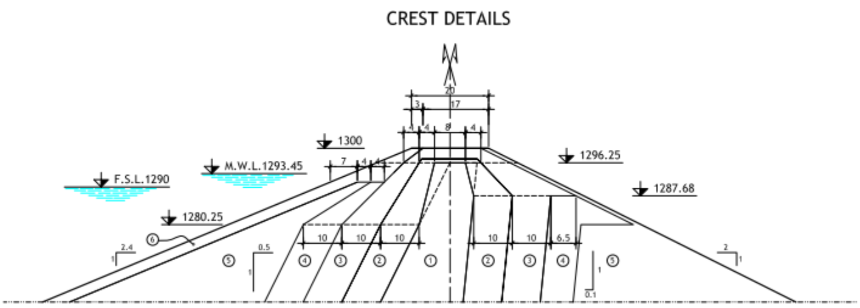


Figure 9: Top of dam - details.

Main dam body (Phase B):

The main dam body is the area where the placement rate reaches the maximum value due to the very large section. The mean placement rate 800,000 m3/Working Month is fixed for Phase B. It has been considered a difference of 50,000 m3/Working month between each alternative.

Conclusion:

The placement rate for each area and alternative are summarized in Figure 10.

Placement rates

Mean per Working Month

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	*300,000*	*300,000*	*300,000*
Stage 1	*600,000*	*550,000*	*500,000*
Phase B	*800,000*	*750,000*	*700,000*
Phase C	*350,000*	*300,000*	*250,000*

Mean per Month for 1 year

	Alt. 1290	Alt. 1255	Alt. 1220
Cofferdam	*275,000*	*275,000*	*275,000*
Stage 1	*550,000*	*504,167*	*458,333*
Phase B	*733,333*	*687,500*	*641,667*
Phase C	*320,833*	*275,000*	*229,167*

Figure 10: Placement rates

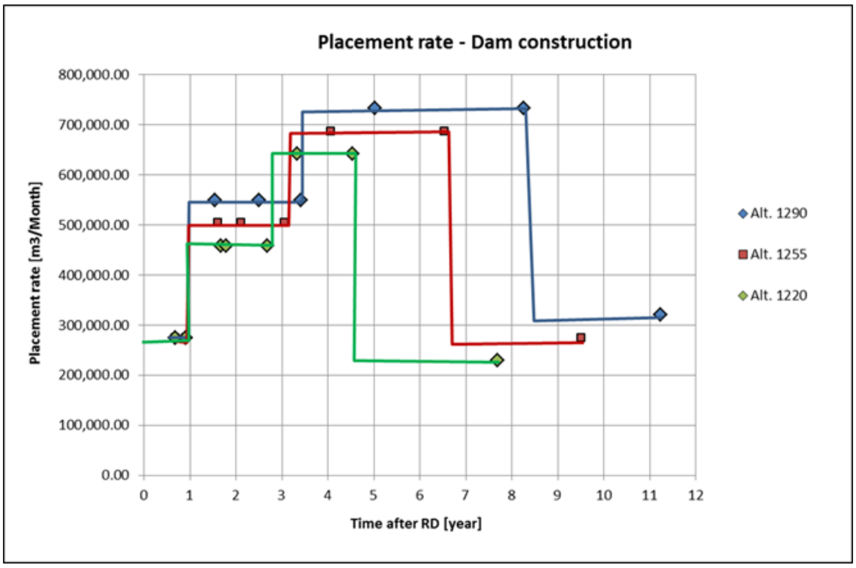


Figure 11: Placement rates representation

Alt. 1290 *from River diversion*

	Elevation [m asl]	Volume	% of the Volume	Vol. Cum	Placement rate [m3/Month]	Δt [Month]	Cumulative t [Month]	Cumulative t [years]
	970	0	0	0		0	0	0
Cofferdam	*1050*	2,274,500	3%	2,274,500	275,000	8	8	0.7
Δt1 (Cofferdam - Stage 1)	*1050*	727,144	1%	3,001,644	275,000	3	11	0.9
St1 El. 1050	*1050*	4,203,121	6%	7,204,764	550,000	8	19	1.5
Stage 1	*1110*	6,322,379	9%	13,527,144	550,000	11	30	2.5
Δt2 (Stage 1 - Main dam)	*1110*	6,037,788	8%	19,564,932	550,000	11	41	3.4
MD El S1	*1110*	14,140,313	19%	33,705,245	733,333	19	60	5.0
Up to Phase B	*1210*	28,450,758	39%	62,156,003	733,333	39	99	8.3
Phase C	*1300*	11,441,695	16%	73,597,698	320,833	36	135	**11.2**

Alt. 1255

	Elevation [m asl]	Volume	% of the Volume	Vol. Cum	Placement rate [m3/Month]	Δt [Month]	Cumulative t [Month]	Cumulative t [years]
	970	0	0	0		0	0	0
Cofferdam	*1050*	2,274,500	3%	2,274,500	275,000	8	8	0.7
Δt1 (Cofferdam - Stage 1)	*1050*	732,329	1%	3,006,829	275,000	3	11	0.9
St1 El. 1050	*1050*	4,203,121	6%	7,209,949	504,167	8	19	1.6
Stage 1	*1090*	3,062,459	4%	10,272,409	504,167	6	25	2.1
Δt2 (Stage 1 - Main dam)	*1090*	5,729,488	8%	16,001,897	504,167	11	37	3.1
MD El S1	*1090*	8,341,103	11%	24,343,000	687,500	12	49	4.1
Up to Phase B	*1175*	20,402,739	28%	44,745,739	687,500	30	79	6.5
Phase C	*1265*	9,794,784	13%	54,540,523	275,000	36	114	**9.5**

Alt. 1220

	Elevation [m asl]	Volume	% of the Volume	Vol. Cum	Placement rate [m3/Month]	Δt [Month]	Cumulative t [Month]	Cumulative t [years]
	970	0	0	0		0	0	0
Cofferdam	*1050*	2,274,500	3%	2,274,500	275,000	8	8	0.7
Δt1 (Cofferdam - Stage 1)	*1050*	732,329	1%	3,006,829	275,000	3	11	0.9
St1 El. 1050	*1050*	4,203,121	6%	7,209,949	458,333	9	20	1.7
Stage 1	*1075*	632,550	1%	7,842,500	458,333	1	21	1.8
Δt2 (Stage 1 - Main dam)	*1075*	4,928,713	7%	12,771,212	458,333	11	32	2.7
MD El S1	*1075*	4,942,788	7%	17,714,000	641,667	8	40	3.3
Up to Phase B	*1140*	9,278,516	13%	26,992,516	641,667	14	54	4.5
Phase C	*1230*	8,667,951	12%	35,660,467	229,167	38	92	**7.7**

Figure 12: Calculation of Dam crest raising

4.2.1 Critical path

As discussed previously (cf. paragraph 2), the critical path remains the same as in the version presented in May.

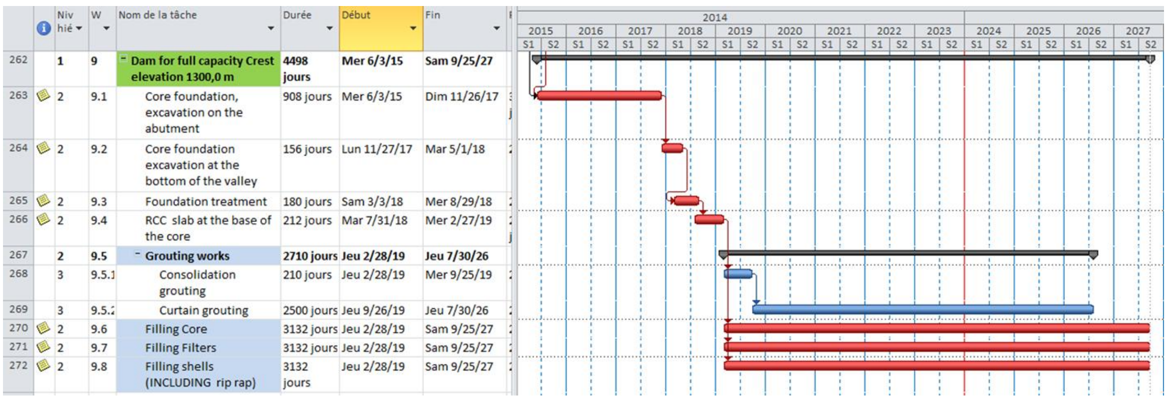


Figure 13: Critical path analysis

4.2.2 *Conclusion*

The dam crest rising for each alternative is shown in Figure 14.

The total durations of dam body construction for each alternative are:

- Alternative 1290: 11.2 years
- Alternative1255: 9.5 years
- Alternative 1220: 7.7 years

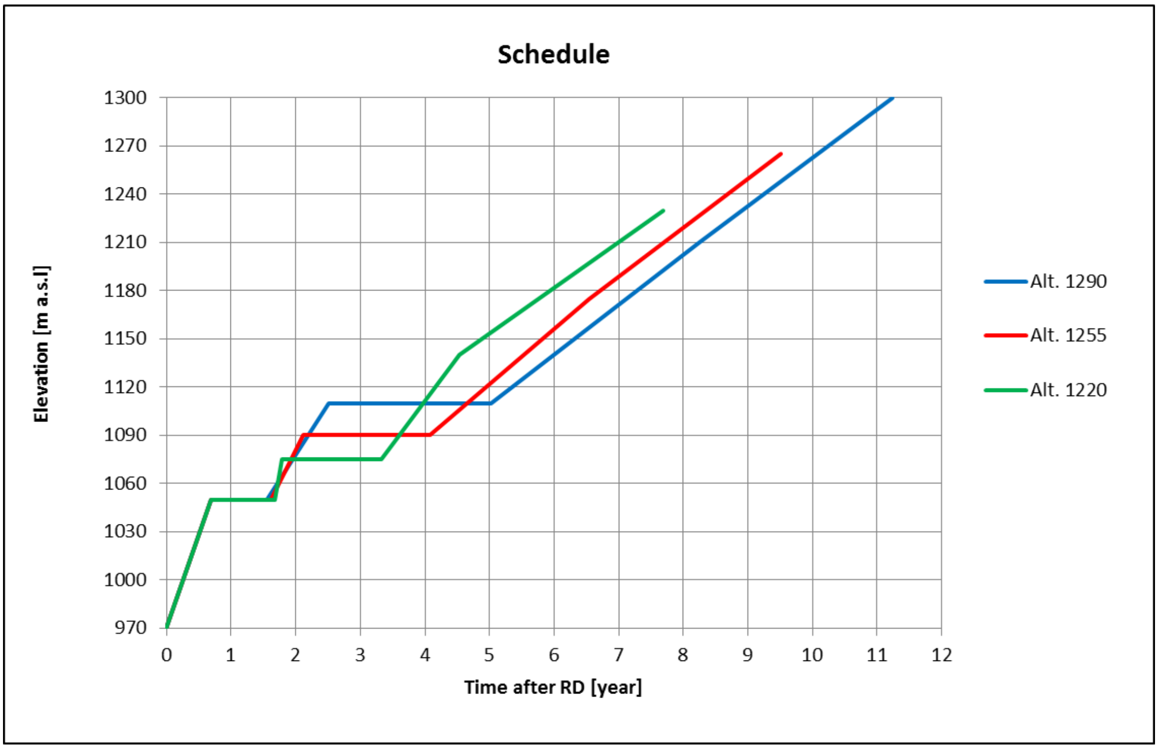


Figure 14: Dam crest raising

Table 4: Summary of the main project milestones of the 3 envisaged alternatives

Time from Pre-Contract (in months)

	ALT. Fsl 1290	ALT. Fsl 1255	ALT. Fsl 1220
TEAS validation	0	0	0
River Diversion date	28	28	28
End of cofferdam construction	36	36	36
End of stage 1 dam construction	58	53	49
End of dam construction	163	142	120

	1290 masl	1255 masl	1220 masl
TEAS Validation	0	0	0
Diversion	28	28	28
Commissioning U 6 Temp.	73	73	82
Commissioning U 5 Temp.	75	75	84
End of Erection U4	85	85	85
End of Erection U3	98	98	98
End of Erection U2	112	112	112
End of Erection U1	112	112	112
Minimum Reservoir level reach	112	94	80
Temp U5 and U6 shut down	117	114	
Commissioning U 4	115	101	101
Commissioning U 3	117	114	114
Commissioning U 2	119	116	116
Commissioning U 1	121	118	118
Commissioning U 6	123	120	
Commissioning U 5	127	122	

5 DAM REFERENCES WITH HIGH PLACEMENT RATES

Some references are given below in order to justify the mean placement rate which can be assumed for Rogun construction.

5.1 Grand Maison (France)

The Grand'Maison Dam is an embankment dam on L'Eau d'Olle, a tributary of the Romanche River. It is located in Vaujany of Isère within the French Alps. The primary purpose of the dam is to serve as the upper reservoir for a pumped-storage hydroelectric scheme where Lac du Verney located lower in the valley is the lower reservoir. The dam was constructed between 1978 and 1985 with its power station being commissioned in 1987. With an installed capacity of 1,800 MW, it is the largest hydroelectric power station in France.

The Grand'Maison is an embankment dam with a height of 140 m (459 ft) from the riverbed and 160 m (525 ft) from foundation. It is 550 m (1,804 ft) long and has a fill volume of **12,000,000 m^3** (15,695,407 cu yd).

Beginning of construction: **1978**

Opening date: **1985**

5.2 Tarbela (Pakistan)

Tarbela Dam, giant rock-fill dam on the Indus River, Pakistan. Built between 1968 and 1976, it has a volume of 138,600,000 cubic yards (106,000,000 cubic m). With a reservoir capacity of 11,098,000 acre-feet (13,690,000,000 cubic m), the dam is 469 feet (143 m) high and 8,997 feet (2,743 m) wide at its crest. Tarbela Dam is one of two main structures (the other is Mangla Dam on the Jhelum River) in the Indus Basin project, which resulted from the Indus Waters Agreement between India and Pakistan.

Beginning of construction: **1968**

Opening date: **1976**

Stage II construction involved placement of the long reach of the MED across the valley floor and the river channel, from the left abutment to the first stage embankment, and construction of the two auxiliary dams. The work proceeded with only brief interruptions in the form of labour strikes and the short India-Pakistan war in December 1971 (when night work was temporarily stopped because of a nationwide blackout). In each instance the lost time was rapidly made up, and for most of Stage II progress was on schedule, with only minor technical difficulties being experienced. The availability of large quantities of fill material from varied sources enabled the Contractor to maximize the use of his processing plants, conveyor system, and haul units. In April 1972 a new world placement record was established when 301,000 cu yd (230,000 cu m) of material were placed in the embankments in one day. Another world record was established soon after with the maximum monthly placement of 6,550,000 cu yd (5,010,000 cu m). By June of 1973 the main embankment was constructed to El. 1520 (463 m) throughout both the Stage I and Stage II sections with some reaches approaching El. 1540 (470 m).

Figure 15: Tarbela dam project – Completion report on design and construction (chapter 26)

5.3 Xiaolangdi Hydroelectric Project

The Xiaolangdi Dam is a dam in Jiyuan, Henan Province, China, and impounds the Yellow River. The facility is located about 20km to the northwest of Luoyang. It has a total installed capacity of 1,836 MW and generates up to 5.1 TWh annually with the help of six 306 MW turbines. The dam stands 154 m (505 ft) tall and 1,317 m (4,321 ft) wide, and cost US$3.5 billion to construct.

The Xiaolangdi Hydroelectric Project in China has a total volume of approx. 52,000,000 m3. The Project was financed by the World Bank and the civil works have been carried out by a joint venture of two international contractors in approx. 60 months with monthly rates of placed fill materials ranging from 750,000 m3 to 850,000 m3.

For the construction a fleet of approx. 90 rear type dumpers having a pay load capacity of 75 tons each was used. The construction was uninterrupted 12 months a year. The width of service roads in the area was suitable for the selected dumpers.

5.4 Al Wahda (Maroc)

Al Wahda Dam, formerly known as M'Jaara Dam, is an embankment dam on the Ouergha River near M´Jaara in Sidi Kacem Province, Morocco. It was constructed for flood control, irrigation, water supply and hydroelectric power production. It is the second largest dam in Africa and the largest in Morocco. It was described by Land Ocean Interactions in the Coastal Zone (LOICZ) as "the second most important dam in Africa after the High Aswan dam."

The dam is an earthen embankment type made of 28,000,000 m3 (990,000,000 cu ft) of material and 720,000 m3 (25,000,000 cu ft) of concrete. It is 88 m (289 ft) tall at its highest point and the main portion of the dam is 1,600 m (5,200 ft) long.

Beginning of construction: **1991**

Opening date: **1997**

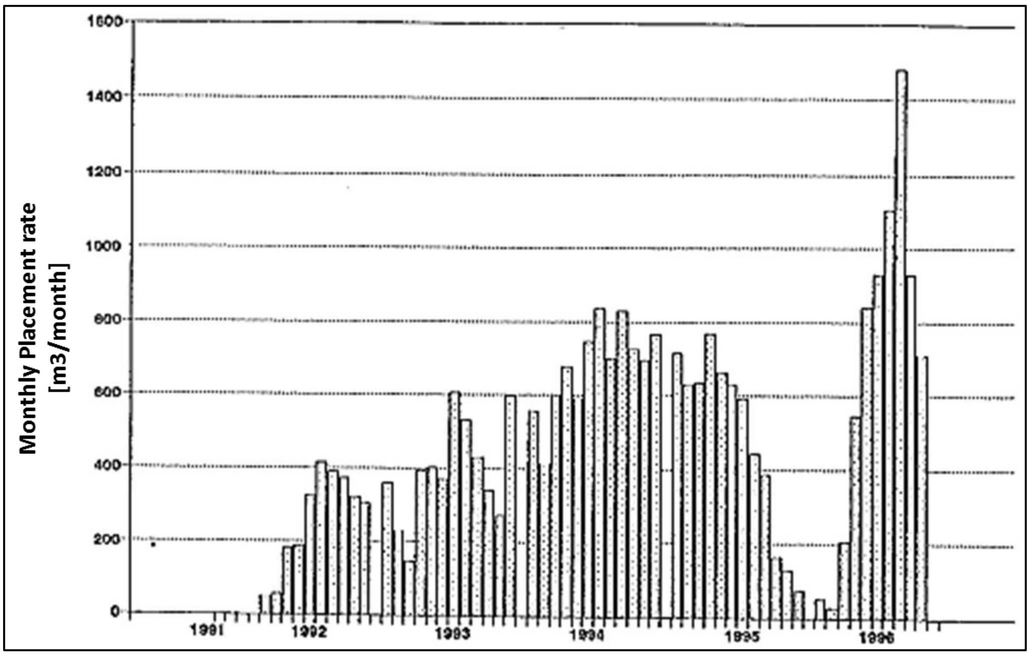


Figure 16: Al Wahda - Monthly placement rate for dam fill

5.5 Guavio (Colombia)

The Alberto Lleras Dam, also known as the Guavio Dam, is a rock-fill embankment dam on the Guavio River near Guavio, Colombia.

The dam was built in 1989 with a height of 243 m (797 ft).The dam has an installed hydroelectric generation capacity of 1,150 MW, a crest length of 390 m (1,280 ft), and a structural volume of 17,100,000 m3 (600,000,000 cu ft).

Opening date: **1989**

5.6 Karahnjukar (Iceland)

Kárahnjúkar Hydropower Plant is a hydroelectric power plant in eastern Iceland designed to produce 4,600 GWh annually for Alcoa's Fjardaál aluminum smelter 75 kilometers (47 mi) to the east in Reyðarfjörður. The project, named after nearby Mount Kárahnjúkur, involves damming the Jökulsá á Dal River and the Jökulsá í Fljótsdal River with five dams, creating three reservoirs. Water from the reservoirs is then diverted through 73 kilometers (45 mi) of underground water tunnels and down a 420-metre (1,380 ft) vertical penstock towards a single underground power station. The smelter became fully operational in 2008 and the hydro-power project was completed in 2009.

The Kárahnjúkastífla Dam is the centerpiece of the five dams and the largest of its type in Europe, standing 193 meters (633 ft) tall with a length of 730 meters (2,400 ft) and comprising 8.5 million cubic meters (300×106 cu ft) of material.

For the construction of Karahnjukar dam, the monthly production was about **400,000 m^3/month.**

Opening date: **2009**

5.7 Nam Ngum 2 (Laos)

The Nam Ngum Dam is a hydroelectric dam on the Nam Ngum River, a major tributary of the Mekong in Laos. It is the oldest dam in Laos, and its reservoir is the largest water body in the country.

The maximum monthly production reached 770,000 m3/month, and the mean value was 460,000 m3/month

5.8 Bakun dam (Malaysia)

BAKUN DAM (Malaysia) (tender in year 2002 - constructed 2003 2007)

CFRD of total **15 000 000 mc** of rockfill

Data from tender estimate by M. Vassallo:

- 1st period : 6 months at 260 000 mc of fill per month
- 2nd period : 23 months at **570 000 mc of fill per month**
- 3rd period ; 5 months at 270 000 mc of fill per month

5.9 Polihali dam (Lesotho)

POLIHALI DAM (Lesotho) (year 2007) **–** tender, not yet constructed

CFRD of total **12 000 000 mc** of rockfill

The extended peak production estimated has been **500 000 mc of fill per month**

5.10 Other placement rate assumed for studies

5.10.1 Gibe III (Ethiopia)

Gibe III – CFRD alternative with an average 650,000 m3/month. An offer has been proposed with this mean placement rate.

