11-12 December 2017

The CHRICHIRA Hydropower pilot project

And the Manoubia Bas Montfleury project in Tunis

Tunisia SONEDE

Henri Boyé
– Senior engineer- ESCWA Consultant
Former Coordinator of the Energy and Climate College

Regional Capacity meeting on the Water Energy Nexus in the Arab Region Beirut Lebanon 11-12 december 2017

Renewable Energy
Hydroelectricity on Water Pipes

A clean renewable energy
using the power of water to produce electricity.

A Pilot action for SONEDE in the framework of cooperation with ESCWA:

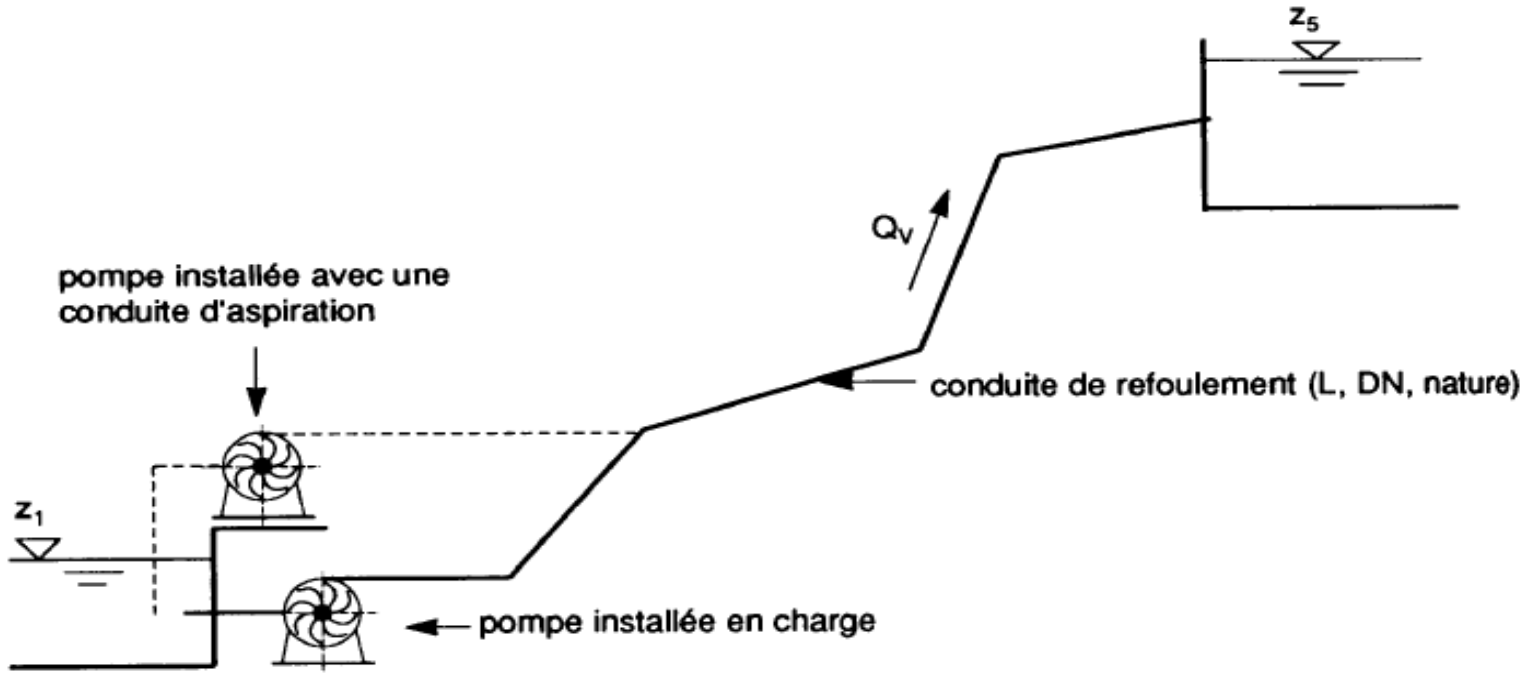
Identification of a hydroelectric potential
at the Chrichira adduction (1,3GWh / year)

The technical and economic feasibility study
of the 200 kW micro-hydroelectric plant will be carried out
within the framework of the cooperation with ESCWA.

The principle of energy economy and recovery of energy lost in water pumping

In drinking water systems, much energy is spent for pumping, to raise water in water towers and reservoirs on a high point.

When the water goes down, the potential energy is not used, and is lost



Reducing the energy consumption of the hydraulic system at CHRICHIRA

- This project consists of studying the possibility of reducing the energy consumption of the hydraulic system of the "Kairouanais" network (Chrichira system)
- by modifying the existing network and **installing a hydroelectric micro-turbine to produce electrical energy.**

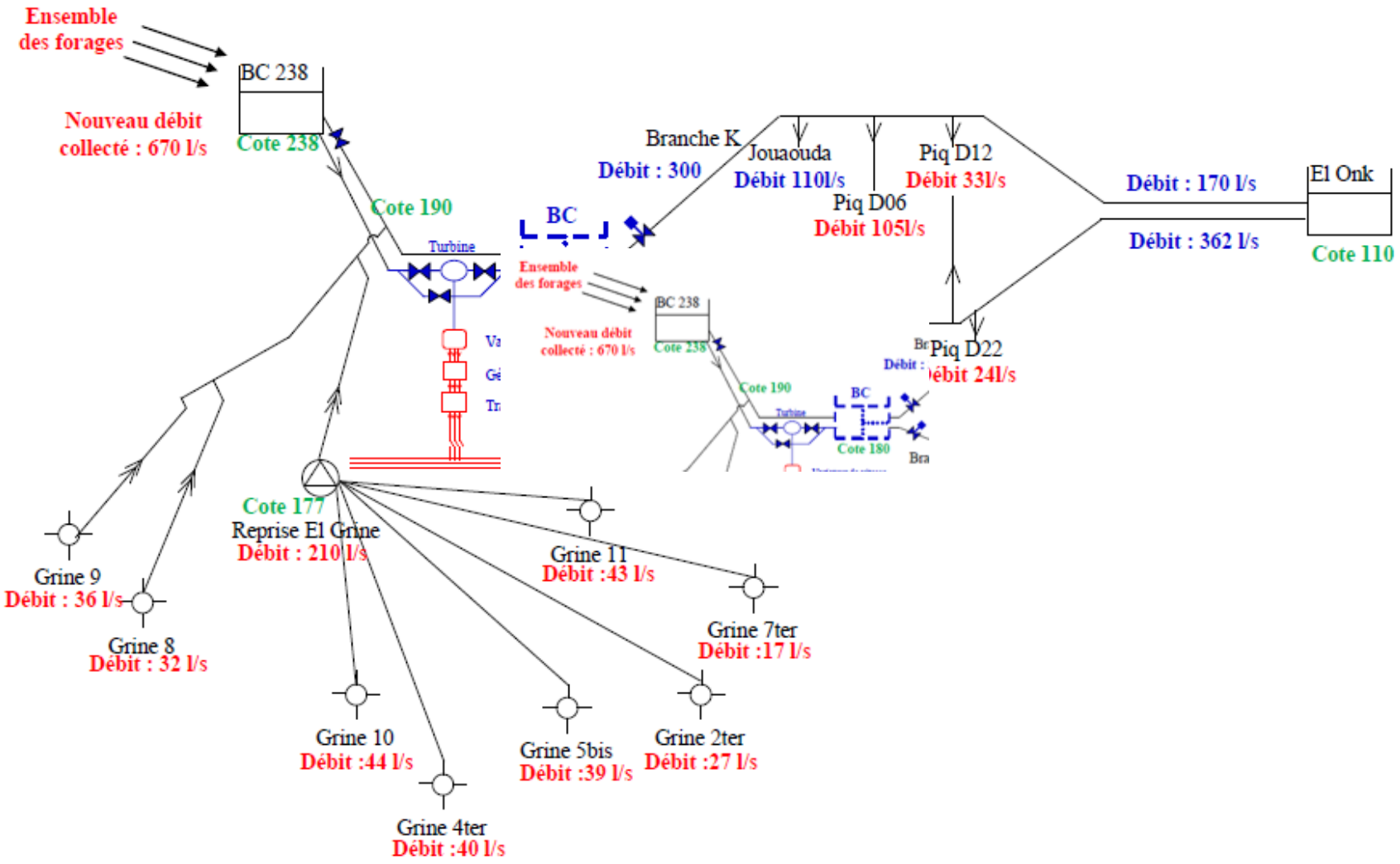
And also **optimizing the pumping** in Chrichira