5.10.2 Nam-Ngum 3 (Laos)

CFRD of total **13 000 000 mc** of rockfill

The extended peak production estimated has been **550 000 mc of fill per month** general average 380 000 mc of fill)

5.11 Conclusion/Comparison

Name	Height	Volume [Mm3]	Crest Length	Starting Date	End Date	Average Placement rate [Mm3/Month]	Maximum placement rate [Mm3/Month]
Grand Maison	140	12	550	1978	1988		1.21
Tarbela	106	150	2743.2	1968	1974		6.55
Al Wahda	88	28		1991	1997		
Guavio	243	17.1	390		1989		0.62
Karahnjukar	193	8.5	730		2009	0.42	
Nam Ngun 2	182	9.7	500	2005	2009	0.46	0.77
Xiaolangdi Hydroelectric Project	154	52	1317	1998	2003		0.85
Nam Ngun 3						0.55	
Bakun dam		15		2002	…..	0.57	
Polihali dam		12					0.5

6 GENERAL CONCLUSION

To conclude, the main data deducted from the optimization of the schedule are reminded in the table and figure below.

	Alternative 1290 m asl	Alternative 1255 m asl	Alternative 1220 m asl
TEAS Validation and GoT decision to proceed	0	0	0
River diversion date	28	28	28
End of cofferdam construction	36	36	36
End of stage 1 dam construction	58	53	49
Commissioning of U6 Temp.	73	73	82
Commissioning of U5 Temp.	75	75	84
End of Erection U4	85	85	85
End of Erection U3	98	98	98
End of Erection U2	112	112	112
End of Erection U1	112	112	112
Minimum reservoir level reached	112	94	80
Temp. U5 and U6 shut down	117	114	
Commissioning of U4	115	101	101
Commissioning of U3	117	114	114
Commissioning of U2	119	116	116
Commissioning of U1	121	118	118
Commissioning of U6	123	120	
Commissioning of U5	127	122	
End of dam construction	163	142	120

Table 5: Summary of the main project milestones of the 3 envisaged alternatives, in months from Pre Contract beginning.

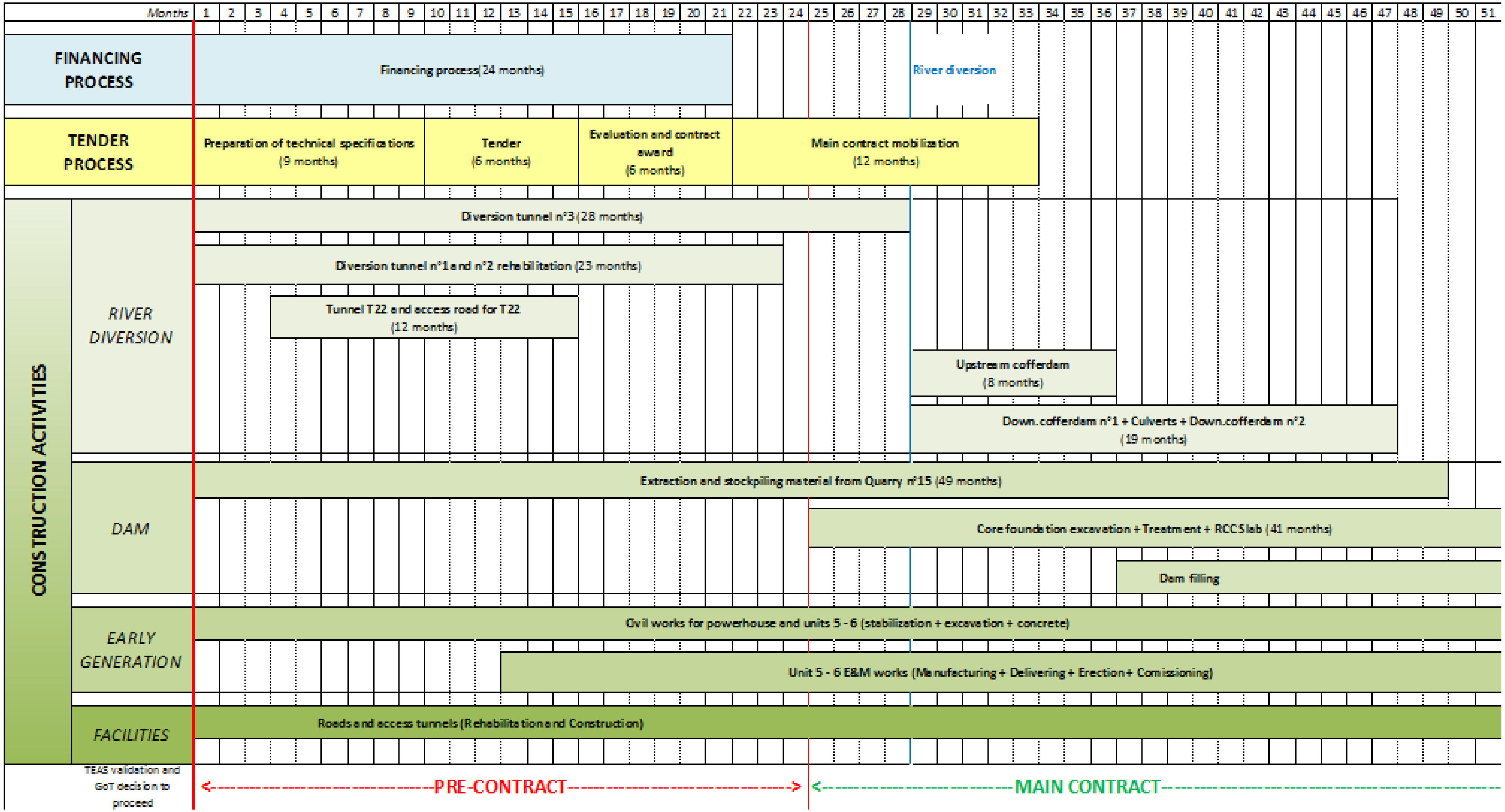
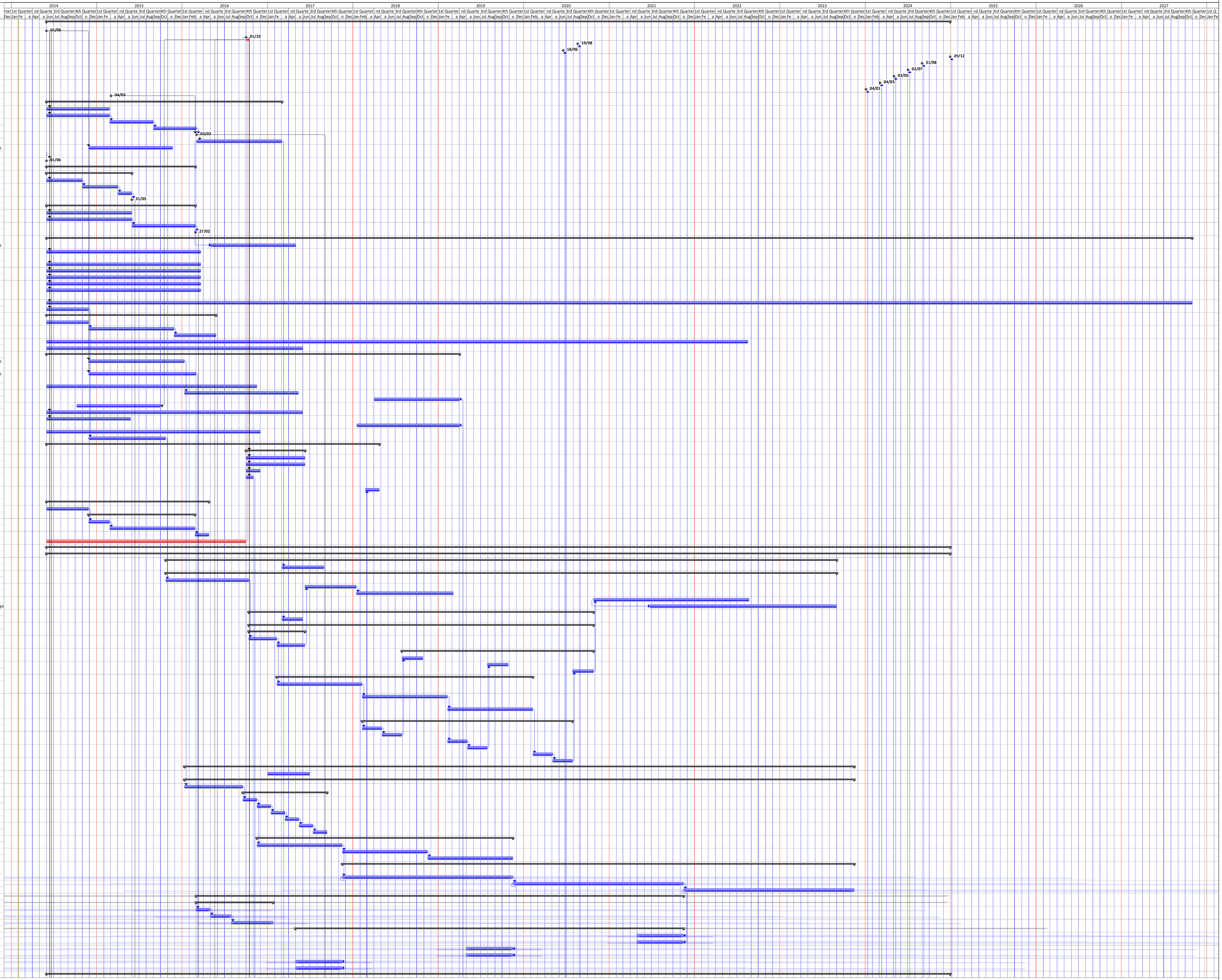


Figure 17: Pre-contract and Main contract definition, alternative 1290.

ANNEX 3 – IMPLEMENTATION SCHEDULES FOR THE THREE ALTERNATIVES

ID	Out Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
1	1	1	**Key events**	**3865 days**	**Sun 01/06/14**	**Sun 29/12/24**	
2	2	1.1	TEAS validation	0 days	Sun 01/06/14	Sun 01/06/14	
3	2	1.2	Vakhsh River diversion	0 days	**Sat 01/10/16**	Sat 01/10/16	75
4	2	1.3	**UNIT 5 final runners and temporary generators**	0 days	Wed 19/08/20	Wed 19/08/20	145
5	2	1.4	**UNIT 6 final runners and temporary generators**	0 days	Thu 18/06/20	Thu 18/06/20	144
6	2	1.5	**UNIT 5 final generators**	0 days	Sun 29/12/24	Sun 29/12/24	156
7	2	1.6	**UNIT 6 final generators**	0 days	Sat 31/08/24	Sat 31/08/24	154
8	2	1.7	**UNIT 1**	0 days	Tue 02/07/24	Tue 02/07/24	167
9	2	1.8	**UNIT 2**	0 days	Fri 03/05/24	Fri 03/05/24	166
10	2	1.9	**UNIT 3**	0 days	Mon 04/03/24	Mon 04/03/24	165
11	2	1.1	**UNIT 4**	0 days	Thu 04/01/24	Thu 04/01/24	164
12	2	1.1	**FINANCIAL CLOSURE**	0 days	Wed 04/03/15	Wed 04/03/15	
13	**2**	**1.1**	**CIVIL WORKS MAIN CONTRACTOR**	**1007 days**	**Sun 01/06/14**	**Fri 03/03/17**	
14	3	1.1	Technical specification	270 days	Sun 01/06/14	Wed 25/02/15	2
15	3	1.1	Condition of contract	270 days	Sun 01/06/14	Wed 25/02/15	2
16	3	1.1	Tender	187 days	Thu 26/02/15	Mon 31/08/15	15
17	3	1.1	Award of contract	185 days	Tue 01/09/15	Thu 03/03/16	16
18	3	1.1	Contract signature	0 days	Thu 03/03/16	Thu 03/03/16	17;12
19	3	1.1	Main Contractor mobilisation	365 days	Fri 04/03/16	Fri 03/03/17	18
20	3	1.1	Tests on Physical Models of hydraulic facilities and design	360 days	Fri 28/11/14	Sun 22/11/15	2FS+180 days
21	2	1.1	**CIVIL WORKS PRE - CONTRACT**	1 day	Sun 01/06/14	Sun 01/06/14	22
22	2	1.1	Commencement of pre-contract	0 days	Sun 01/06/14	Sun 01/06/14	
23	**2**	**1.1**	**EM**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
24	**3**	**1.1**	**UNIT 5-6 Final runners**	**365 days**	**Sun 01/06/14**	**Sun 31/05/15**	
25	4	1.1	Design specifications	153 days	Sun 01/06/14	Fri 31/10/14	2
26	4	1.1	Contract preparation	153 days	Sat 01/11/14	Thu 02/04/15	25
27	4	1.1	Negotiation	59 days	Fri 03/04/15	Sun 31/05/15	26
28	4	1.1	Contract signature	0 days	Sun 31/05/15	Sun 31/05/15	27
29	**3**	**1.1**	**UNIT 1 - 2 - 3 - 4**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
30	4	1.1	Design specifications	365 days	Sun 01/06/14	Sun 31/05/15	2
31	4	1.1	Contract preparation	365 days	Sun 01/06/14	Sun 31/05/15	2
32	4	1.1	Tender	272 days	Mon 01/06/15	Sat 27/02/16	31
33	4	1.1	Contract signature	0 days	Sat 27/02/16	Sat 27/02/16	32
34	**1**	**2**	**ROADS AND SITE INSTALLATIONS**	**4900 days**	**Sun 01/06/14**	**Sat 30/10/27**	
35	2	2.1	Site installations main contractor	365 days	Tue 03/05/16	Tue 02/05/17	19SS+60 days
36	2	2.2	REHABILITATION OF ALL EXISTING ROADS INCLUDING ROGUN TOWN ACCESS ROAD	660 days	Sun 01/06/14	Mon 21/03/16	2
37	2	2.3	BATCH PLANT+ AGGREGATE PLANT REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
38	2	2.4	ROGUN BUILDING REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
39	2	2.5	FRESH WATER + SEWAGE SYSTEM REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
40	2	2.6	TELECOMMUNICATION SYSTEM	660 days	Sun 01/06/14	Mon 21/03/16	2
41	2	2.7	REMOVAL OF SCRAP MATERIALS AND EQUIPMENT LOCATED IN CONSTRUCTION SITE N.1	660 days	Sun 01/06/14	Mon 21/03/16	2
42	2	2.8	Construction of temporary roads+Services roads	4900 days	Sun 01/06/14	Sat 30/10/27	2
43	2	2.9	Road to tunnel T-50	180 days	Sun 01/06/14	Thu 27/11/14	2
44	**2**	**2.1**	**Conveyor**	**725 days**	**Sun 01/06/14**	**Wed 25/05/16**	
45	3	2.1	Order	180 days	Sun 01/06/14	Thu 27/11/14	
46	3	2.1	Delivering	365 days	Fri 28/11/14	Fri 27/11/15	45
47	3	2.1	Installation	180 days	Sat 28/11/15	Wed 25/05/16	46
48	2	2.1	Quarrying activities	3000 days	Sun 01/06/14	Wed 17/08/22	
49	2	2.1	Material extraction from quarry N.15	1097 days	Sun 01/06/14	Thu 01/06/17	
50	**1**	**3**	**Transportation structures**	**1767 days**	**Sun 01/06/14**	**Tue 02/04/19**	
51	2	3.1	T18 ADIT TO UPPER PENSTOCK ELBOW and completion of P28 ADIT TO LOWER PENSTOCK ELBOW	410 days	Fri 28/11/14	Mon 11/01/16	2FS+180 days
52	2	3.2	REHABILITATION/COMPLETION Access Adit P21 - Constr. Adit P37	460 days	Fri 28/11/14	Tue 01/03/16	2FS+180 days
53	2	3.3	Conveyor tunnel 7B and 9 + EXT	900 days	Sun 01/06/14	Wed 16/11/16	
54	2	3.4	VENTILATION GALLERY AND VENTILATION SHAFT	488 days	Tue 12/01/16	Sat 13/05/17	51
55	2	3.5	T-10, T-10 A	365 days	Tue 03/04/18	Tue 02/04/19	257FF
56	2	3.6	T-22	360 days	Wed 08/10/14	Sat 03/10/15	3SF-365 days
57	2	3.7	REMEDIAL WORKS T-3', T-4, T-6, T-37, T-3, T-37', drainage galleries	1095 days	Sun 01/06/14	Tue 30/05/17	2
58	2	3.8	COMPLETION T-2 and T-8	360 days	Sun 01/06/14	Tue 26/05/15	2
59	2	3.9	T-3a	440 days	Thu 18/01/18	Tue 02/04/19	257FF
60	2	3.1	T-39	915 days	Sun 01/06/14	Thu 01/12/16	
61	2	3.1	T-50	330 days	Fri 28/11/14	Fri 23/10/15	43
62	**1**	**4**	**RIVER DIVERSION STRUCTURES**	**1424 days**	**Sun 01/06/14**	**Tue 24/04/18**	
63	**2**	**4.1**	**Upstream cofferdam CREST ELEVATION 1050**	**252 days**	**Sun 02/10/16**	**Sat 10/06/17**	**3**
64	3	4.1.	Cofferdam Shells Filling	252 days	Sun 02/10/16	Sat 10/06/17	3
65	3	4.1.	Bituminous Core	252 days	Sun 02/10/16	Sat 10/06/17	3
66	3	4.1.	Grouting works	60 days	Sun 02/10/16	Wed 30/11/16	3
67	2	4.2	**Downstream cofferdam n1 located D/S the culverts + three temporary cofferdam including dewatering**	30 days	Sun 02/10/16	Mon 31/10/16	3
68	2	4.3	**Downstream cofferdam n2 located U/S the final outlet of DT 1 and DT2**	60 days	Sat 24/02/18	Tue 24/04/18	236
69	**2**	**4.4**	**DT1 and DT2**	**695 days**	**Sun 01/06/14**	**Mon 25/04/16**	
70	3	4.4.	Design	180 days	Sun 01/06/14	Thu 27/11/14	
71	**3**	**4.4.**	**Rehabilitation works CIVIL WORKS**	**455 days**	**Fri 28/11/14**	**Thu 25/02/16**	
72	4	4.4.	Contractor mobilisation	90 days	Fri 28/11/14	Wed 25/02/15	70
73	4	4.4.	Rehabilitation works	365 days	Thu 26/02/15	Thu 25/02/16	72
74	3	4.4.	**Rehabilitation works HSS WORKS**	60 days	Fri 26/02/16	Mon 25/04/16	73
75	2	4.5	DT3	854 days	Sun 01/06/14	Sat 01/10/16	
76	**1**	**5**	**POWER SYSTEM STRUCTURES**	**3865 days**	**Sun 01/06/14**	**Sun 29/12/24**	
77	**2**	**5.1**	**Power waterways**	**3865 days**	**Sun 01/06/14**	**Sun 29/12/24**	
78	**3**	**5.1.**	**Intakes**	**2870 days**	**Sat 24/10/15**	**Fri 01/09/23**	
79	4	5.1.	Temporary intake excavation + concreting	180 days	Sat 04/03/17	Wed 30/08/17	19
80	**4**	**5.1.**	**Permanent intakes**	**2870 days**	**Sat 24/10/15**	**Fri 01/09/23**	
81	5	5.1.	INTAKES EXCAVATION down to Power Tunnel	355 days	Sat 24/10/15	Wed 12/10/16	61
82	5	5.1.	INTAKES EXCAVATION below the Power Tunnel	220 days	Sat 10/06/17	Mon 15/01/18	91
83	5	5.1.	INTAKES CONCRETE WORKS up to the Power Tunnel	415 days	Tue 16/01/18	Wed 06/03/19	82
84	5	5.1.	INTAKES CONCRETE WORKS up to the crest elevation	665 days	Tue 27/10/20	Mon 22/08/22	95
85	5	5.1.	HSS (trashracks and gates) including gates shaft	800 days	Thu 24/06/21	Fri 01/09/23	84SS+240 days
86	**3**	**5.1.**	**Headrace tunnel**	**1475 days**	**Thu 13/10/16**	**Mon 26/10/20**	
87	4	5.1.	Headrace tunnel - temporary	90 days	Sat 04/03/17	Thu 01/06/17	19
88	**4**	**5.1.**	**Headrace tunnel - permanent**	**1475 days**	**Thu 13/10/16**	**Mon 26/10/20**	
89	**5**	**5.1.**	**HORIZONTAL TUNNEL EXCAVATION el 1167**	**240 days**	**Thu 13/10/16**	**Fri 09/06/17**	
90	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Thu 13/10/16	Thu 09/02/17	81
91	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Fri 10/02/17	Fri 09/06/17	90
92	**5**	**5.1.**	**Horizontal tunnels Concreting works el 1167**	**820 days**	**Mon 30/07/18**	**Mon 26/10/20**	
93	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Mon 30/07/18	Sat 27/10/18	102
94	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Tue 30/07/19	Sun 27/10/19	104
95	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Wed 29/07/20	Mon 26/10/20	106
96	**5**	**5.1.**	**GATES EXCAVATION**	**1095 days**	**Fri 10/02/17**	**Sun 09/02/20**	
97	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Fri 10/02/17	Fri 09/02/18	90
98	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Sat 10/02/18	Sat 09/02/19	97
99	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Sun 10/02/19	Sun 09/02/20	98
100	**5**	**5.1.**	**GATES SHAFT CONCRETING**	**900 days**	**Sat 10/02/18**	**Tue 28/07/20**	
101	6	5.1.	Gates shaft 1	85 days	Sat 10/02/18	Sat 05/05/18	97
102	6	5.1.	Gates shaft 2	85 days	Sun 06/05/18	Sun 29/07/18	101
103	6	5.1.	Gates shaft 3	85 days	Sun 10/02/19	Sun 05/05/19	98
104	6	5.1.	Gates shaft 4	85 days	Mon 06/05/19	Mon 29/07/19	103
105	6	5.1.	Gates shaft 5	85 days	Mon 10/02/20	Mon 04/05/20	99
106	6	5.1.	Gates shaft 6	85 days	Tue 05/05/20	Tue 28/07/20	105
107	**3**	**5.1.**	**Penstocks**	**2865 days**	**Tue 12/01/16**	**Wed 15/11/23**	
108	4	5.1.	TEMPORARY	180 days	Sun 01/01/17	Thu 29/06/17	
109	**4**	**5.1.**	**PERMANENT**	**2865 days**	**Tue 12/01/16**	**Wed 15/11/23**	
110	5	5.1.	PENSTOCK ERECTION CHAMBER	250 days	Tue 12/01/16	Sat 17/09/16	51
111	**5**	**5.1.**	**SHAFT EXCAVATION RAISE BORER**	**360 days**	**Sun 18/09/16**	**Tue 12/09/17**	
112	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 5	60 days	Sun 18/09/16	Wed 16/11/16	110
113	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 6	60 days	Thu 17/11/16	Sun 15/01/17	112
114	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 3	60 days	Mon 16/01/17	Thu 16/03/17	113
115	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 4	60 days	Fri 17/03/17	Mon 15/05/17	114
116	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 1	60 days	Tue 16/05/17	Fri 14/07/17	115
117	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 2	60 days	Sat 15/07/17	Tue 12/09/17	116
118	**5**	**5.1.**	**PENSTOCK ENLARGEMENT**	**1095 days**	**Thu 17/11/16**	**Sat 16/11/19**	
119	6	5.1.	ENLARGEMENT PENSTOCK 6 AND 5	365 days	Thu 17/11/16	Thu 16/11/17	112
120	6	5.1.	ENLARGEMENT PENSTOCK 3 AND 4	365 days	Fri 17/11/17	Fri 16/11/18	119
121	6	5.1.	ENLARGEMENT PENSTOCK 1 AND 2	365 days	Sat 17/11/18	Sat 16/11/19	120
122	**5**	**5.1.**	**STEEL LINING PENSTOCKS INCLUDING CONCRETE WORKS**	**2190 days**	**Fri 17/11/17**	**Wed 15/11/23**	
123	6	5.1.	Steel lining PENSTOCK 5 6	730 days	Fri 17/11/17	Sat 16/11/19	119
124	6	5.1.	Steel lining PENSTOCK 3 4	730 days	Sun 17/11/19	Mon 15/11/21	123
125	6	5.1.	Steel lining PENSTOCK 1 2	730 days	Tue 16/11/21	Wed 15/11/23	124
126	**3**	**5.1.**	**Manifold**	**2085 days**	**Wed 02/03/16**	**Tue 16/11/21**	
127	**4**	**5.1.**	**Excavation**	**330 days**	**Wed 02/03/16**	**Wed 25/01/17**	
128	5	5.1.	U4	60 days	Wed 02/03/16	Sat 30/04/16	52
129	5	5.1.	U1	90 days	Sun 01/05/16	Fri 29/07/16	128
130	5	5.1.	U2 - U3 - U5 - U6	180 days	Sat 30/07/16	Wed 25/01/17	129
131	**4**	**5.1.**	**Steel lining**	**1660 days**	**Mon 01/05/17**	**Tue 16/11/21**	
132	5	5.1.	UNIT 1	200 days	Fri 30/04/21	Tue 16/11/21	125SF
133	5	5.1.	UNIT 2	200 days	Fri 30/04/21	Tue 16/11/21	125SF
134	5	5.1.	UNIT 3	200 days	Wed 01/05/19	Sun 17/11/19	124SF
135	5	5.1.	UNIT 4	200 days	Wed 01/05/19	Sun 17/11/19	124SF
136	5	5.1.	UNIT 5	200 days	Mon 01/05/17	Fri 17/11/17	123SF
137	5	5.1.	UNIT 6	200 days	Mon 01/05/17	Fri 17/11/17	123SF
138	**3**	**5.1.**	**Powerhouse cavern and relevant structures**	**3865 days**	**Sun 01/06/14**	**Sun 29/12/24**	



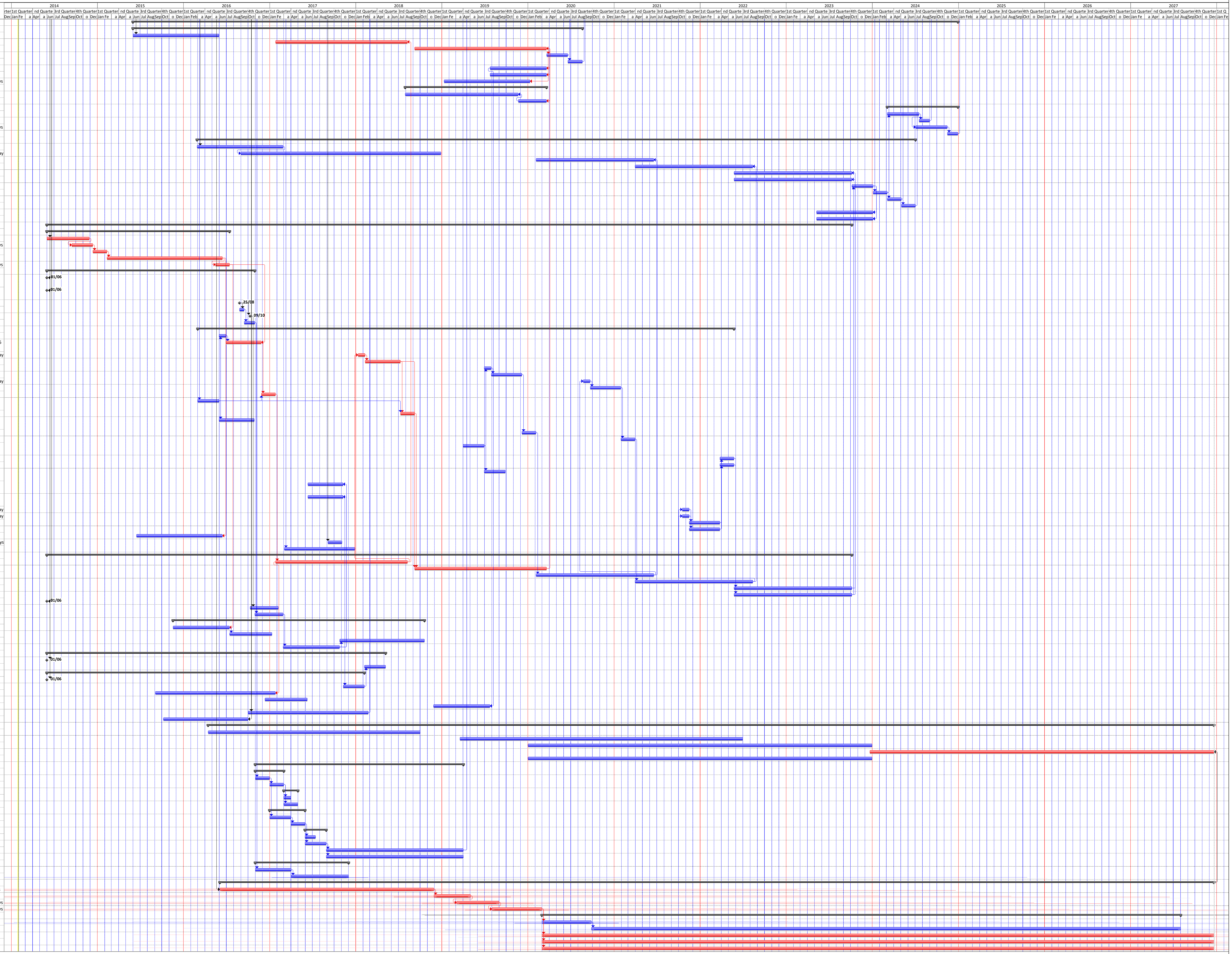
Projet : 2013-1-3ROGUN
Date : Wed 29/01/14

Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

rogun

ROGUN FSL 1290

ID	Info	Outline Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
139		4	5.1.	**EM EQUIPMENT**	**3500 days**	**Mon 01/06/15**	**Sun 29/12/24**	
140		5	5.1.	**UNIT 5-6 final runners and temporary generators**	**1907 days**	**Mon 01/06/15**	**Wed 19/08/20**	
141		6	5.1.	Manufacturing + Delivering	365 days	Mon 01/06/15	Mon 30/05/16	28
142		6	5.1.	UNIT 6 ERECTION	560 days	Thu 26/01/17	Wed 08/08/18	213FF
143		6	5.1.	UNIT 5 ERECTION	560 days	Sat 08/09/18	Fri 20/03/20	214FF
144		6	5.1.	UNIT 6 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 21/03/20	Thu 18/06/20	143
145		6	5.1.	UNIT 5 (COMMISSIONING - DRY AND WET TESTS)	62 days	Fri 19/06/20	Wed 19/08/20	144
146		6	5.1.	Switchyard	240 days	Thu 25/07/19	Fri 20/03/20	143FF
147		6	5.1.	Transmission line	240 days	Thu 25/07/19	Fri 20/03/20	143FF
148		6	5.1.	Control room	365 days	Fri 11/01/19	Fri 10/01/20	143FF-70 days
149		6	5.1.	**TRANSFORMERS**	**600 days**	**Mon 30/07/18**	**Fri 20/03/20**	
150		7	5.1.	Delivering+Assembling on site	480 days	Mon 30/07/18	Fri 22/11/19	151SF
151		7	5.1.	Erection	120 days	Fri 22/11/19	Fri 20/03/20	143FF
152		5	5.1.	**UNIT 5-6 final generators**	**300 days**	**Tue 05/03/24**	**Sun 29/12/24**	
153		6	5.1.	U6 generator modification	135 days	Tue 05/03/24	Wed 17/07/24	165
154		6	5.1.	U6 COMMISSIONING	45 days	Thu 18/07/24	Sat 31/08/24	153
155		6	5.1.	U5 generator modification	135 days	Wed 03/07/24	Thu 14/11/24	153FS-15 days
156		6	5.1.	U5 COMMISSIONING	45 days	Fri 15/11/24	Sun 29/12/24	155
157		5	5.1.	**UNIT 1 - 2 - 3 - 4**	**3048 days**	**Sun 28/02/16**	**Tue 02/07/24**	
158		6	5.1.	Design	365 days	Sun 28/02/16	Sun 26/02/17	33
159		6	5.1.	Manufacturing + Delivering	850 days	Wed 31/08/16	Fri 28/12/18	158FS-180 day
160		6	5.1.	UNIT 4 ERECTION	500 days	Wed 05/02/20	Fri 18/06/21	215FF
161		6	5.1.	UNIT 3 ERECTION	500 days	Wed 31/03/21	Fri 12/08/22	216FF
162		6	5.1.	UNIT 2 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	217FF
163		6	5.1.	UNIT 1 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	218FF
164		6	5.1.	UNIT 4 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 07/10/23	Thu 04/01/24	218
165		6	5.1.	UNIT 3 (COMMISSIONING - DRY AND WET TESTS)	60 days	Fri 05/01/24	Mon 04/03/24	164
166		6	5.1.	UNIT 2 (COMMISSIONING - DRY AND WET TESTS)	60 days	Tue 05/03/24	Fri 03/05/24	165
167		6	5.1.	UNIT 1 (COMMISSIONING - DRY AND WET TESTS)	60 days	Sat 04/05/24	Tue 02/07/24	166
168		6	5.1.	Switchyard	240 days	Wed 10/05/23	Thu 04/01/24	164FF
169		6	5.1.	TRANSFORMERS	240 days	Wed 10/05/23	Thu 04/01/24	164FF
170		4	5.1.	**CIVIL WORKS**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
171		5	5.1.	**Wall support**	**775 days**	**Sun 01/06/14**	**Thu 14/07/16**	
172		6	5.1.	Design	180 days	Sun 01/06/14	Thu 27/11/14	2
173		6	5.1.	Mobilization	90 days	Sun 14/09/14	Fri 12/12/14	172FS-75 days
174		6	5.1.	Scaffolding installation	60 days	Sat 13/12/14	Tue 10/02/15	173
175		6	5.1.	MPSP system & tendons drilling, grouting and tensioni	490 days	Wed 11/02/15	Tue 14/06/16	174
176		6	5.1.	Scaffolding removal	60 days	Mon 16/05/16	Thu 14/07/16	175FS-30 days
177		5	5.1.	**BUS DUCT**	**882 days**	**Sun 01/06/14**	**Sat 29/10/16**	
178		6	5.1.	BUS DUCT EXCAVATION EL 969 Units 6 ,5, 4 (already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
179		6	5.1.	BUS DUCT EXCAVATION EL 983 Units 6, 5, 4 (already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
180		6	5.1.	BUS DUCT EXCAVATION EL 969 Unit 3 (completed)	0 days	Thu 25/08/16	Thu 25/08/16	
181		6	5.1.	BUS DUCT EXCAVATION EL 969 Units 2, 1	20 days	Fri 26/08/16	Wed 14/09/16	180
182		6	5.1.	BUS DUCT EXCAVATION EL 983 Unit 3 (completed)	0 days	Sun 09/10/16	Sun 09/10/16	180
183		6	5.1.	BUS DUCT EXCAVATION EL 983 Units 2, 1	45 days	Thu 15/09/16	Sat 29/10/16	181
184		5	5.1.	**Cavern excavation**	**2275 days**	**Wed 02/03/16**	**Tue 24/05/22**	
185		6	5.1.	Excavation of shaft of Unit 6	30 days	Tue 31/05/16	Wed 29/06/16	198
186		6	5.1.	Excavation of Unit 6 from el. 964.25 to el. 946.90	150 days	Thu 30/06/16	Sat 26/11/16	185;176FF-15 days
187		6	5.1.	Excavation of shaft of Unit 5	30 days	Thu 11/01/18	Fri 09/02/18	213FS-210 day
188		6	5.1.	Excavation of Unit 5 from el. 964.25 to el. 946.90	150 days	Sat 10/02/18	Mon 09/07/18	187
189		6	5.1.	Excavation of shaft of Unit 4	30 days	Sun 30/06/19	Mon 29/07/19	203
190		6	5.1.	Excavation of Unit 4 from el. 964.25 to el. 946.90	130 days	Tue 30/07/19	Fri 06/12/19	189
191		6	5.1.	Excavation of shaft of Unit 3	30 days	Sun 23/08/20	Mon 21/09/20	215FS-300 day
192		6	5.1.	Excavation of Unit 3 from el. 964.25 to el. 946.90	130 days	Tue 22/09/20	Fri 29/01/21	191
197		6	5.1.	Excavation of Pit of Unit 6	60 days	Sun 27/11/16	Wed 25/01/17	198;186
198		6	5.1.	DT Units 5 and 6 at el 932, from drainage gallery to pit (U/S direction)	90 days	Wed 02/03/16	Mon 30/05/16	52
199		6	5.1.	Excavation of Pit of Unit 5	60 days	Tue 10/07/18	Fri 07/09/18	198;188
200		6	5.1.	DT Units 5 and 6 from el 932 to 966 - from drainage gallery to transformer chambers	150 days	Tue 31/05/16	Thu 27/10/16	198
201		6	5.1.	Excavation of Pit of Unit 4	60 days	Sat 07/12/19	Tue 04/02/20	190
202		6	5.1.	Excavation of Pit of Unit 3	60 days	Sat 30/01/21	Tue 30/03/21	192
203		6	5.1.	DT Units 4 and 3 at el 932, from drainage gallery to pit (U/S direction)	90 days	Mon 01/04/19	Sat 29/06/19	
204		6	5.1.	Excavation of Pit of Unit 2	60 days	Sat 26/03/22	Tue 24/05/22	194
205		6	5.1.	Excavation of Pit of Unit 1	60 days	Sat 26/03/22	Tue 24/05/22	196
206		6	5.1.	DT Units 2 and 1 at el 932, from drainage gallery to pit (U/S direction)	90 days	Sun 30/06/19	Fri 27/09/19	203
207		6	5.1.	DT Units 4 and 3 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	225FF+15 days
208		6	5.1.	DT Units 2 and 1 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	225FF+15 days
193		6	5.1.	Excavation of shaft of Unit 2	30 days	Sun 17/10/21	Mon 15/11/21	216FS-300 day
195		6	5.1.	Excavation of shaft of Unit 1	30 days	Sun 17/10/21	Mon 15/11/21	216FS-300 day
194		6	5.1.	Excavation of Unit 2 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	193
196		6	5.1.	Excavation of Unit 1 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	195
209		5	5.1.	Stabilization works of overhead travelling crane beam	365 days	Tue 16/06/15	Tue 14/06/16	175FF
210		5	5.1.	Main gantry crane erection	60 days	Tue 05/09/17	Fri 03/11/17	18FS+550 days
211		5	5.1.	Grouting works	300 days	Sat 04/03/17	Thu 28/12/17	19
212		5	5.1.	**Concrete works (made in parallel with E&M erection)**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
213		6	5.1.	UNIT 6	560 days	Thu 26/01/17	Wed 08/08/18	197
214		6	5.1.	UNIT 5	560 days	Sat 08/09/18	Fri 20/03/20	188;199
215		6	5.1.	UNIT 4	500 days	Wed 05/02/20	Fri 18/06/21	201
216		6	5.1.	UNIT 3	500 days	Wed 31/03/21	Fri 12/08/22	202
217		6	5.1.	UNIT 2	500 days	Wed 25/05/22	Fri 06/10/23	204
218		6	5.1.	UNIT 1	500 days	Wed 25/05/22	Fri 06/10/23	205
219		6	5.1.	Bus Duct Lining Units 6, 5 (already done)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
220		6	5.1.	Bus duct lining Units 4, 3	120 days	Mon 10/10/16	Mon 06/02/17	182
221		6	5.1.	Bus duct lining Units 2, 1	120 days	Sun 30/10/16	Sun 26/02/17	183
222		5	5.1.	**TRANSFORMER HALL**	**1067 days**	**Wed 18/11/15**	**Fri 19/10/18**	
223		6	5.1.	Excavation transformer chamber for Units 6 and 5	240 days	Wed 18/11/15	Thu 14/07/16	176FF
224		6	5.1.	Concreting+ finishing for units 6 and 5	180 days	Fri 15/07/16	Tue 10/01/17	223
226		6	5.1.	Concreting+ finishing for Units 4, 3, 2, 1	360 days	Wed 25/10/17	Fri 19/10/18	225
225		6	5.1.	Excavation transformer chamber for Units 4, 3, 2, 1	240 days	Mon 27/02/17	Tue 24/10/17	221
227		5	5.1.	**Branches from transformer chamber to main collector**	**1437 days**	**Sun 01/06/14**	**Mon 07/05/18**	
228		6	5.1.	U4 U5 U6 (already done)	0 days	Sun 01/06/14	Sun 01/06/14	2
229		6	5.1.	U1 U2 U3	90 days	Wed 07/02/18	Mon 07/05/18	232
230		5	5.1.	**Main collector**	**1347 days**	**Sun 01/06/14**	**Tue 06/02/18**	
231		6	5.1.	U4 U5 U6 (already done)	0 days	Sun 01/06/14	Sun 01/06/14	2
232		6	5.1.	U1 U2 U3	90 days	Thu 09/11/17	Tue 06/02/18	208
233		3	5.1.	Cable gallery lining rehabilitation works N1 and N2	510 days	Fri 04/09/15	Thu 26/01/17	213SF
234		3	5.1.	Control room	180 days	Mon 12/12/16	Fri 09/06/17	
235		3	5.1.	Switchyard	240 days	Tue 27/11/18	Thu 25/07/19	146SF
236		3	5.1.	DT1 and DT2 Culverts in the river bed	510 days	Sun 02/10/16	Fri 23/02/18	3
237		3	5.1.	Excavation in the riverbed at DTs outlets	360 days	Thu 08/10/15	Sat 01/10/16	3FF
238		1	6	**FLOOD MANAGEMENT STRUCTURES**	**4267 days**	**Fri 15/04/16**	**Mon 20/12/27**	
239		2	6.1	**Middle level outlet 1**	900 days	Fri 15/04/16	Mon 01/10/18	
240		2	6.2	**Middle level outlet 2**	1200 days	Tue 19/03/19	Thu 30/06/22	
241		2	6.3	**High level outlet tunnel spillway 1**	1460 days	Thu 02/01/20	Sun 31/12/23	
243		2	6.5	**Surface Spillway**	1460 days	Fri 22/12/23	Mon 20/12/27	262FF
242		2	6.3	**High level outlet tunnel spillway 2**	1460 days	Thu 02/01/20	Sun 31/12/23	
244		1	7	**Stage 1 Dam Crest Elevation 1110 masl**	**883 days**	**Tue 01/11/16**	**Tue 02/04/19**	
245		2	7.1	**Concrete plinth (BOTTOM OF THE VALLEY)**	**121 days**	**Tue 01/11/16**	**Wed 01/03/17**	
246		3	7.1.	Excavation + foundation treatment	61 days	**Tue 01/11/16**	Sat 31/12/16	67
247		3	7.1.	Concrete works including anchor bars	60 days	Sun 01/01/17	Wed 01/03/17	246
248		2	7.2	**Grouting works (BOTTOM OF THE VALLEY)**	**60 days**	**Thu 02/03/17**	**Sun 30/04/17**	
249		3	7.2.	Consolidation grouting	30 days	Thu 02/03/17	Fri 31/03/17	247
250		3	7.2.	Curtain grouting	60 days	Thu 02/03/17	Sun 30/04/17	247
251		2	7.3	**Concrete plinth (ABUTMENT)**	**150 days**	**Sun 01/01/17**	**Tue 30/05/17**	
252		3	7.3.	Excavation + foundation treatment	90 days	Sun 01/01/17	Fri 31/03/17	246
253		3	7.3.	Concrete works including anchor bars	60 days	Sat 01/04/17	Tue 30/05/17	252
254		2	7.4	**Grouting works (ABUTMENT)**	**90 days**	**Wed 31/05/17**	**Mon 28/08/17**	
255		3	7.4.	Consolidation grouting	45 days	Wed 31/05/17	Fri 14/07/17	253
256		3	7.4.	Curtain grouting	90 days	Wed 31/05/17	Mon 28/08/17	253
257		2	7.5	Asphalt concrete core including transition layers	582 days	Tue 29/08/17	Tue 02/04/19	256
258		2	7.6	Dam Shells Filling	582 days	Tue 29/08/17	Tue 02/04/19	256
259		1	8	**Salt dome works**	**396 days**	**Tue 01/11/16**	**Fri 01/12/17**	
260		2	8.1	Excavation + foundation treatment + Concrete slab	153 days	Tue 01/11/16	Sun 02/04/17	67
261		2	8.2	Grouting + Drainage	243 days	Mon 03/04/17	Fri 01/12/17	260
262		1	9	**Dam for full capacity Crest elevation 1300,0 m**	**4217 days**	**Sat 04/06/16**	**Mon 20/12/27**	
263		2	9.1	Core foundation, excavation on the abutment	908 days	Sat 04/06/16	Wed 28/11/18	3FS-120 days
264		2	9.2	Core foundation excavation at the bottom of the valley	156 days	Thu 29/11/18	Fri 03/05/19	**263**
265		2	9.3	Foundation treatment	180 days	Tue 05/03/19	Sat 31/08/19	264FS-60 days
266		2	9.4	RCC slab at the base of the core	212 days	Fri 02/08/19	Sat 29/02/20	265FS-30 days
267		2	9.5	**Grouting works**	**2710 days**	**Sun 01/03/20**	**Sun 01/08/27**	
268		3	9.5.	Consolidation grouting	210 days	Sun 01/03/20	Sat 26/09/20	266
269		3	9.5.	Curtain grouting	2500 days	Sun 27/09/20	Sun 01/08/27	268
270		2	9.6	Filling Core	2851 days	Sun 01/03/20	Mon 20/12/27	266
271		2	9.7	Filling Filters	2851 days	Sun 01/03/20	Mon 20/12/27	266
272		2	9.8	Filling shells (INCLUDING rip rap)	2851 days	Sun 01/03/20	Mon 20/12/27	266



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Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

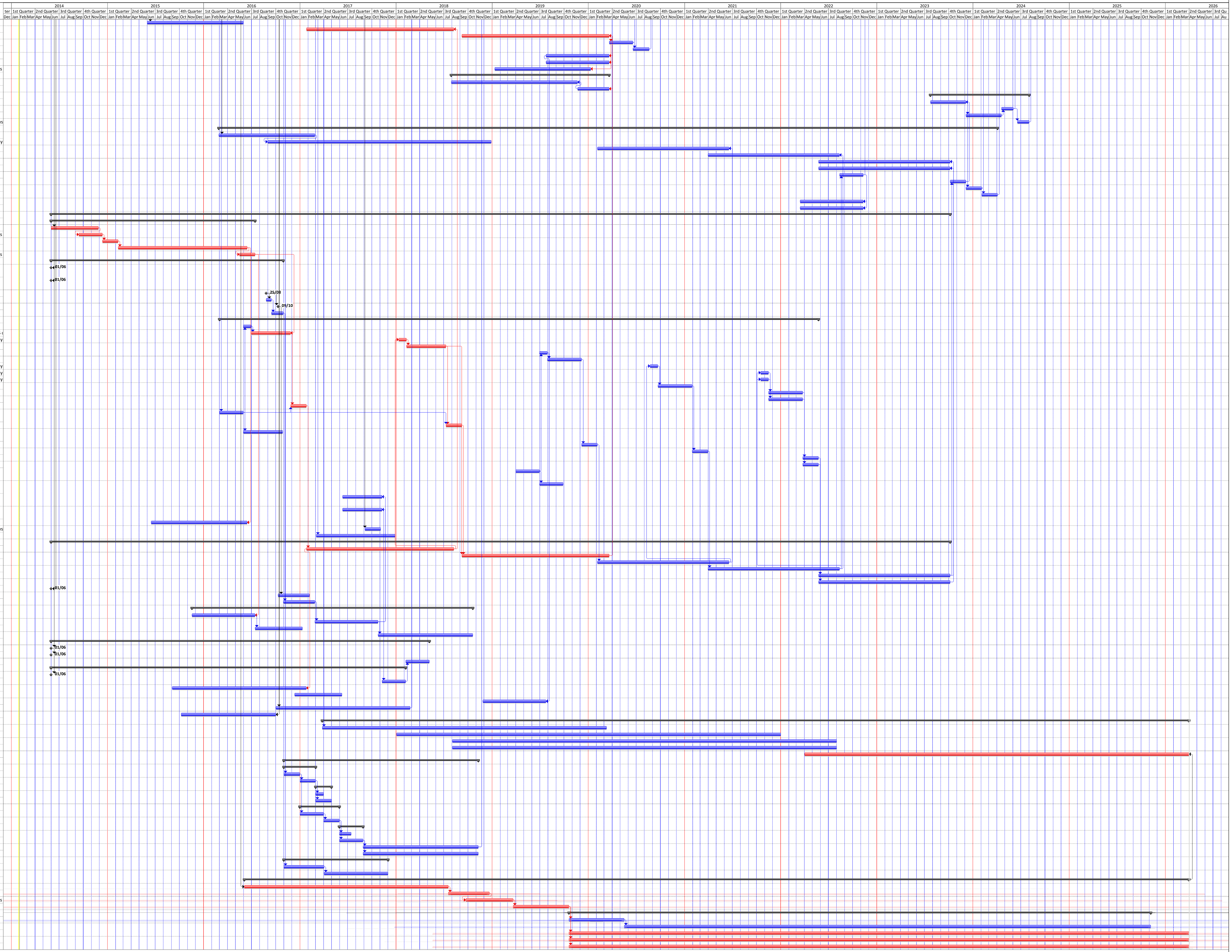
ID	Out Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
1	1	1	**Key events**	**3715 days**	**Sun 01/06/14**	**Thu 01/08/24**	
2	2	1.1	Client / FUNDING AGENCIES TEAS validation	0 days	Sun 01/06/14	Sun 01/06/14	
3	2	1.2	Vakhsh River diversion	0 days	**Sat 01/10/16**	Sat 01/10/16	75
4	2	1.3	**UNIT 5 final runners and temporary generators**	0 days	Wed 19/08/20	Wed 19/08/20	145
5	2	1.4	**UNIT 6 final runners and temporary generators**	0 days	Thu 18/06/20	Thu 18/06/20	144
6	2	1.5	**UNIT 5 final generators**	0 days	Thu 01/08/24	Thu 01/08/24	156
7	2	1.6	**UNIT 6 final generators**	0 days	Sun 02/06/24	Sun 02/06/24	154
8	2	1.7	**UNIT 1**	0 days	Wed 03/04/24	Wed 03/04/24	167
9	2	1.8	**UNIT 2**	0 days	Sat 03/02/24	Sat 03/02/24	166
10	2	1.9	**UNIT 3**	0 days	Tue 05/12/23	Tue 05/12/23	165
11	2	1.1	**UNIT 4**	0 days	Thu 10/11/22	Thu 10/11/22	164
12	**2**	**1.1**	**CIVIL WORKS MAIN CONTRACTOR**	**1007 days**	**Sun 01/06/14**	**Fri 03/03/17**	
13	3	1.1	Technical specification	270 days	Sun 01/06/14	Wed 25/02/15	2
14	3	1.1	Condition of contract	270 days	Sun 01/06/14	Wed 25/02/15	2
15	3	1.1	Tender	187 days	Thu 26/02/15	Mon 31/08/15	14
16	3	1.1	Award of contract	185 days	Tue 01/09/15	Thu 03/03/16	15
17	3	1.1	Contract signature	0 days	Thu 03/03/16	Thu 03/03/16	16
18	3	1.1	Main Contractor mobilisation	365 days	Fri 04/03/16	Fri 03/03/17	17
19	3	1.1	Tests on Physical Models of hydraulic facilities and design	360 days	Fri 28/11/14	Sun 22/11/15	2FS+180 days
20	2	1.1	**CIVIL WORKS PRE - CONTRACT**	1 day	Sun 01/06/14	Sun 01/06/14	21
21	2	1.1	Commencement of pre-contract	0 days	Sun 01/06/14	Sun 01/06/14	2
22	**2**	**1.1**	**EM**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
23	**3**	**1.1**	**UNIT 5-6 Final Runners**	**365 days**	**Sun 01/06/14**	**Sun 31/05/15**	
24	4	1.1	Design specifications	153 days	Sun 01/06/14	Fri 31/10/14	2
25	4	1.1	Contract preparation	153 days	Sat 01/11/14	Thu 02/04/15	24
26	4	1.1	Negotiation	59 days	Fri 03/04/15	Sun 31/05/15	25
27	4	1.1	Contract signature	0 days	Sun 31/05/15	Sun 31/05/15	26
28	**3**	**1.1**	**UNIT 1 - 2 - 3 - 4**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
29	4	1.1	Design specifications	365 days	Sun 01/06/14	Sun 31/05/15	2
30	4	1.1	Contract preparation	365 days	Sun 01/06/14	Sun 31/05/15	2
31	4	1.1	Tender	272 days	Mon 01/06/15	Sat 27/02/16	30
32	4	1.1	Contract signature	0 days	Sat 27/02/16	Sat 27/02/16	31
33	1	2	**ROADS AND SITE INSTALLATIONS**	**4270 days**	**Sun 01/06/14**	**Sat 07/02/26**	
34	2	2.1	Site installations main contractor	365 days	Tue 03/05/16	Tue 02/05/17	18SS+60 days
35	2	2.2	REHABILITATION OF ALL EXISTING ROADS INCLUDING ROGUN TOWN ACCESS ROAD	660 days	Sun 01/06/14	Mon 21/03/16	2
36	2	2.3	BATCH PLANT+ AGGREGATE PLANT REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
37	2	2.4	ROGUN BUILDING REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
38	2	2.5	FRESH WATER + SEWAGE SYSTEM REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
39	2	2.6	TELECOMMUNICATION SYSTEM	660 days	Sun 01/06/14	Mon 21/03/16	2
40	2	2.7	REMOVAL OF SCRAP MATERIALS AND EQUIPMENT LOCATED IN CONSTRUCTION SITE N.1	660 days	Sun 01/06/14	Mon 21/03/16	2
41	2	2.8	Construction of temporary roads+Services roads	4270 days	Sun 01/06/14	Sat 07/02/26	2
42	2	2.9	Road to tunnel T-50A	155 days	Sun 01/06/14	Sun 02/11/14	2
43	2	2.1	Road from tunnel T-50A to perm. intake and gates shaft yard	50 days	Tue 29/09/15	Tue 17/11/15	61
44	**2**	**2.1**	**Conveyor**	**725 days**	**Sun 01/06/14**	**Wed 25/05/16**	
45	3	2.1	Order	180 days	Sun 01/06/14	Thu 27/11/14	
46	3	2.1	Delivering	365 days	Fri 28/11/14	Fri 27/11/15	45
47	3	2.1	Installation	180 days	Sat 28/11/15	Wed 25/05/16	46
48	2	2.1	Quarrying activities	3000 days	Sun 01/06/14	Wed 17/08/22	2
49	2	2.1	Material extraction from quarry N.15	1097 days	Sun 01/06/14	Thu 01/06/17	2
50	1	3	**Transportation structures**	**1623 days**	**Sun 01/06/14**	**Fri 09/11/18**	
51	2	3.1	T18 ADIT TO UPPER PENSTOCK ELBOW and completion of P28 ADIT TO LOWER PENSTOCK ELBOW	410 days	Fri 28/11/14	Mon 11/01/16	2FS+180 days
52	2	3.2	REHABILITATION/COMPLETION Access Adit P21 - Constr. Adit P37	460 days	Fri 28/11/14	Tue 01/03/16	2FS+180 days
53	2	3.3	Conveyor tunnel 7B and 9 + EXT	900 days	Sun 01/06/14	Wed 16/11/16	
54	2	3.4	VENTILATION GALLERY AND VENTILATION SHAFT	488 days	Tue 12/01/16	Sat 13/05/17	51
55	2	3.5	T-10, T-10 A	365 days	Fri 10/11/17	Fri 09/11/18	258FF
56	2	3.6	T-22	360 days	Wed 08/10/14	Sat 03/10/15	3SF-365 days
57	2	3.7	REMEDIAL WORKS T-3', T-4, T-6, T-37, T-3, T-37', drainage galleries	1095 days	Sun 01/06/14	Tue 30/05/17	2
58	2	3.8	COMPLETION T-2 and T-8	360 days	Sun 01/06/14	Tue 26/05/15	2
59	2	3.9	T-3a	440 days	Sun 27/08/17	Fri 09/11/18	258FF
60	2	3.1	T-39	1030 days	Sun 01/06/14	Sun 26/03/17	2
61	2	3.1	T-50A	330 days	Mon 03/11/14	Mon 28/09/15	42
62	1	4	**RIVER DIVERSION STRUCTURES**	**1424 days**	**Sun 01/06/14**	**Tue 24/04/18**	
63	**2**	**4.1**	**Upstream cofferdam CREST ELEVATION 1050**	**252 days**	**Sun 02/10/16**	**Sat 10/06/17**	**3**
64	3	4.1.	Cofferdam Shells Filling	252 days	Sun 02/10/16	Sat 10/06/17	3
65	3	4.1.	Membrane installation including cut off excavation	252 days	Sun 02/10/16	Sat 10/06/17	
66	3	4.1.	Grouting works	60 days	Sun 02/10/16	Wed 30/11/16	
67	2	4.2	**Downstream cofferdam n1 located D/S the culverts + three temporary cofferdam including dewatering**	30 days	Sun 02/10/16	Mon 31/10/16	3
68	2	4.3	**Downstream cofferdam n2 located U/S the final outlet of DT 1 and DT2**	60 days	Sat 24/02/18	Tue 24/04/18	237
69	**2**	**4.4**	**DT1 and DT2**	**695 days**	**Sun 01/06/14**	**Mon 25/04/16**	
70	3	4.4.	Design	180 days	Sun 01/06/14	Thu 27/11/14	2
71	**3**	**4.4.**	**Rehabilitation works CIVIL WORKS**	**455 days**	**Fri 28/11/14**	**Thu 25/02/16**	
72	4	4.4.	Contractor mobilisation	90 days	Fri 28/11/14	Wed 25/02/15	70
73	4	4.4.	Rehabilitation works	365 days	Thu 26/02/15	Thu 25/02/16	72
74	3	4.4.	**Rehabilitation works HSS WORKS**	60 days	Fri 26/02/16	Mon 25/04/16	73
75	2	4.5	DT3	854 days	Sun 01/06/14	Sat 01/10/16	
76	1	5	**POWER SYSTEM STRUCTURES**	**3715 days**	**Sun 01/06/14**	**Thu 01/08/24**	
77	**2**	**5.1**	**Power waterways**	**3715 days**	**Sun 01/06/14**	**Thu 01/08/24**	
78	**3**	**5.1.**	**Intakes**	**2830 days**	**Wed 18/11/15**	**Thu 17/08/23**	
79	4	5.1.	Temporary intake excavation + concreting	180 days	Sat 04/03/17	Wed 30/08/17	18
80	**4**	**5.1.**	**Permanent intakes**	**2830 days**	**Wed 18/11/15**	**Thu 17/08/23**	
81	5	5.1.	INTAKES EXCAVATION down to Power Tunnel	340 days	Wed 18/11/15	Sat 22/10/16	43
82	5	5.1.	INTAKES EXCAVATION below the Power Tunnel	140 days	Tue 20/06/17	Mon 06/11/17	91
83	5	5.1.	INTAKES CONCRETE WORKS up to Power Tunnel	260 days	Tue 07/11/17	Tue 24/07/18	82
84	5	5.1.	INTAKES CONCRETE WORKS to the crest elevation	640 days	Fri 06/11/20	Sun 07/08/22	95
85	5	5.1.	HSS (trashracks and gates) including gates shaft	775 days	Sun 04/07/21	Thu 17/08/23	84SS+240 days
86	**3**	**5.1.**	**Headrace tunnel**	**1475 days**	**Sun 23/10/16**	**Thu 05/11/20**	
87	4	5.1.	Headrace tunnel - temporary	90 days	Sat 04/03/17	Thu 01/06/17	18
88	**4**	**5.1.**	**Headrace tunnel - permanent**	**1475 days**	**Sun 23/10/16**	**Thu 05/11/20**	
89	**5**	**5.1.**	**HORIZONTAL TUNNEL EXCAVATION el 1140**	**240 days**	**Sun 23/10/16**	**Mon 19/06/17**	
90	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Sun 23/10/16	Sun 19/02/17	81
91	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Mon 20/02/17	Mon 19/06/17	90
92	**5**	**5.1.**	**Horizontal tunnels Concreting works el 1140**	**820 days**	**Thu 09/08/18**	**Thu 05/11/20**	
93	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Thu 09/08/18	Tue 06/11/18	102;83
94	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Fri 09/08/19	Wed 06/11/19	104
95	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Sat 08/08/20	Thu 05/11/20	106
96	**5**	**5.1.**	**GATES EXCAVATION**	**1095 days**	**Mon 20/02/17**	**Wed 19/02/20**	
97	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Mon 20/02/17	Mon 19/02/18	90
98	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Tue 20/02/18	Tue 19/02/19	97
99	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Wed 20/02/19	Wed 19/02/20	98
100	**5**	**5.1.**	**GATES SHAFT CONCRETING**	**900 days**	**Tue 20/02/18**	**Fri 07/08/20**	
101	6	5.1.	Gates shaft 1	85 days	Tue 20/02/18	Tue 15/05/18	97
102	6	5.1.	Gates shaft 2	85 days	Wed 16/05/18	Wed 08/08/18	101
103	6	5.1.	Gates shaft 3	85 days	Wed 20/02/19	Wed 15/05/19	98
104	6	5.1.	Gates shaft 4	85 days	Thu 16/05/19	Thu 08/08/19	103
105	6	5.1.	Gates shaft 5	85 days	Thu 20/02/20	Thu 14/05/20	99
106	6	5.1.	Gates shaft 6	85 days	Fri 15/05/20	Fri 07/08/20	105
107	**3**	**5.1.**	**Pentocks**	**2835 days**	**Tue 12/01/16**	**Mon 16/10/23**	
108	4	5.1.	TEMPORARY	180 days	Sun 01/01/17	Thu 29/06/17	
109	**4**	**5.1.**	**PERMANENT**	**2835 days**	**Tue 12/01/16**	**Mon 16/10/23**	
110	5	5.1.	PENSTOCK ERECTION CHAMBER	250 days	Tue 12/01/16	Sat 17/09/16	51
111	**5**	**5.1.**	**SHAFT EXCAVATION RAISE BORER**	**360 days**	**Sun 18/09/16**	**Tue 12/09/17**	
112	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 5	60 days	Sun 18/09/16	Wed 16/11/16	110
113	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 6	60 days	Thu 17/11/16	Sun 15/01/17	112
114	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 3	60 days	Mon 16/01/17	Thu 16/03/17	113
115	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 4	60 days	Fri 17/03/17	Mon 15/05/17	114
116	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 1	60 days	Tue 16/05/17	Fri 14/07/17	115
117	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 2	60 days	Sat 15/07/17	Tue 12/09/17	116
118	**5**	**5.1.**	**PENSTOCK ENLARGEMENT**	**1095 days**	**Thu 17/11/16**	**Sat 16/11/19**	
119	6	5.1.	ENLARGEMENT PENSTOCK 6 AND 5	365 days	Thu 17/11/16	Thu 16/11/17	112
120	6	5.1.	ENLARGEMENT PENSTOCK 3 AND 4	365 days	Fri 17/11/17	Fri 16/11/18	119
121	6	5.1.	ENLARGEMENT PENSTOCK 1 AND 2	365 days	Sat 17/11/18	Sat 16/11/19	120
122	**5**	**5.1.**	**STEEL LINING PENSTOCKS INCLUDING CONCRETE WORKS**	**2160 days**	**Fri 17/11/17**	**Mon 16/10/23**	
123	6	5.1.	Steel lining PENSTOCK 5, 6	720 days	Fri 17/11/17	Wed 06/11/19	119
124	6	5.1.	Steel lining PENSTOCK 3, 4	720 days	Thu 07/11/19	Tue 26/10/21	123
125	6	5.1.	Steel lining PENSTOCK 1, 2	720 days	Wed 27/10/21	Mon 16/10/23	124
126	**3**	**5.1.**	**Manifold**	**2065 days**	**Wed 02/03/16**	**Wed 27/10/21**	
127	**4**	**5.1.**	**Excavation**	**330 days**	**Wed 02/03/16**	**Wed 25/01/17**	
128	5	5.1.	U4	60 days	Wed 02/03/16	Sat 30/04/16	52
129	5	5.1.	U1	90 days	Sun 01/05/16	Fri 29/07/16	128
130	5	5.1.	U2 - U3 - U5 - U6	180 days	Sat 30/07/16	Wed 25/01/17	129
131	**4**	**5.1.**	**Steel lining**	**1640 days**	**Mon 01/05/17**	**Wed 27/10/21**	
132	5	5.1.	UNIT 1	200 days	Sat 10/04/21	Wed 27/10/21	125SF
133	5	5.1.	UNIT 2	200 days	Sat 10/04/21	Wed 27/10/21	125SF
134	5	5.1.	UNIT 3	200 days	Sun 21/04/19	Thu 07/11/19	124SF
135	5	5.1.	UNIT 4	200 days	Sun 21/04/19	Thu 07/11/19	124SF
136	5	5.1.	UNIT 5	200 days	Mon 01/05/17	Fri 17/11/17	123SF
137	5	5.1.	UNIT 6	200 days	Mon 01/05/17	Fri 17/11/17	123SF
138	**3**	**5.1.**	**Powerhouse cavern and relevant structures**	**3715 days**	**Sun 01/06/14**	**Thu 01/08/24**	
139	**4**	**5.1.**	**EM EQUIPMENT**	**3350 days**	**Mon 01/06/15**	**Thu 01/08/24**	
140	**5**	**5.1.**	**UNIT 5-6 final runners and temporary generators**	**1907 days**	**Mon 01/06/15**	**Wed 19/08/20**	

Projet : 2013-1-3ROGUN
Date : Wed 29/01/14

Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

ROGUN FSL 1255

ID	Out Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
141	6	5.1.	Manufacturing + Delivering	365 days	Mon 01/06/15	Mon 30/05/16	27
142	6	5.1.	UNIT 6 ERECTION	560 days	Thu 26/01/17	Wed 08/08/18	213FF
143	6	5.1.	UNIT 5 ERECTION	560 days	Sat 08/09/18	Fri 20/03/20	214FF
144	6	5.1.	UNIT 6 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 21/03/20	Thu 18/06/20	143
145	6	5.1.	UNIT 5 (COMMISSIONING - DRY AND WET TESTS)	62 days	Fri 19/06/20	Wed 19/08/20	144
146	6	5.1.	Switchyard	240 days	Thu 25/07/19	Fri 20/03/20	143FF
147	6	5.1.	Transmission line	240 days	Thu 25/07/19	Fri 20/03/20	143FF
148	6	5.1.	Control room	365 days	Fri 11/01/19	Fri 10/01/20	143FF-70 days
149	**6**	**5.1.**	**TRANSFORMERS**	**600 days**	**Mon 30/07/18**	**Fri 20/03/20**	
150	7	5.1.	Delivering+Assembling on site	480 days	Mon 30/07/18	Fri 22/11/19	151SF
151	7	5.1.	Erection	120 days	Fri 22/11/19	Fri 20/03/20	143FF
152	**5**	**5.1.**	**UNIT 5-6 final generators**	**375 days**	**Mon 24/07/23**	**Thu 01/08/24**	
153	6	5.1.	U6 generator modification	135 days	Mon 24/07/23	Tue 05/12/23	165FF
154	6	5.1.	U6 COMMISSIONING	45 days	Fri 19/04/24	Sun 02/06/24	155
155	6	5.1.	U5 generator modification	135 days	Wed 06/12/23	Thu 18/04/24	153
156	6	5.1.	U5 COMMISSIONING	45 days	Tue 18/06/24	Thu 01/08/24	154FS+15 days
157	**5**	**5.1.**	**UNIT 1 - 2 - 3 - 4**	**2958 days**	**Sun 28/02/16**	**Wed 03/04/24**	
158	6	5.1.	Design	365 days	Sun 28/02/16	Sun 26/02/17	32
159	6	5.1.	Manufacturing + Delivering	850 days	Wed 31/08/16	Fri 28/12/18	158FS-180 day
160	6	5.1.	UNIT 4 ERECTION	500 days	Wed 05/02/20	Fri 18/06/21	215FF
161	6	5.1.	UNIT 3 ERECTION	500 days	Wed 31/03/21	Fri 12/08/22	216FF
162	6	5.1.	UNIT 2 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	217FF
163	6	5.1.	UNIT 1 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	218FF
164	6	5.1.	UNIT 4 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 13/08/22	Thu 10/11/22	216
165	6	5.1.	UNIT 3 (COMMISSIONING - DRY AND WET TESTS)	60 days	Sat 07/10/23	Tue 05/12/23	217
166	6	5.1.	UNIT 2 (COMMISSIONING - DRY AND WET TESTS)	60 days	Wed 06/12/23	Sat 03/02/24	165
167	6	5.1.	UNIT 1 (COMMISSIONING - DRY AND WET TESTS)	60 days	Sun 04/02/24	Wed 03/04/24	166
168	6	5.1.	Switchyard	240 days	Wed 16/03/22	Thu 10/11/22	164FF
169	6	5.1.	TRANSFORMERS	240 days	Wed 16/03/22	Thu 10/11/22	164FF
170	**4**	**5.1.**	**CIVIL WORKS**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
171	**5**	**5.1.**	**Wall support**	**775 days**	**Sun 01/06/14**	**Thu 14/07/16**	
172	6	5.1.	Design	180 days	Sun 01/06/14	Thu 27/11/14	2
173	6	5.1.	Mobilization	90 days	Sun 14/09/14	Fri 12/12/14	172FS-75 days
174	6	5.1.	Scaffolding installation	60 days	Sat 13/12/14	Tue 10/02/15	173
175	6	5.1.	MPSP system & tendons drilling, grouting and tensioni	490 days	Wed 11/02/15	Tue 14/06/16	174
176	6	5.1.	Scaffolding removal	60 days	Mon 16/05/16	Thu 14/07/16	175FS-30 days
177	**5**	**5.1.**	**BUS DUCT**	**882 days**	**Sun 01/06/14**	**Sat 29/10/16**	
178	6	5.1.	BUS DUCT EXCAVATION EL 969 Units 6, 5, 4 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
179	6	5.1.	BUS DUCT EXCAVATION EL 983 Units 6,5, 4 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
180	6	5.1.	BUS DUCT EXCAVATION EL 969 Unit 3 (completed)	0 days	Thu 25/08/16	Thu 25/08/16	
181	6	5.1.	BUS DUCT EXCAVATION EL 969 Units 2, 1	20 days	Fri 26/08/16	Wed 14/09/16	180
182	6	5.1.	BUS DUCT EXCAVATION EL 983 Unit 3 (completed)	0 days	Sun 09/10/16	Sun 09/10/16	180
183	6	5.1.	BUS DUCT EXCAVATION EL 983 Units 2, 1	45 days	Thu 15/09/16	Sat 29/10/16	181
184	**5**	**5.1.**	**Cavern excavation**	**2275 days**	**Wed 02/03/16**	**Tue 24/05/22**	
185	6	5.1.	Excavation of shaft of Unit 6	30 days	Tue 31/05/16	Wed 29/06/16	198
186	6	5.1.	Excavation of Unit 6 from el. 964.25 to el. 946.90	150 days	Thu 30/06/16	Sat 26/11/16	185;176FF-15 d
187	6	5.1.	Excavation of shaft of Unit 5	30 days	Thu 11/01/18	Fri 09/02/18	213FS-210 day
188	6	5.1.	Excavation of Unit 5 from el. 964.25 to el. 946.90	150 days	Sat 10/02/18	Mon 09/07/18	187
189	6	5.1.	Excavation of shaft of Unit 4	30 days	Sun 30/06/19	Mon 29/07/19	205
190	6	5.1.	Excavation of Unit 4 from el. 964.25 to el. 946.90	130 days	Tue 30/07/19	Fri 06/12/19	189
191	6	5.1.	Excavation of shaft of Unit 3	30 days	Sun 23/08/20	Mon 21/09/20	215FS-300 day
193	6	5.1.	Excavation of shaft of Unit 2	30 days	Sun 17/10/21	Mon 15/11/21	216FS-300 day
195	6	5.1.	Excavation of shaft of Unit 1	30 days	Sun 17/10/21	Mon 15/11/21	216FS-300 day
192	6	5.1.	Excavation of Unit 3 from el. 964.25 to el. 946.90	130 days	Tue 22/09/20	Fri 29/01/21	191
194	6	5.1.	Excavation of Unit 2 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	193
196	6	5.1.	Excavation of Unit 1 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	195
197	6	5.1.	Excavation of Pit of Unit 6	60 days	Sun 27/11/16	Wed 25/01/17	198;186
198	6	5.1.	DT Units 5 and 6 at el 932, from drainage gallery to pit (U/S direction)	90 days	Wed 02/03/16	Mon 30/05/16	52
199	6	5.1.	Excavation of Pit of Unit 5	60 days	Tue 10/07/18	Fri 07/09/18	198;188
200	6	5.1.	DT Units 5 and 6 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Tue 31/05/16	Thu 27/10/16	198
201	6	5.1.	Excavation of Pit of Unit 4	60 days	Sat 07/12/19	Tue 04/02/20	190
202	6	5.1.	Excavation of Pit of Unit 3	60 days	Sat 30/01/21	Tue 30/03/21	192
203	6	5.1.	Excavation of Pit of Unit 2	60 days	Sat 26/03/22	Tue 24/05/22	194
204	6	5.1.	Excavation of Pit of Unit 1	60 days	Sat 26/03/22	Tue 24/05/22	196
205	6	5.1.	DT Units 4 and 3 at el 932, from drainage gallery to pit (U/S direction)	90 days	Mon 01/04/19	Sat 29/06/19	
206	6	5.1.	DT Units 2 and 1 at el 932, from drainage gallery to pit (U/S direction)	90 days	Sun 30/06/19	Fri 27/09/19	205
207	6	5.1.	DT Units 4 and 3 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	225FF+15 days
208	6	5.1.	DT Units 2 and 1 - from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	225FF+15 days
209	5	5.1.	Stabilization works of overhead travelling crane beam	365 days	Tue 16/06/15	Tue 14/06/16	175FF
210	5	5.1.	Main gantry crane erection	60 days	Tue 05/09/17	Fri 03/11/17	17FS+550 days
211	5	5.1.	Grouting works	300 days	Sat 04/03/17	Thu 28/12/17	18
212	**5**	**5.1.**	**Concrete works (made in parallel with E&M erection)**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
213	6	5.1.	UNIT 6	560 days	Thu 26/01/17	Wed 08/08/18	197
214	6	5.1.	UNIT 5	560 days	Sat 08/09/18	Fri 20/03/20	188;199
215	6	5.1.	UNIT 4	500 days	Wed 05/02/20	Fri 18/06/21	201
216	6	5.1.	UNIT 3	500 days	Wed 31/03/21	Fri 12/08/22	202
217	6	5.1.	UNIT 2	500 days	Wed 25/05/22	Fri 06/10/23	203
218	6	5.1.	UNIT 1	500 days	Wed 25/05/22	Fri 06/10/23	204
219	6	5.1.	Bus Duct Lining Units 6, 5 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
220	6	5.1.	Bus duct lining Units 4, 3	120 days	Mon 10/10/16	Mon 06/02/17	182
221	6	5.1.	Bus duct lining Units 2, 1	120 days	Sun 30/10/16	Sun 26/02/17	183
222	**5**	**5.1.**	**TRANSFORMER HALL**	**1067 days**	**Wed 18/11/15**	**Fri 19/10/18**	
223	6	5.1.	Excavation transformer chamber for Units 6 and 5	240 days	Wed 18/11/15	Thu 14/07/16	176FF
225	6	5.1.	Excavation transformer chamber for Units 4, 3, 2, 1	240 days	Mon 27/02/17	Tue 24/10/17	221
224	6	5.1.	Concreting+ finishing for units 6 and 5	180 days	Fri 15/07/16	Tue 10/01/17	223
226	6	5.1.	Concreting+ finishing for Units 4, 3, 2, 1	360 days	Wed 25/10/17	Fri 19/10/18	225
227	**5**	**5.1.**	**Branches from transformer chamber to main collector**	**1437 days**	**Sun 01/06/14**	**Mon 07/05/18**	
228	6	5.1.	U4 U5 U6 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2
229	6	5.1.	Slot U6	0 days	Sun 01/06/14	Sun 01/06/14	228
230	6	5.1.	U1 U2 U3	90 days	Wed 07/02/18	Mon 07/05/18	233
231	**5**	**5.1.**	**Main collector**	**1347 days**	**Sun 01/06/14**	**Tue 06/02/18**	
232	6	5.1.	U4 U5 U6 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2
233	6	5.1.	U1 U2 U3	90 days	Thu 09/11/17	Tue 06/02/18	208
234	3	5.1.	Cable galleries lining rehabilitation works N1 and N2	510 days	Fri 04/09/15	Thu 26/01/17	213SF
235	3	5.1.	Control room	180 days	Mon 12/12/16	Fri 09/06/17	
236	3	5.1.	Switchyard	240 days	Tue 27/11/18	Thu 25/07/19	146SF
237	3	5.1.	DT1 and DT2 Culverts in the river bed	510 days	Sun 02/10/16	Fri 23/02/18	3
238	3	5.1.	Excavation in the riverbed at DTs outlets	360 days	Thu 08/10/15	Sat 01/10/16	3FF
239	**1**	**6**	**FLOOD MANAGEMENT STRUCTURES**	**3292 days**	**Mon 27/03/17**	**Tue 31/03/26**	
240	2	6.1	**Middle level outlet 1**	1080 days	Mon 27/03/17	Tue 10/03/20	60
241	2	6.2	**High level outlet tunnel spillway 1**	1460 days	Wed 03/01/18	Sat 01/01/22	
242	2	6.3	**High level outlet tunnel spillway 2**	1460 days	Fri 03/08/18	Mon 01/08/22	
243	2	6.4	**High level outlet tunnel spillway 3**	1460 days	Fri 03/08/18	Mon 01/08/22	
244	2	6.5	**Surface Spillway**	1460 days	Sat 02/04/22	Tue 31/03/26	263FF
245	**1**	**7**	**Stage 1 Dam Crest Elevation 1090 masl**	**739 days**	**Tue 01/11/16**	**Fri 09/11/18**	
246	**2**	**7.1**	**Concrete plinth (BOTTOM OF THE VALLEY)**	**121 days**	**Tue 01/11/16**	**Wed 01/03/17**	
247	3	7.1.	Excavation + foundation treatment	61 days	Tue 01/11/16	Sat 31/12/16	67
248	3	7.1.	Concrete works including anchor bars	60 days	Sun 01/01/17	Wed 01/03/17	247
249	**2**	**7.2**	**Grouting works (BOTTOM OF THE VALLEY)**	**60 days**	**Thu 02/03/17**	**Sun 30/04/17**	
250	3	7.2.	Consolidation grouting	30 days	Thu 02/03/17	Fri 31/03/17	248
251	3	7.2.	Curtain grouting	60 days	Thu 02/03/17	Sun 30/04/17	248
252	**2**	**7.3**	**Concrete plinth (ABUTMENT)**	**150 days**	**Sun 01/01/17**	**Tue 30/05/17**	
253	3	7.3.	Excavation + foundation treatment	90 days	Sun 01/01/17	Fri 31/03/17	247
254	3	7.3.	Concrete works including anchor bars	60 days	Sat 01/04/17	Tue 30/05/17	253
255	**2**	**7.4**	**Grouting works (ABUTMENT)**	**90 days**	**Wed 31/05/17**	**Mon 28/08/17**	
256	3	7.4.	Consolidation grouting	45 days	Wed 31/05/17	Fri 14/07/17	254
257	3	7.4.	Curtain grouting	90 days	Wed 31/05/17	Mon 28/08/17	254
258	2	7.5	Asphalt concrete core including transition layers	438 days	Tue 29/08/17	Fri 09/11/18	257
259	2	7.6	Dam Shells Filling	438 days	Tue 29/08/17	Fri 09/11/18	257
260	**1**	**8**	**Salt dome works**	**396 days**	**Tue 01/11/16**	**Fri 01/12/17**	
261	2	8.1	Excavation + foundation treatment + Concrete slab	153 days	Tue 01/11/16	Sun 02/04/17	67
262	2	8.2	Grouting + Drainage	243 days	Mon 03/04/17	Fri 01/12/17	261
263	**1**	**9**	**Dam for full capacity Crest elevation 1265 m**	**3588 days**	**Sat 04/06/16**	**Tue 31/03/26**	
264	2	9.1	Core foundation, excavation on the abutment	775 days	Sat 04/06/16	Wed 18/07/18	3FS-120 days
265	2	9.2	Core foundation excavation at the bottom of the valley	156 days	Thu 19/07/18	Fri 21/12/18	264
266	2	9.3	Foundation treatment	180 days	Sun 23/09/18	Thu 21/03/19	265FS-90 days
267	2	9.4	RCC slab at the base of the core	212 days	Fri 22/03/19	Sat 19/10/19	266
268	**2**	**9.5**	**Grouting works**	**2210 days**	**Sun 20/10/19**	**Thu 06/11/25**	
269	3	9.5.	ConsolidatIon grouting	210 days	Sun 20/10/19	Sat 16/05/20	267
270	3	9.5.	Curtain grouting	2000 days	Sun 17/05/20	Thu 06/11/25	269
271	2	9.6	Filling Core	2355 days	Sun 20/10/19	Tue 31/03/26	267
272	2	9.7	Filling Filters	2355 days	Sun 20/10/19	Tue 31/03/26	267
273	2	9.8	Filling shells (INCLUDING rip rap)	2355 days	Sun 20/10/19	Tue 31/03/26	267



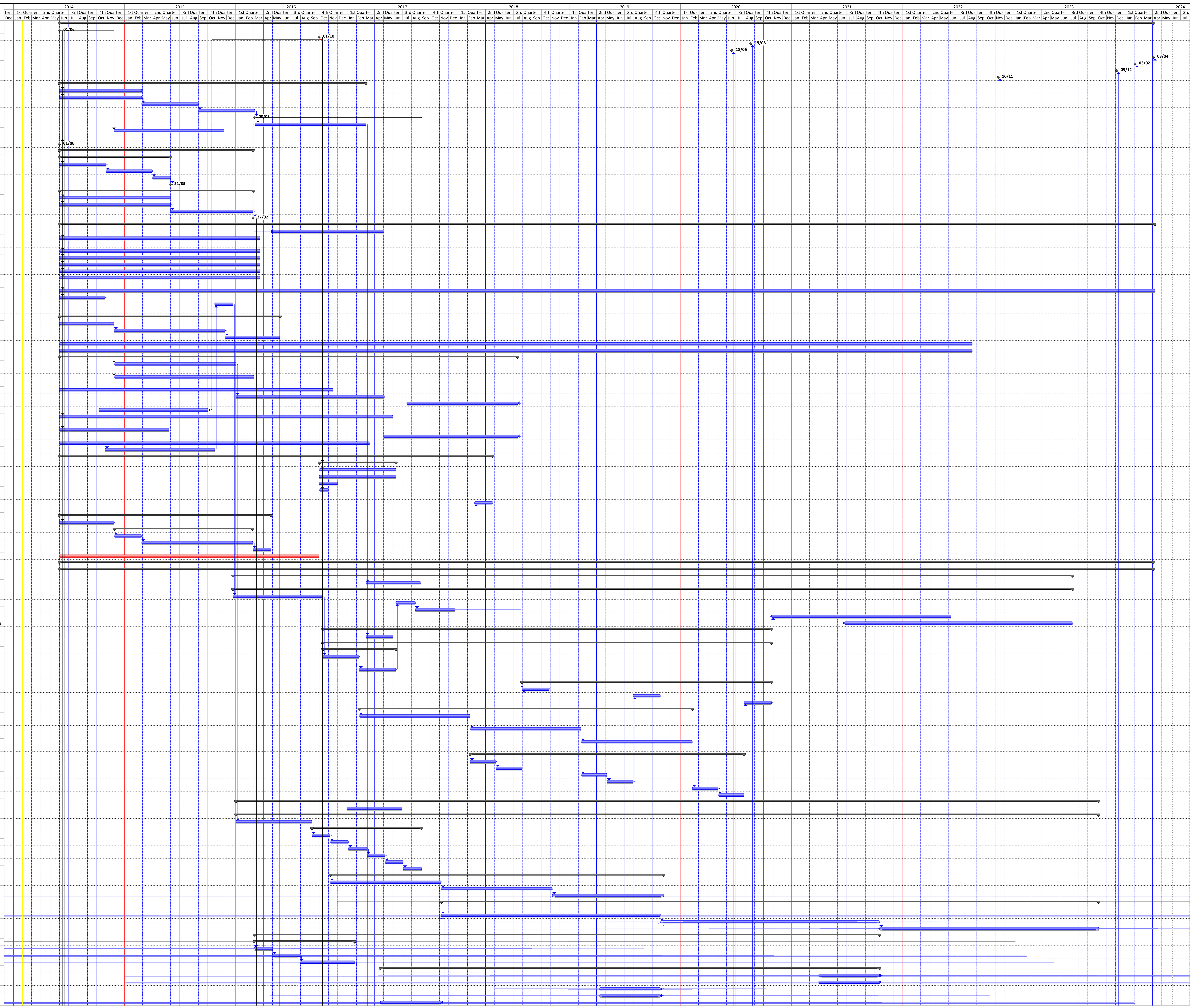
Projet : 2013-1-3ROGUN
Date : Wed 29/01/14

Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

ROGUN FSL 1220

Wed 29/01/14 16:06

ID	Outline Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
1	**1**	**1**	**Key events**	**3595 days**	**Sun 01/06/14**	**Wed 03/04/24**	
2	2	1.1	Client / FUNDING AGENCIES TEAS validation	0 days	Sun 01/06/14	Sun 01/06/14	
3	2	1.2	Vakhsh River diversion	0 days	**Sat 01/10/16**	Sat 01/10/16	73
4	2	1.3	**UNIT 5 final runner and final generator**	0 days	Wed 19/08/20	Wed 19/08/20	143
5	2	1.4	**UNIT 6 final runner and final generator**	0 days	Thu 18/06/20	Thu 18/06/20	142
6	2	1.5	**UNIT 1**	0 days	Wed 03/04/24	Wed 03/04/24	160
7	2	1.6	**UNIT 2**	0 days	Sat 03/02/24	Sat 03/02/24	159
8	2	1.7	**UNIT 3**	0 days	Tue 05/12/23	Tue 05/12/23	158
9	2	1.8	**UNIT 4**	0 days	Thu 10/11/22	Thu 10/11/22	157
10	**2**	**1.9**	**CIVIL WORKS MAIN CONTRACTOR**	**1007 days**	**Sun 01/06/14**	**Fri 03/03/17**	
11	3	1.9.	Technical specification	270 days	Sun 01/06/14	Wed 25/02/15	2
12	3	1.9.	Condition of contract	270 days	Sun 01/06/14	Wed 25/02/15	2
13	3	1.9.	Tender	187 days	Thu 26/02/15	Mon 31/08/15	12
14	3	1.9.	Award of contract	185 days	Tue 01/09/15	Thu 03/03/16	13
15	3	1.9.	Contract signature	0 days	Thu 03/03/16	Thu 03/03/16	14
16	3	1.9.	Main Contractor mobilisation	365 days	Fri 04/03/16	Fri 03/03/17	15
17	3	1.9.	Tests on Physical Models of hydraulic facilities and design	360 days	Fri 28/11/14	Sun 22/11/15	2FS+180 days
18	2	1.1	**CIVIL WORKS PRE - CONTRACT**	1 day	Sun 01/06/14	Sun 01/06/14	19
19	2	1.1	Commencement of pre-contract	0 days	Sun 01/06/14	Sun 01/06/14	
20	**2**	**1.1**	**EM**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
21	**3**	**1.1**	**UNIT 5-6 Final runners**	**365 days**	**Sun 01/06/14**	**Sun 31/05/15**	
22	4	1.1	Design specifications	153 days	Sun 01/06/14	Fri 31/10/14	2
23	4	1.1	Contract preparation	153 days	Sat 01/11/14	Thu 02/04/15	22
24	4	1.1	Negotiation	59 days	Fri 03/04/15	Sun 31/05/15	23
25	4	1.1	Contract signature	0 days	Sun 31/05/15	Sun 31/05/15	24
26	**3**	**1.1**	**UNIT 1 - 2 - 3 - 4**	**637 days**	**Sun 01/06/14**	**Sat 27/02/16**	
27	4	1.1	Design specifications	365 days	Sun 01/06/14	Sun 31/05/15	2
28	4	1.1	Contract preparation	365 days	Sun 01/06/14	Sun 31/05/15	2
29	4	1.1	Tender	272 days	Mon 01/06/15	Sat 27/02/16	28
30	4	1.1	Contract signature	0 days	Sat 27/02/16	Sat 27/02/16	29
31	**1**	**2**	**ROADS AND SITE INSTALLATIONS**	**3600 days**	**Sun 01/06/14**	**Mon 08/04/24**	
32	2	2.1	Site installations main contractor	365 days	Tue 03/05/16	Tue 02/05/17	16SS+60 days
33	2	2.2	REHABILITATION OF ALL EXISTING ROADS INCLUDING ROGUN TOWN ACCESS ROAD	660 days	Sun 01/06/14	Mon 21/03/16	2
34	2	2.3	BATCH PLANT+ AGGREGATE PLANT REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
35	2	2.4	ROGUN BUILDING REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
36	2	2.5	FRESH WATER + SEWAGE SYSTEM REHABILITATION	660 days	Sun 01/06/14	Mon 21/03/16	2
37	2	2.6	TELECOMMUNICATION SYSTEM	660 days	Sun 01/06/14	Mon 21/03/16	2
38	2	2.7	REMOVAL OF SCRAP MATERIALS AND EQUIPMENT LOCATED IN CONSTRUCTION SITE N.1	660 days	Sun 01/06/14	Mon 21/03/16	2
39	2	2.8	Construction of temporary roads+Services roads	3600 days	Sun 01/06/14	Mon 08/04/24	2
40	2	2.9	Road to tunnel T-50A	150 days	Sun 01/06/14	Tue 28/10/14	2
41	2	2.1	Road from tunnel T-50A to perm. intake and gates shaft yard	60 days	Sat 24/10/15	Tue 22/12/15	59
42	**2**	**2.1**	**Conveyor**	**725 days**	**Sun 01/06/14**	**Wed 25/05/16**	
43	3	2.1	Order	180 days	Sun 01/06/14	Thu 27/11/14	
44	3	2.1	Delivering	365 days	Fri 28/11/14	Fri 27/11/15	43
45	3	2.1	Installation	180 days	Sat 28/11/15	Wed 25/05/16	44
46	2	2.1	Quarrying activities	3000 days	Sun 01/06/14	Wed 17/08/22	
47	2	2.1	Material extraction from quarry N.15	3000 days	Sun 01/06/14	Wed 17/08/22	
48	**1**	**3**	**Transportation structures**	**1506 days**	**Sun 01/06/14**	**Sun 15/07/18**	
49	2	3.1	T18 ADIT TO UPPER PENSTOCK ELBOW and completion of P28 ADIT TO LOWER PENSTOCK ELBOW	400 days	Fri 28/11/14	Fri 01/01/16	2FS+180 days
50	2	3.2	REHABILITATION/COMPLETION Access Adit P21 - Constr. Adit P37	460 days	Fri 28/11/14	Tue 01/03/16	2FS+180 days
51	2	3.3	Conveyor tunnel 7B and 9 + EXT	900 days	Sun 01/06/14	Wed 16/11/16	
52	2	3.4	VENTILATION GALLERY AND VENTILATION SHAFT	488 days	Sat 02/01/16	Wed 03/05/17	49
53	2	3.5	T-10, T-10 A	365 days	Sun 16/07/17	Sun 15/07/18	249FF
54	2	3.6	T-22	360 days	Wed 08/10/14	Sat 03/10/15	3SF-365 days
55	2	3.7	REMEDIAL WORKS T-3', T-4, T-6, T-37, T-3, T-37', drainage galleries	1095 days	Sun 01/06/14	Tue 30/05/17	2
56	2	3.8	COMPLETION T-2 and T-8	360 days	Sun 01/06/14	Tue 26/05/15	2
57	2	3.9	T-3a	440 days	Tue 02/05/17	Sun 15/07/18	249FF
58	2	3.1	T-39	1020 days	Sun 01/06/14	Thu 16/03/17	
59	2	3.1	T-50A	360 days	Wed 29/10/14	Fri 23/10/15	40
60	**1**	**4**	**RIVER DIVERSION STRUCTURES**	**1424 days**	**Sun 01/06/14**	**Tue 24/04/18**	
61	**2**	**4.1**	**Upstream cofferdam CREST ELEVATION 1050**	**252 days**	**Sun 02/10/16**	**Sat 10/06/17**	**3**
62	3	4.1.	Cofferdam Shells Filling	252 days	Sun 02/10/16	Sat 10/06/17	3
63	3	4.1.	Membrane installation including cut off excavation	252 days	Sun 02/10/16	Sat 10/06/17	
64	3	4.1.	Grouting works	60 days	Sun 02/10/16	Wed 30/11/16	
65	2	4.2	**Downstream cofferdam n1 located D/S the culverts + three temporary cofferdam including dewatering**	30 days	Sun 02/10/16	Mon 31/10/16	3
66	2	4.3	**Downstream cofferdam n2 located U/S the final outlet of DT 1 and DT2**	60 days	Sat 24/02/18	Tue 24/04/18	230
67	**2**	**4.4**	**DT1 and DT2**	**695 days**	**Sun 01/06/14**	**Mon 25/04/16**	
68	3	4.4.	Design	180 days	Sun 01/06/14	Thu 27/11/14	2
69	**3**	**4.4.**	**Rehabilitation works CIVIL WORKS**	**455 days**	**Fri 28/11/14**	**Thu 25/02/16**	
70	4	4.4.	Contractor mobilisation	90 days	Fri 28/11/14	Wed 25/02/15	68
71	4	4.4.	Rehabilitation works	365 days	Thu 26/02/15	Thu 25/02/16	70
72	3	4.4.	**Rehabilitation works HSS WORKS**	60 days	Fri 26/02/16	Mon 25/04/16	71
73	2	4.5	DT3	854 days	Sun 01/06/14	Sat 01/10/16	
74	**1**	**5**	**POWER SYSTEM STRUCTURES**	**3595 days**	**Sun 01/06/14**	**Wed 03/04/24**	
75	**2**	**5.1**	**Power waterways**	**3595 days**	**Sun 01/06/14**	**Wed 03/04/24**	
76	**3**	**5.1.**	**Intakes**	**2760 days**	**Wed 23/12/15**	**Thu 13/07/23**	
77	4	5.1.	Temporary intake excavation + concreting	180 days	Sat 04/03/17	Wed 30/08/17	16
78	**4**	**5.1.**	**Permanent intakes**	**2760 days**	**Wed 23/12/15**	**Thu 13/07/23**	
79	5	5.1.	INTAKES EXCAVATION down to Power Tunnel	295 days	Wed 23/12/15	Wed 12/10/16	41
80	5	5.1.	INTAKES EXCAVATION below the Power Tunnel	65 days	Sat 10/06/17	Sun 13/08/17	89
81	5	5.1.	INTAKES CONCRETE WORKS up to Power Tunnel	130 days	Mon 14/08/17	Thu 21/12/17	80
82	5	5.1.	INTAKES CONCRETE WORKS to the crest elevation	590 days	Tue 27/10/20	Wed 08/06/22	93
83	5	5.1.	HSS (trashracks and gates) including gates shaft	750 days	Thu 24/06/21	Thu 13/07/23	82SS+240 days
84	**3**	**5.1.**	**Headrace tunnel**	**1475 days**	**Thu 13/10/16**	**Mon 26/10/20**	
85	4	5.1.	Headrace tunnel - temporary	90 days	Sat 04/03/17	Thu 01/06/17	16
86	**4**	**5.1.**	**Headrace tunnel - permanent**	**1475 days**	**Thu 13/10/16**	**Mon 26/10/20**	
87	**5**	**5.1.**	**HORIZONTAL TUNNEL EXCAVATION el 1115**	**240 days**	**Thu 13/10/16**	**Fri 09/06/17**	
88	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Thu 13/10/16	Thu 09/02/17	79
89	6	5.1.	HORIZONTAL TUNNEL EXCAVATION 3 IN PARALLEL	120 days	Fri 10/02/17	Fri 09/06/17	88
90	**5**	**5.1.**	**Horizontal tunnels Concreting works el 1115**	**820 days**	**Mon 30/07/18**	**Mon 26/10/20**	
91	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Mon 30/07/18	Sat 27/10/18	100;81
92	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Tue 30/07/19	Sun 27/10/19	102
93	6	5.1.	Horizontal tunnel 2 in parallel	90 days	Wed 29/07/20	Mon 26/10/20	104
94	**5**	**5.1.**	**GATES EXCAVATION**	**1095 days**	**Fri 10/02/17**	**Sun 09/02/20**	
95	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Fri 10/02/17	Fri 09/02/18	88
96	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Sat 10/02/18	Sat 09/02/19	95
97	6	5.1.	EXC GATES SHAFT 2 IN PARALLEL (INCLUDING RAISE BORING)	365 days	Sun 10/02/19	Sun 09/02/20	96
98	**5**	**5.1.**	**GATES SHAFT CONCRETING**	**900 days**	**Sat 10/02/18**	**Tue 28/07/20**	
99	6	5.1.	Gates shaft 1	85 days	Sat 10/02/18	Sat 05/05/18	95
100	6	5.1.	Gates shaft 2	85 days	Sun 06/05/18	Sun 29/07/18	99
101	6	5.1.	Gates shaft 3	85 days	Sun 10/02/19	Sun 05/05/19	96
102	6	5.1.	Gates shaft 4	85 days	Mon 06/05/19	Mon 29/07/19	101
103	6	5.1.	Gates shaft 5	85 days	Mon 10/02/20	Mon 04/05/20	97
104	6	5.1.	Gates shaft 6	85 days	Tue 05/05/20	Tue 28/07/20	103
105	**3**	**5.1.**	**Pentocks**	**2835 days**	**Sat 02/01/16**	**Fri 06/10/23**	
106	4	5.1.	TEMPORARY	180 days	Sun 01/01/17	Thu 29/06/17	
107	**4**	**5.1.**	**PERMANENT**	**2835 days**	**Sat 02/01/16**	**Fri 06/10/23**	
108	5	5.1.	PENSTOCK ERECTION CHAMBER	250 days	Sat 02/01/16	Wed 07/09/16	49
109	**5**	**5.1.**	**SHAFT EXCAVATION RAISE BORER**	**360 days**	**Thu 08/09/16**	**Sat 02/09/17**	
110	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 5	60 days	Thu 08/09/16	Sun 06/11/16	108
111	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 6	60 days	Mon 07/11/16	Thu 05/01/17	110
112	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 3	60 days	Fri 06/01/17	Mon 06/03/17	111
113	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 4	60 days	Tue 07/03/17	Fri 05/05/17	112
114	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 1	60 days	Sat 06/05/17	Tue 04/07/17	113
115	6	5.1.	SHAFT EXCAVATION RAISE BORER PENSTOCK 2	60 days	Wed 05/07/17	Sat 02/09/17	114
116	**5**	**5.1.**	**PENSTOCK ENLARGEMENT**	**1095 days**	**Mon 07/11/16**	**Wed 06/11/19**	
117	6	5.1.	ENLARGEMENT PENSTOCK 6 AND 5	365 days	Mon 07/11/16	Mon 06/11/17	110
118	6	5.1.	ENLARGEMENT PENSTOCK 3 AND 4	365 days	Tue 07/11/17	Tue 06/11/18	117
119	6	5.1.	ENLARGEMENT PENSTOCK 1 AND 2	365 days	Wed 07/11/18	Wed 06/11/19	118
120	**5**	**5.1.**	**STEEL LINING PENSTOCKS INCLUDING CONCRETE WORKS**	**2160 days**	**Tue 07/11/17**	**Fri 06/10/23**	
121	6	5.1.	Steel lining PENSTOCK 5, 6	720 days	Tue 07/11/17	Sun 27/10/19	117
122	6	5.1.	Steel lining PENSTOCK 3, 4	720 days	Mon 28/10/19	Sat 16/10/21	121
123	6	5.1.	Steel lining PENSTOCK 1, 2	720 days	Sun 17/10/21	Fri 06/10/23	122
124	**3**	**5.1.**	**Manifold**	**2055 days**	**Wed 02/03/16**	**Sun 17/10/21**	
125	**4**	**5.1.**	**Excavation**	**330 days**	**Wed 02/03/16**	**Wed 25/01/17**	
126	5	5.1.	U4	60 days	Wed 02/03/16	Sat 30/04/16	50
127	5	5.1.	U1	90 days	Sun 01/05/16	Fri 29/07/16	126
128	5	5.1.	U2 - U3 - U5 - U6	180 days	Sat 30/07/16	Wed 25/01/17	127
129	**4**	**5.1.**	**Steel lining**	**1640 days**	**Fri 21/04/17**	**Sun 17/10/21**	
130	5	5.1.	UNIT 1	200 days	Wed 31/03/21	Sun 17/10/21	123SF
131	5	5.1.	UNIT 2	200 days	Wed 31/03/21	Sun 17/10/21	123SF
132	5	5.1.	UNIT 3	200 days	Thu 11/04/19	Mon 28/10/19	122SF
133	5	5.1.	UNIT 4	200 days	Thu 11/04/19	Mon 28/10/19	122SF
134	5	5.1.	UNIT 5	200 days	Fri 21/04/17	Tue 07/11/17	121SF

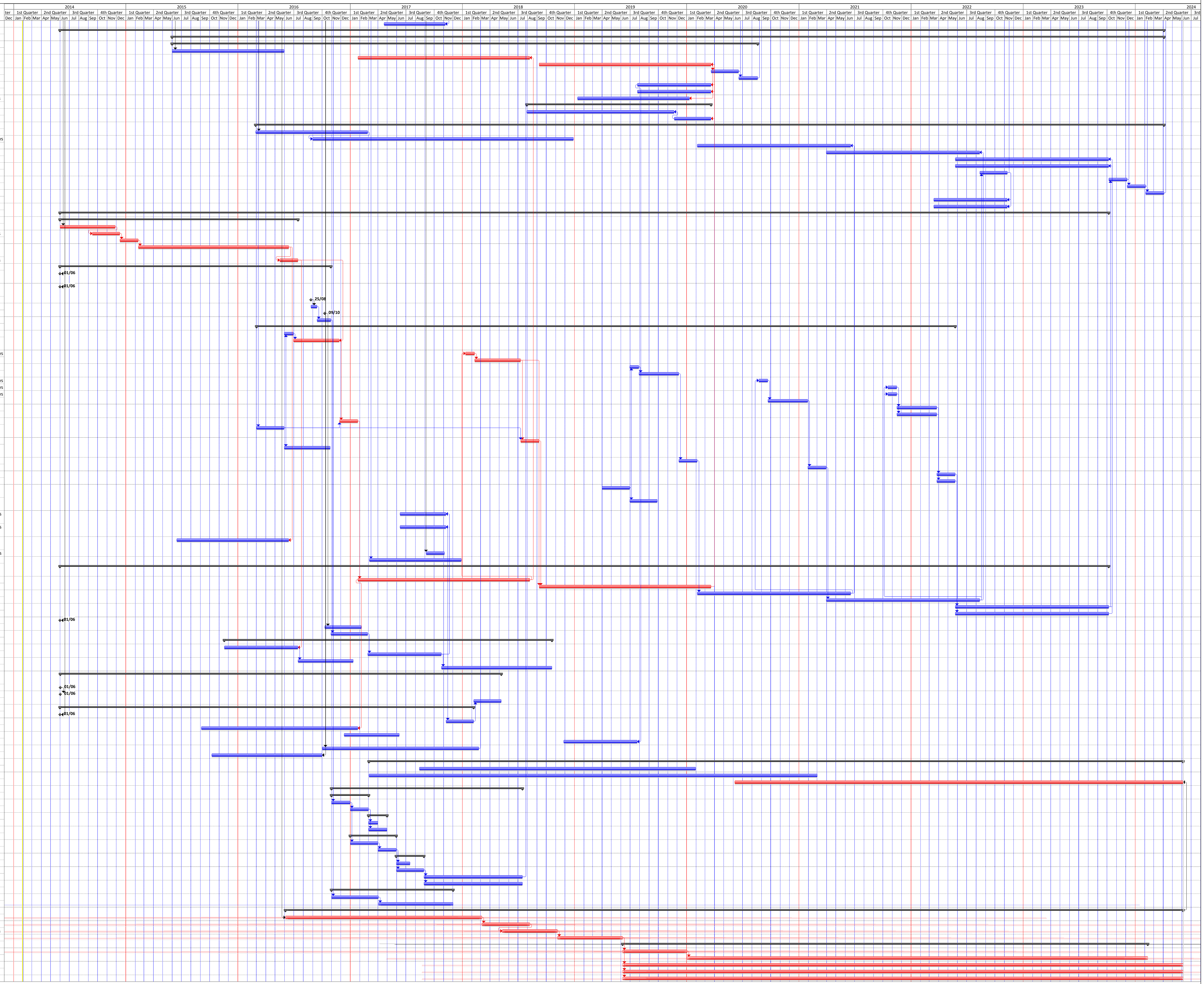


Projet : 2013-1-3ROGUN
Date : Wed 29/01/14

Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

rogun

ID	Out Level	WBS	Nom de la tâche	Duration	Start	Finish	Predecessors
135	5	5.1.	UNIT 6	200 days	Fri 21/04/17	Tue 07/11/17	121SF
136	**3**	**5.1.**	**Powerhouse cavern and relevant structures**	**3595 days**	**Sun 01/06/14**	**Wed 03/04/24**	
137	**4**	**5.1.**	**EM EQUIPMENT**	**3230 days**	**Mon 01/06/15**	**Wed 03/04/24**	
138	**5**	**5.1.**	**UNIT 5-6 final runners and final generators**	**1907 days**	**Mon 01/06/15**	**Wed 19/08/20**	
139	6	5.1.	Manufacturing + Delivering	365 days	Mon 01/06/15	Mon 30/05/16	25
140	6	5.1.	UNIT 6 ERECTION	560 days	Thu 26/01/17	Wed 08/08/18	206FF
141	6	5.1.	UNIT 5 ERECTION	560 days	Sat 08/09/18	Fri 20/03/20	207FF
142	6	5.1.	UNIT 6 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 21/03/20	Thu 18/06/20	141
143	6	5.1.	UNIT 5 (COMMISSIONING - DRY AND WET TESTS)	62 days	Fri 19/06/20	Wed 19/08/20	142
144	6	5.1.	Switchyard	240 days	Thu 25/07/19	Fri 20/03/20	141FF
145	6	5.1.	Transmission line	240 days	Thu 25/07/19	Fri 20/03/20	141FF
146	6	5.1.	Control room	365 days	Fri 11/01/19	Fri 10/01/20	141FF-70 days
147	**6**	**5.1.**	**TRANSFORMERS**	**600 days**	**Mon 30/07/18**	**Fri 20/03/20**	
148	7	5.1.	Delivering+Assembling on site	480 days	Mon 30/07/18	Fri 22/11/19	149SF
149	7	5.1.	Erection	120 days	Fri 22/11/19	Fri 20/03/20	141FF
150	**5**	**5.1.**	**UNIT 1 - 2 - 3 - 4**	**2958 days**	**Sun 28/02/16**	**Wed 03/04/24**	
151	6	5.1.	Design	365 days	Sun 28/02/16	Sun 26/02/17	30
152	6	5.1.	Manufacturing + Delivering	850 days	Wed 31/08/16	Fri 28/12/18	151FS-180 days
153	6	5.1.	UNIT 4 ERECTION	500 days	Wed 05/02/20	Fri 18/06/21	208FF
154	6	5.1.	UNIT 3 ERECTION	500 days	Wed 31/03/21	Fri 12/08/22	209FF
155	6	5.1.	UNIT 2 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	210FF
156	6	5.1.	UNIT 1 ERECTION	500 days	Wed 25/05/22	Fri 06/10/23	211FF
157	6	5.1.	UNIT 4 (COMMISSIONING - DRY AND WET TESTS)	90 days	Sat 13/08/22	Thu 10/11/22	209
158	6	5.1.	UNIT 3 (COMMISSIONING - DRY AND WET TESTS)	60 days	Sat 07/10/23	Tue 05/12/23	210
159	6	5.1.	UNIT 2 (COMMISSIONING - DRY AND WET TESTS)	60 days	Wed 06/12/23	Sat 03/02/24	158
160	6	5.1.	UNIT 1 (COMMISSIONING - DRY AND WET TESTS)	60 days	Sun 04/02/24	Wed 03/04/24	159
161	6	5.1.	Switchyard	240 days	Wed 16/03/22	Thu 10/11/22	157FF
162	6	5.1.	TRANSFORMERS	240 days	Wed 16/03/22	Thu 10/11/22	157FF
163	**4**	**5.1.**	**CIVIL WORKS**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
164	**5**	**5.1.**	**Wall support**	**775 days**	**Sun 01/06/14**	**Thu 14/07/16**	
165	6	5.1.	Design	180 days	Sun 01/06/14	Thu 27/11/14	2
166	6	5.1.	Mobilization	90 days	Sun 14/09/14	Fri 12/12/14	165FS-75 days
167	6	5.1.	Scaffolding installation	60 days	Sat 13/12/14	Tue 10/02/15	166
168	6	5.1.	MPSP system & tendons drilling, grouting and tensioning	490 days	Wed 11/02/15	Tue 14/06/16	167
169	6	5.1.	Scaffolding removal	60 days	Mon 16/05/16	Thu 14/07/16	168FS-30 days
170	**5**	**5.1.**	**BUS DUCT**	**882 days**	**Sun 01/06/14**	**Sat 29/10/16**	
171	6	5.1.	BUS DUCT EXCAVATION EL 969 Units 6,5,4 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
172	6	5.1.	BUS DUCT EXCAVATION EL 983 Units 6,5,4 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
173	6	5.1.	BUS DUCT EXCAVATION EL 969 Units 3 (completed)	0 days	Thu 25/08/16	Thu 25/08/16	
174	6	5.1.	BUS DUCT EXCAVATION EL 969 Units 2,1	20 days	Fri 26/08/16	Wed 14/09/16	173
175	6	5.1.	BUS DUCT EXCAVATION EL 983 Units 3 (completed)	0 days	Sun 09/10/16	Sun 09/10/16	
176	6	5.1.	BUS DUCT EXCAVATION EL 983 Units 2,1	45 days	Thu 15/09/16	Sat 29/10/16	174
177	**5**	**5.1.**	**Cavern excavation**	**2275 days**	**Wed 02/03/16**	**Tue 24/05/22**	
178	6	5.1.	Excavation of shaft of Unit 6	30 days	Tue 31/05/16	Wed 29/06/16	191
179	6	5.1.	Excavation of Unit 6 from el. 964.25 to el. 946.90	150 days	Thu 30/06/16	Sat 26/11/16	178;169FF-15 days
180	6	5.1.	Excavation of shaft of Unit 5	30 days	Thu 11/01/18	Fri 09/02/18	206FS-210 days
181	6	5.1.	Excavation of Unit 5 from el. 964.25 to el. 946.90	150 days	Sat 10/02/18	Mon 09/07/18	180
182	6	5.1.	Excavation of shaft of Unit 4	30 days	Sun 30/06/19	Mon 29/07/19	198
183	6	5.1.	Excavation of Unit 4 from el. 964.25 to el. 946.90	130 days	Tue 30/07/19	Fri 06/12/19	182
184	6	5.1.	Excavation of shaft of Unit 3	30 days	Sun 23/08/20	Mon 21/09/20	208FS-300 days
186	6	5.1.	Excavation of shaft of Unit 2	30 days	Sun 17/10/21	Mon 15/11/21	209FS-300 days
188	6	5.1.	Excavation of shaft of Unit 1	30 days	Sun 17/10/21	Mon 15/11/21	209FS-300 days
185	6	5.1.	Excavation of Unit 3 from el. 964.25 to el. 946.90	130 days	Tue 22/09/20	Fri 29/01/21	184
187	6	5.1.	Excavation of Unit 2 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	186
189	6	5.1.	Excavation of Unit 1 from el. 964.25 to el. 946.90	130 days	Tue 16/11/21	Fri 25/03/22	188
190	6	5.1.	Excavation of Pit of Unit 6	60 days	Sun 27/11/16	Wed 25/01/17	191;179
191	6	5.1.	DT Units 5 and 6 at el 932, from drainage gallery to pit (U/S direction)	90 days	Wed 02/03/16	Mon 30/05/16	50
192	6	5.1.	Excavation of Pit of Unit 5	60 days	Tue 10/07/18	Fri 07/09/18	191;181
193	6	5.1.	DT Units 5 and 6 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Tue 31/05/16	Thu 27/10/16	191
194	6	5.1.	Excavation of Pit of Unit 4	60 days	Sat 07/12/19	Tue 04/02/20	183
195	6	5.1.	Excavation of Pit of Unit 3	60 days	Sat 30/01/21	Tue 30/03/21	185
196	6	5.1.	Excavation of Pit of Unit 2	60 days	Sat 26/03/22	Tue 24/05/22	187
197	6	5.1.	Excavation of Pit of Unit 1	60 days	Sat 26/03/22	Tue 24/05/22	189
198	6	5.1.	DT Units 4 and 3 at el 932, from drainage gallery to pit (U/S direction)	90 days	Mon 01/04/19	Sat 29/06/19	
199	6	5.1.	DT Units 2 and 1 at el 932, from drainage gallery to pit (U/S direction)	90 days	Sun 30/06/19	Fri 27/09/19	198
200	6	5.1.	DT Units 4 and 3 from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	218FF+15 days
201	6	5.1.	DT Units 2 and 1 - from el 932 to 966 - from drainage gallery to transformer chamber	150 days	Mon 12/06/17	Wed 08/11/17	218FF+15 days
202	5	5.1.	Stabilization works of overhead travelling crane beam	365 days	Tue 16/06/15	Tue 14/06/16	168FF
203	5	5.1.	Main gantry crane erection	60 days	Tue 05/09/17	Fri 03/11/17	15FS+550 days
204	5	5.1.	Grouting works	300 days	Sat 04/03/17	Thu 28/12/17	16
205	**5**	**5.1.**	**Concrete works (made in parallel with E&M erection)**	**3415 days**	**Sun 01/06/14**	**Fri 06/10/23**	
206	6	5.1.	UNIT 6	560 days	Thu 26/01/17	Wed 08/08/18	190
207	6	5.1.	UNIT 5	560 days	Sat 08/09/18	Fri 20/03/20	181;192
208	6	5.1.	UNIT 4	500 days	Wed 05/02/20	Fri 18/06/21	194
209	6	5.1.	UNIT 3	500 days	Wed 31/03/21	Fri 12/08/22	195
210	6	5.1.	UNIT 2	500 days	Wed 25/05/22	Fri 06/10/23	196
211	6	5.1.	UNIT 1	500 days	Wed 25/05/22	Fri 06/10/23	197
212	6	5.1.	Bus duct lining Units 6, 5 (already completed)	0 days	Sun 01/06/14	Sun 01/06/14	172FF
213	6	5.1.	Bus duct lining Units 4, 3	120 days	Mon 10/10/16	Mon 06/02/17	175
214	6	5.1.	Bus duct lining Units 2, 1	120 days	Sun 30/10/16	Sun 26/02/17	176
215	**5**	**5.1.**	**TRANSFORMER HALL**	**1067 days**	**Wed 18/11/15**	**Fri 19/10/18**	
216	6	5.1.	Excavation transformer chamber for Units 6 and 5	240 days	Wed 18/11/15	Thu 14/07/16	169FF
218	6	5.1.	Excavation transformer chamber for Units 4,3,2,1	240 days	Mon 27/02/17	Tue 24/10/17	214
217	6	5.1.	Concreting+ finishing for units 6 and 5	180 days	Fri 15/07/16	Tue 10/01/17	216
219	6	5.1.	Concreting+ finishing for Units 4, 3, 2, 1	360 days	Wed 25/10/17	Fri 19/10/18	218
220	**5**	**5.1.**	**Branches from transformer chamber to main collector**	**1436 days**	**Sun 01/06/14**	**Mon 07/05/18**	
221	6	5.1.	U4 U5 U6 (Already completed)	0 days	Sun 01/06/14	Sun 01/06/14	
222	6	5.1.	Slot U6	0 days	Sun 01/06/14	Sun 01/06/14	221
223	6	5.1.	U1 U2 U3	90 days	Wed 07/02/18	Mon 07/05/18	226
224	**5**	**5.1.**	**Main collector**	**1347 days**	**Sun 01/06/14**	**Tue 06/02/18**	
225	6	5.1.	U4 U5 U6 (Already Completed)	0 days	Sun 01/06/14	Sun 01/06/14	2FF
226	6	5.1.	U1 U2 U3	90 days	Thu 09/11/17	Tue 06/02/18	201
227	3	5.1.	Cables galleries lining rehabilitation works N1 and N2	510 days	Fri 04/09/15	Thu 26/01/17	206SF
228	3	5.1.	Control room	180 days	Mon 12/12/16	Fri 09/06/17	
229	3	5.1.	Switchyard	240 days	Tue 27/11/18	Thu 25/07/19	144SF
230	3	5.1.	DT1 and DT2 Culverts in the river bed	510 days	Sun 02/10/16	Fri 23/02/18	3
231	3	5.1.	Excavation in the riverbed at DTs outlets	360 days	Thu 08/10/15	Sat 01/10/16	3FF
232	**1**	**6**	**FLOOD MANAGEMENT STRUCTURES**	**2651 days**	**Fri 03/03/17**	**Tue 04/06/24**	
233	2	6.1	**Middle level outlet 1**	900 days	Mon 14/08/17	Thu 30/01/20	
234	2	6.2	**High level outlet tunnel spillway 1**	1460 days	Fri 03/03/17	Mon 01/03/21	
235	2	6.3	**Surface spillway**	1460 days	Sat 06/06/20	Tue 04/06/24	254FF
236	**1**	**7**	**Stage 1 Dam Crest Elevation 1075 masl**	**622 days**	**Tue 01/11/16**	**Sun 15/07/18**	
237	**2**	**7.1**	**Concrete plinth (BOTTOM OF THE VALLEY)**	**121 days**	**Tue 01/11/16**	**Wed 01/03/17**	
238	3	7.1.	Excavation + foundation treatment	61 days	Tue 01/11/16	Sat 31/12/16	65
239	3	7.1.	Concrete works including anchor bars	60 days	Sun 01/01/17	Wed 01/03/17	238
240	**2**	**7.2**	**Grouting works (BOTTOM OF THE VALLEY)**	**60 days**	**Thu 02/03/17**	**Sun 30/04/17**	
241	3	7.2.	Consolidation grouting	30 days	Thu 02/03/17	Fri 31/03/17	239
242	3	7.2.	Curtain grouting	60 days	Thu 02/03/17	Sun 30/04/17	239
243	**2**	**7.3**	**Concrete plinth (ABUTMENT)**	**150 days**	**Sun 01/01/17**	**Tue 30/05/17**	
244	3	7.3.	Excavation + foundation treatment	90 days	Sun 01/01/17	Fri 31/03/17	238
245	3	7.3.	Concrete works including anchor bars	60 days	Sat 01/04/17	Tue 30/05/17	244
246	**2**	**7.4**	**Grouting works (ABUTMENT)**	**90 days**	**Wed 31/05/17**	**Mon 28/08/17**	
247	3	7.4.	Consolidation grouting	45 days	Wed 31/05/17	Fri 14/07/17	245
248	3	7.4.	Curtain grouting	90 days	Wed 31/05/17	Mon 28/08/17	245
249	2	7.5	Asphalt concrete core including transition layers	321 days	Tue 29/08/17	Sun 15/07/18	248
250	2	7.6	Dam Shells Filling	321 days	Tue 29/08/17	Sun 15/07/18	248
251	**1**	**8**	**Salt dome works**	**396 days**	**Tue 01/11/16**	**Fri 01/12/17**	
252	2	8.1	Excavation + foundation treatment + Concrete slab	153 days	Tue 01/11/16	Sun 02/04/17	65
253	2	8.2	Grouting + Drainage	243 days	Mon 03/04/17	Fri 01/12/17	252
254	**1**	**9**	**Dam for full capacity Crest elevation 1230 m**	**2923 days**	**Sat 04/06/16**	**Tue 04/06/24**	
255	2	9.1	Core foundation, excavation on the abutment	640 days	Sat 04/06/16	Mon 05/03/18	3FS-120 days
256	2	9.2	Core foundation excavation at the bottom of the valley	156 days	Tue 06/03/18	Wed 08/08/18	255
257	2	9.3	Foundation treatment	180 days	Fri 11/05/18	Tue 06/11/18	256FS-90 days
258	2	9.4	RCC slab at the base of the core	212 days	Wed 07/11/18	Thu 06/06/19	257
259	**2**	**9.5**	**Grouting works**	**1710 days**	**Fri 07/06/19**	**Sat 10/02/24**	
260	3	9.5.	Consolidation grouting	210 days	Fri 07/06/19	Thu 02/01/20	258
261	3	9.5.	Curtain grouting	1500 days	Fri 03/01/20	Sat 10/02/24	260
262	2	9.6	Filling Core	1825 days	Fri 07/06/19	Tue 04/06/24	258
263	2	9.7	Filling Filters	1825 days	Fri 07/06/19	Tue 04/06/24	258
264	2	9.8	Filling shells (INCLUDING rip rap)	1825 days	Fri 07/06/19	Tue 04/06/24	258

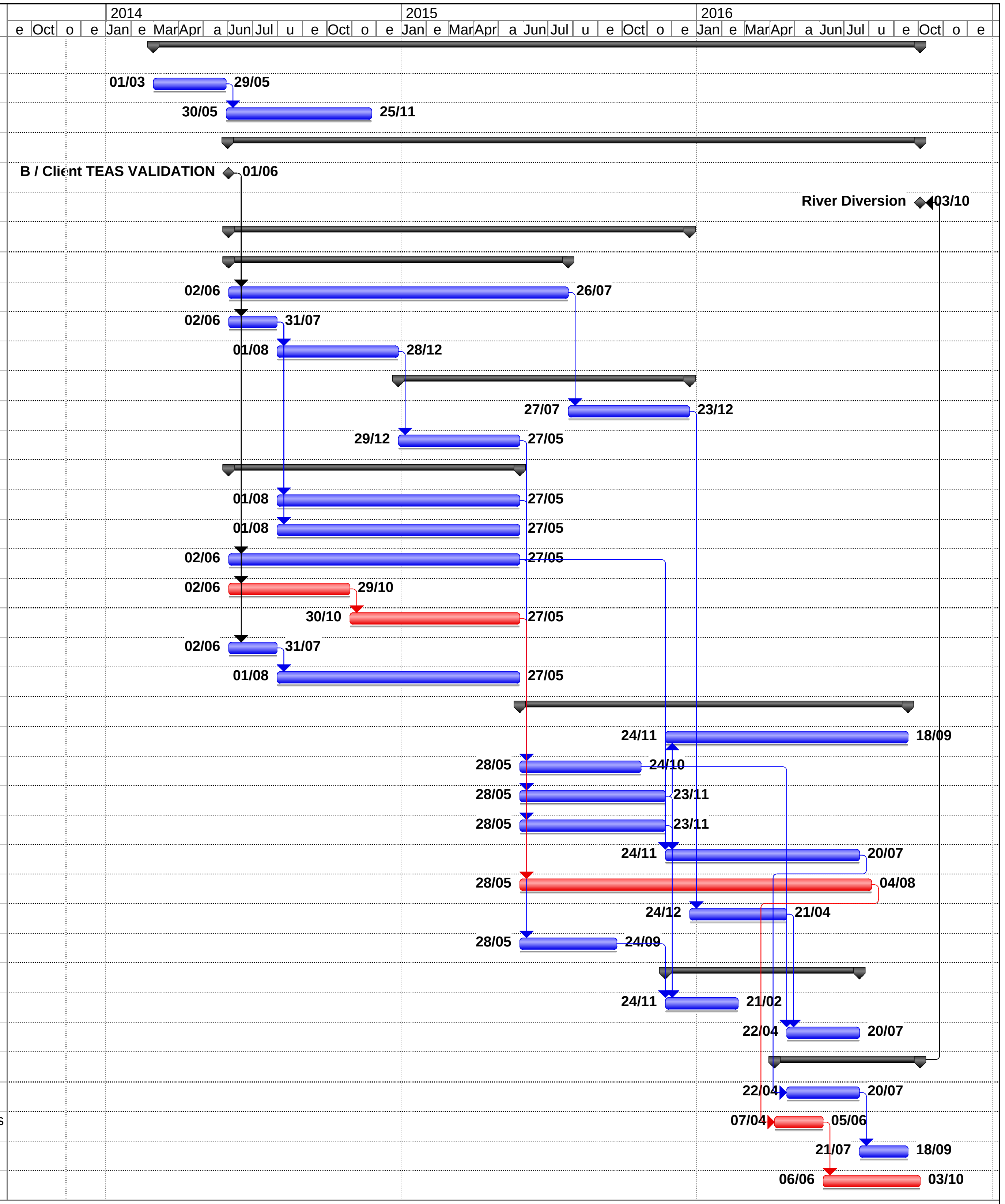


Projet : 2013-1-3ROGUN
Date : Wed 29/01/14

Tâche | Fractionnement | Jalon | Récapitulative | Récapitulatif du projet | Tâches externes | Jalons externes | Échéance | Critique | Fractionnement critique | Avancement

ANNEX 4 – DT3 IMPLEMENTATION SCHEDULE AND REFERENCE DRAWINGS

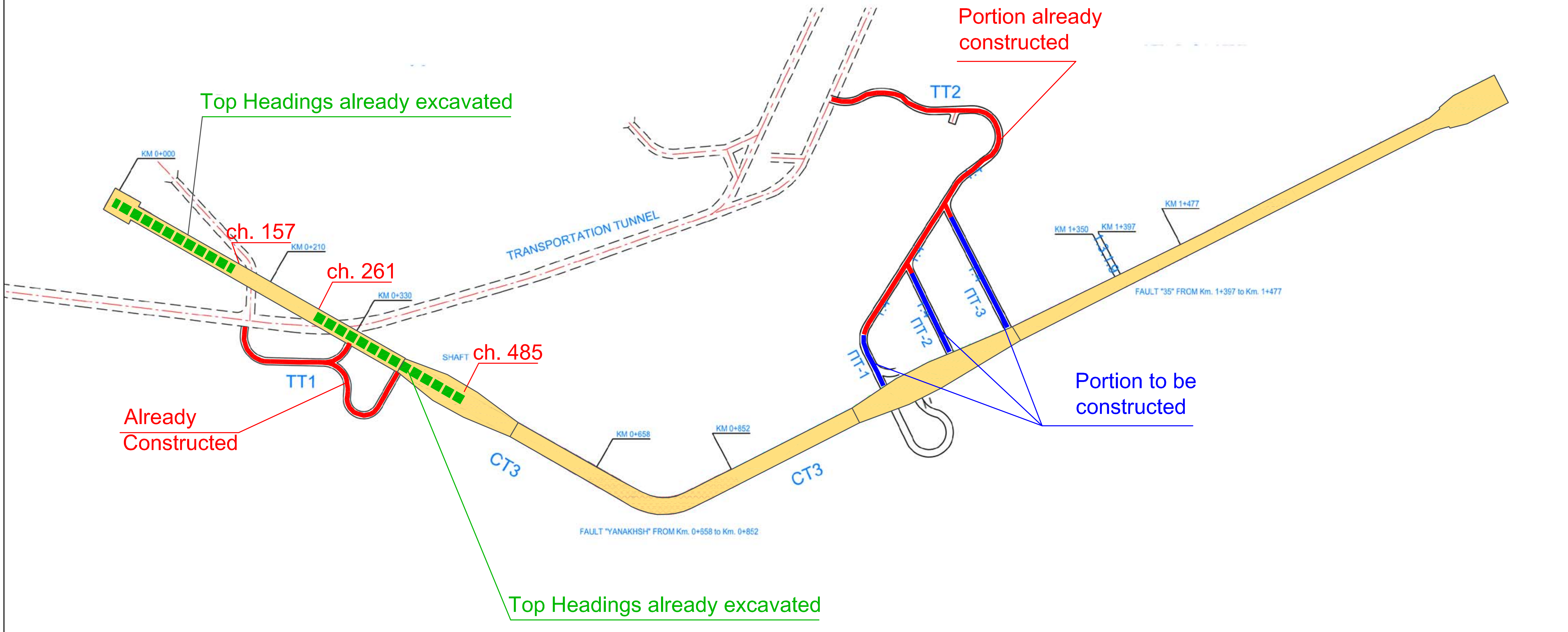
ID		WBS	Task Name	Duration	Start	Finish	Predecessors
1		1	**DT3 CONSTRUCTION**	**948 days**	**Sat 01/03/14**	**Mon 03/10/16**	
2		1.1	Mobilization and Access Roads	90 days	Sat 01/03/14	Thu 29/05/14	
3		1.2	Design	180 days	Fri 30/05/14	Tue 25/11/14	2
4		**1.3**	**MILESTONES**	**856 days**	**Sun 01/06/14**	**Mon 03/10/16**	
5		1.3.1	WB / Client TEAS VALIDATION	1 day	Sun 01/06/14	Sun 01/06/14	
6		1.3.2	River Diversion	1 day	Mon 03/10/16	Mon 03/10/16	35FF
7		**1.4**	**EXCAVATIONS**	**570 days**	**Mon 02/06/14**	**Wed 23/12/15**	
8		**1.4.1**	**Exc. Access and Adits**	**420 days**	**Mon 02/06/14**	**Sun 26/07/15**	
9		1.4.1.1	Excavation of Main Access to Gate Chambers Caverns	420 days	Mon 02/06/14	Sun 26/07/15	5
10		1.4.1.2	Excavation of Main Adit to DT3 from T-3 (TT-2 branches)	60 days	Mon 02/06/14	Thu 31/07/14	5
11		1.4.1.3	Excavation of Adit to D/S Gates Chamber cavern from TT-2	150 days	Fri 01/08/14	Sun 28/12/14	10
12		**1.4.3**	**Exc. Gate Chambers**	**360 days**	**Mon 29/12/14**	**Wed 23/12/15**	
13		1.4.3.1	Excavation of Upstream Gate Chamber Cavern	150 days	Mon 27/07/15	Wed 23/12/15	9
14		1.4.3.2	Excavation of Downstream Gate Chamber Cavern	150 days	Mon 29/12/14	Wed 27/05/15	11
15		**1.4.4**	**Exc. Of Tunnel and Structures**	**360 days**	**Mon 02/06/14**	**Wed 27/05/15**	
16		1.4.4.4	Excavation of D/S Gates chamber from TT-2	300 days	Fri 01/08/14	Wed 27/05/15	10
17		1.4.4.5	Excavation of Tunnel towards Outlet from TT-2	300 days	Fri 01/08/14	Wed 27/05/15	10
18		1.4.4.1	Excavation of U/S Gates Chamber and Tunnel from TT-1	360 days	Mon 02/06/14	Wed 27/05/15	5
19		1.4.4.2	Downstream Portal outdoor Excavations	150 days	Mon 02/06/14	Wed 29/10/14	5
20		1.4.4.3	Excavation of Tunnel from Outlet Portal	210 days	Thu 30/10/14	Wed 27/05/15	19
21		1.4.4.6	Excavation of top heading from ch. 157 to ch. 261 (from Inlet and from TT1)	60 days	Mon 02/06/14	Thu 31/07/14	5
22		1.4.4.7	Excavation of benching from Inlet to ch. 380	300 days	Fri 01/08/14	Wed 27/05/15	21
23		**1.5**	**CONCRETING**	**480 days**	**Thu 28/05/15**	**Sun 18/09/16**	
24		1.5.1	Lining of Access to gate chambers Cavern	300 days	Tue 24/11/15	Sun 18/09/16	26
25		1.5.2	U/S gates chamber concreting	150 days	Thu 28/05/15	Sat 24/10/15	14
26		1.5.3	D/S gates chamber concreting	180 days	Thu 28/05/15	Mon 23/11/15	16
27		1.5.4	Tunnel Lining from D/S Gate Chamber Toward U/S	180 days	Thu 28/05/15	Mon 23/11/15	18
28		1.5.5	Tunnel lining Inlet Stretch	240 days	Tue 24/11/15	Wed 20/07/16	18;27
29		1.5.6	Tunnel Lining to Outlet Portal	435 days	Thu 28/05/15	Thu 04/08/16	20
30		1.5.7	Concreting of Upstream Gate Chamber (Cavern Civil Works)	120 days	Thu 24/12/15	Thu 21/04/16	13
31		1.5.8	Concreting of Downstream Gate Chamber (Cavern Civil Works)	120 days	Thu 28/05/15	Thu 24/09/15	14
32		**1.6**	**E&M AND HSS WORKS**	**240 days**	**Tue 24/11/15**	**Wed 20/07/16**	
33		1.6.1	Downstream Gate Chamber Works	90 days	Tue 24/11/15	Sun 21/02/16	26;31
34		1.6.2	Upstream Gate Chamber works	90 days	Fri 22/04/16	Wed 20/07/16	25;30
35		**1.7**	**EXCAVATION AND CONCRETING - COMPLETION WORKS**	**180 days**	**Thu 07/04/16**	**Mon 03/10/16**	
36		1.7.1	Excavation of Inlet of Main Tunnel - Completion	90 days	Fri 22/04/16	Wed 20/07/16	28FS-90 days
37		1.7.2	Excavation of Outlet of Main Tunnel - Completion	60 days	Thu 07/04/16	Sun 05/06/16	29FS-120 days
38		1.7.3	Inlet of Main Tunnel - Miscellanea	60 days	Thu 21/07/16	Sun 18/09/16	36
39		1.7.4	Outlet of Main Tunnel - Completion Works	120 days	Mon 06/06/16	Mon 03/10/16	37



Project: 130930 - DT3 SCHEDULE_05
Rev. B
Date: Tue 12/11/13

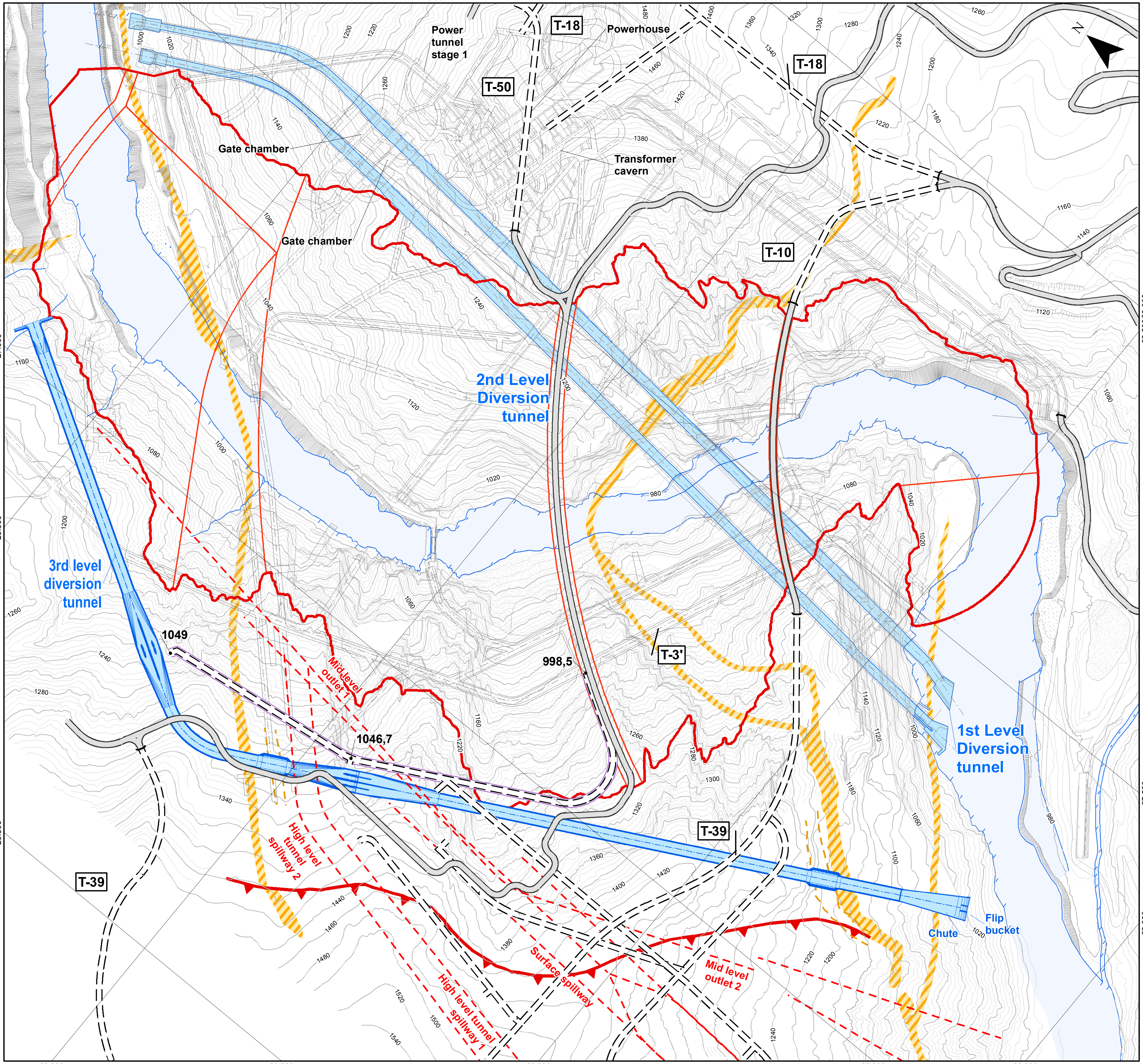
Task	Milestone	Rolled Up Critical Task	Split	Group By Summary
Critical Task	Summary	Rolled Up Milestone	External Tasks	Deadline
Progress	Rolled Up Task	Rolled Up Progress	Project Summary	

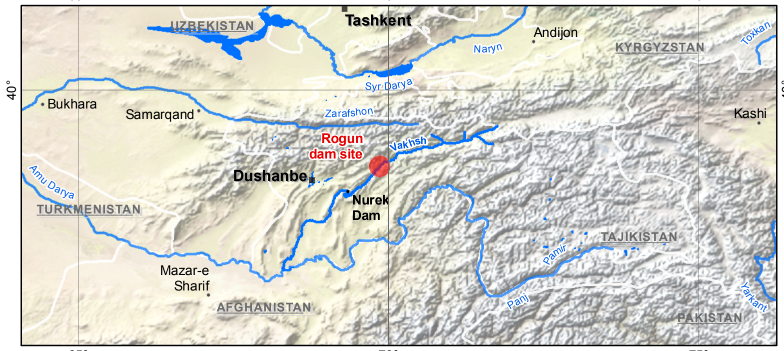
DT3 PLAN (for Implementation Schedule)



Progress of DT3 Construction assumed by TEAS Consultant for the Preparation of the Implementation schedule.

Drawing not in scale.





Legend

Third level diversion tunnel with chainage (m)

Dam layout

Rev.	Y M D	MODIFICATIONS	STATUS	DRAWN	CHECKED	APPROVED	VALIDATED
B	2013 11 12	Second issue	.	BAR	LCO	.	
A	2013 05 17	First issue	.	BAR	LCO	.	

ELECTROCONSULT — IPA Energy + Water Economics

OSHPC BARKI TOJIK

TEAS for ROGUN HPP CONSTRUCTION PROJECT

PHASE II

ROGUN FEASIBILITY STUDY

DAM CREST ELEVATION 1300 M
DIVERSION TUNNELS
GENERAL PLAN

TRACTEBEL Engineering GDF SUEZ
COYNE ET BELLIER Ingénieurs Conseils
TRACTEBEL ENGINEERING S.A.
Le Delage – 5, rue du 19 Mars 1962
92622 Gennevilliers CEDEX – FRANCE

External Reference			
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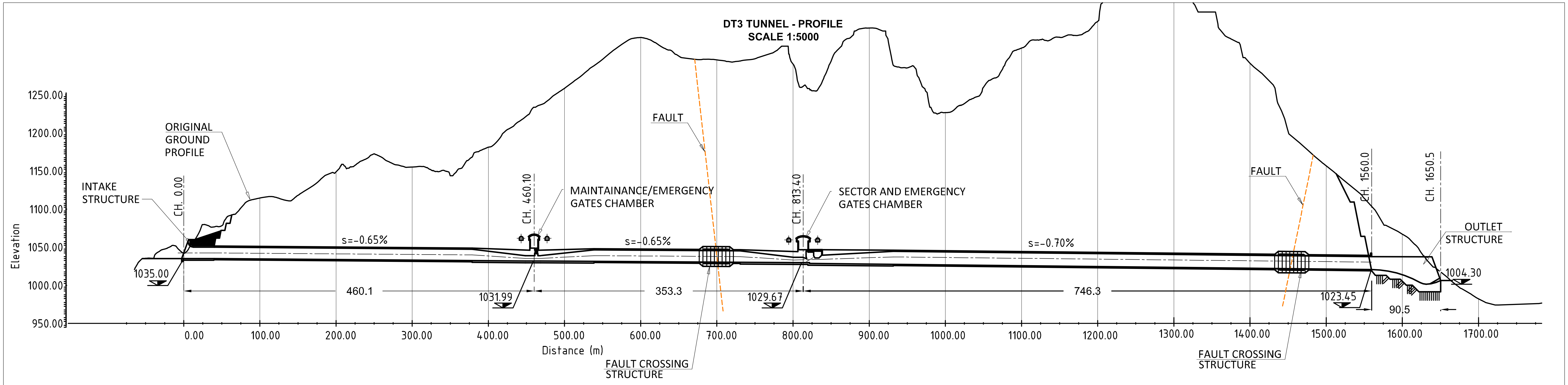
Imputation: RFS 1730	Technical Subdivision: .	Issuer: ELC	
Drawing Reference: 40111		Revision: B	

DT3 TUNNEL - PROFILE
SCALE 1:5000



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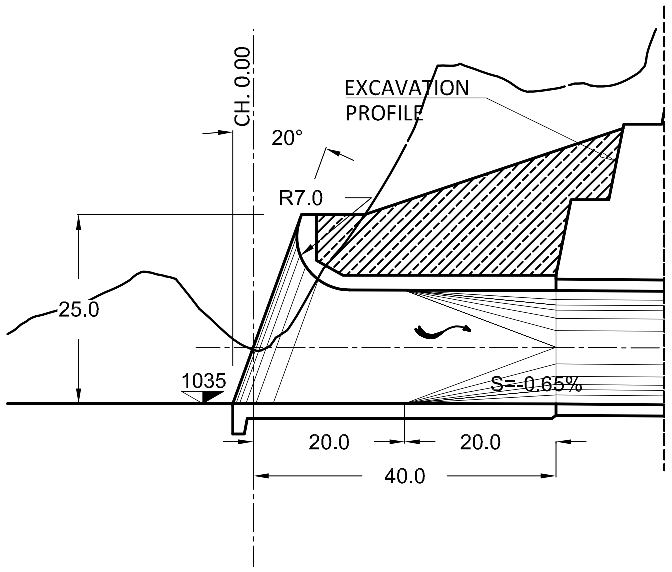

MAINTAINANCE/EMERGENCY GATE CHAMBER - AXIS PROFILE
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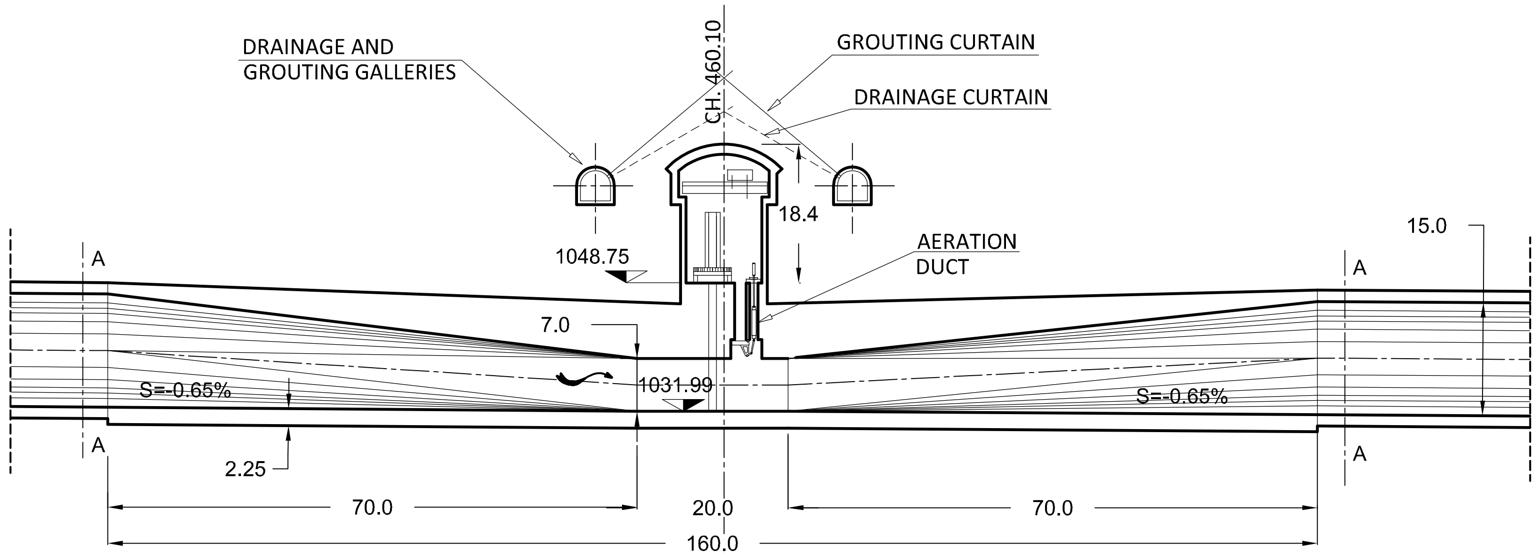

SECTION A-A
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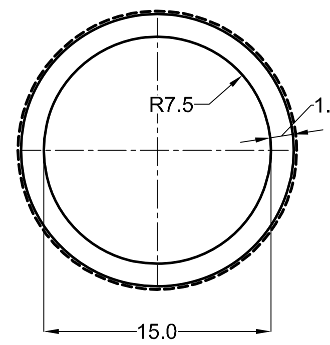

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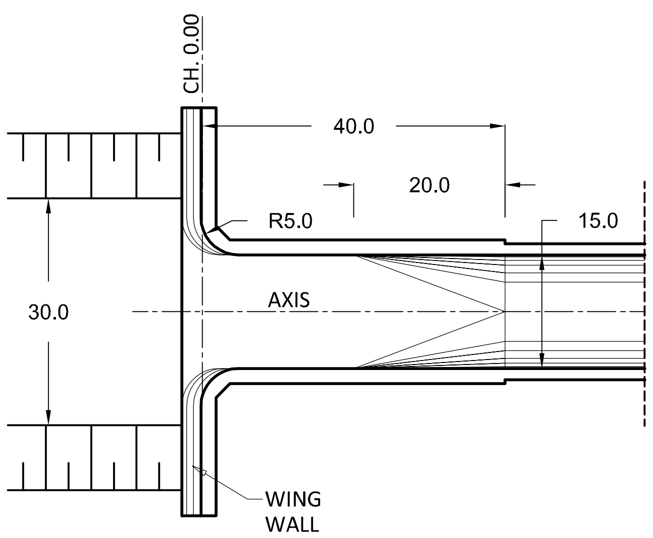

MAINTAINANCE/EMERGENCY GATE CHAMBER - PLAN
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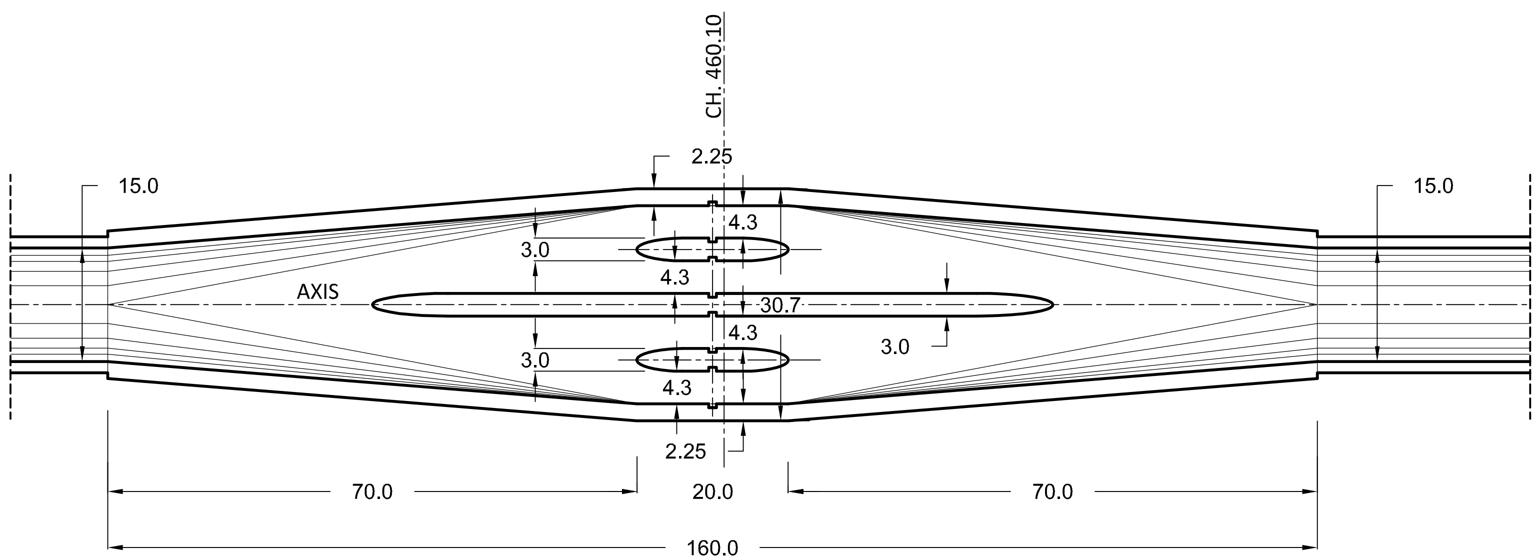

Rev.	Y M D	MODIFICATIONS	STATUS	DRAWN	CHECKED	APPROVED	VALIDATED
A	2013 04 15	FIRST EMISSION		PYR	LCO-PAR	LCO-PAR	

ELC
IPA

OSHPC BARKI TOJIK

TEAS for ROGUN HPP CONSTRUCTION PROJECT
PHASE II

DAM EL. 1300 - 1265 - 1230 - DT3 TUNNEL
PROFILE, INTAKE, GATES CHAMBER AND SECTIONS

TRACTEBEL Engineering
GDF SUEZ
COYNE ET BELLIER
Ingénieurs Conseils
TRACTEBEL ENGINEERING S.A.
Le Delage - 5, rue du 19 Mars 1962
92622 Gennevilliers CEDEX - FRANCE

External Reference				
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Imputation: 1730	Technical Subdivision: .	Issuer: .		
Drawing Reference: 4 0 1 2 1	Revision: A			