(There is no point in pumping the water too high, but just at the right level)

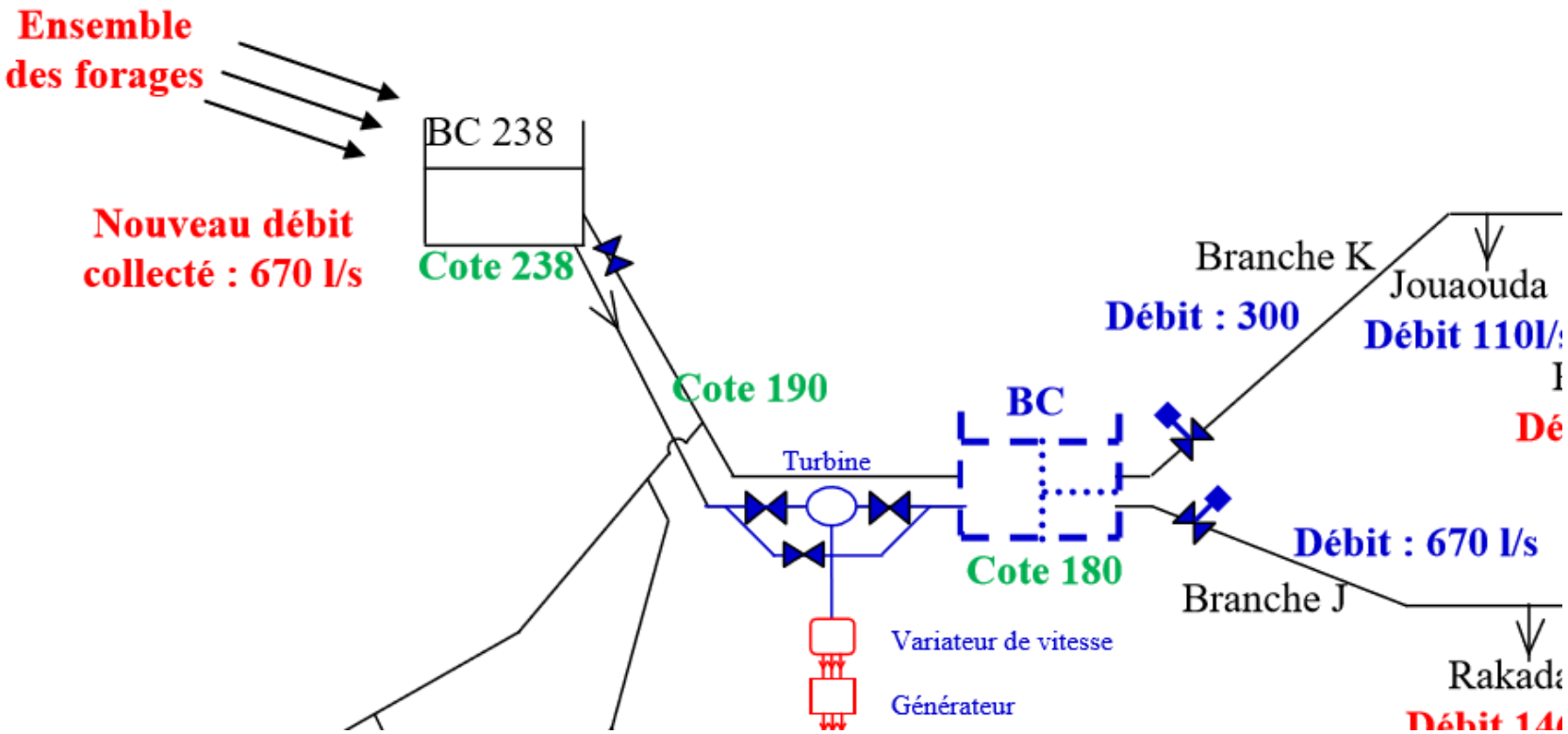
Proposal for Tunisia Technical feasibility study of micro-hydro system for SONEDE

- installing a turbine on a water transmission network to generate electricity.
- assess the technical feasibility of a proposed micro-hydro installation on a water transmission line with elevation differences
- provide technical specifications in order for SONEDE to tender this project.
- Detailed technical feasibility study of micro-hydrosystem
- including site visit, data collection, meetings, etc

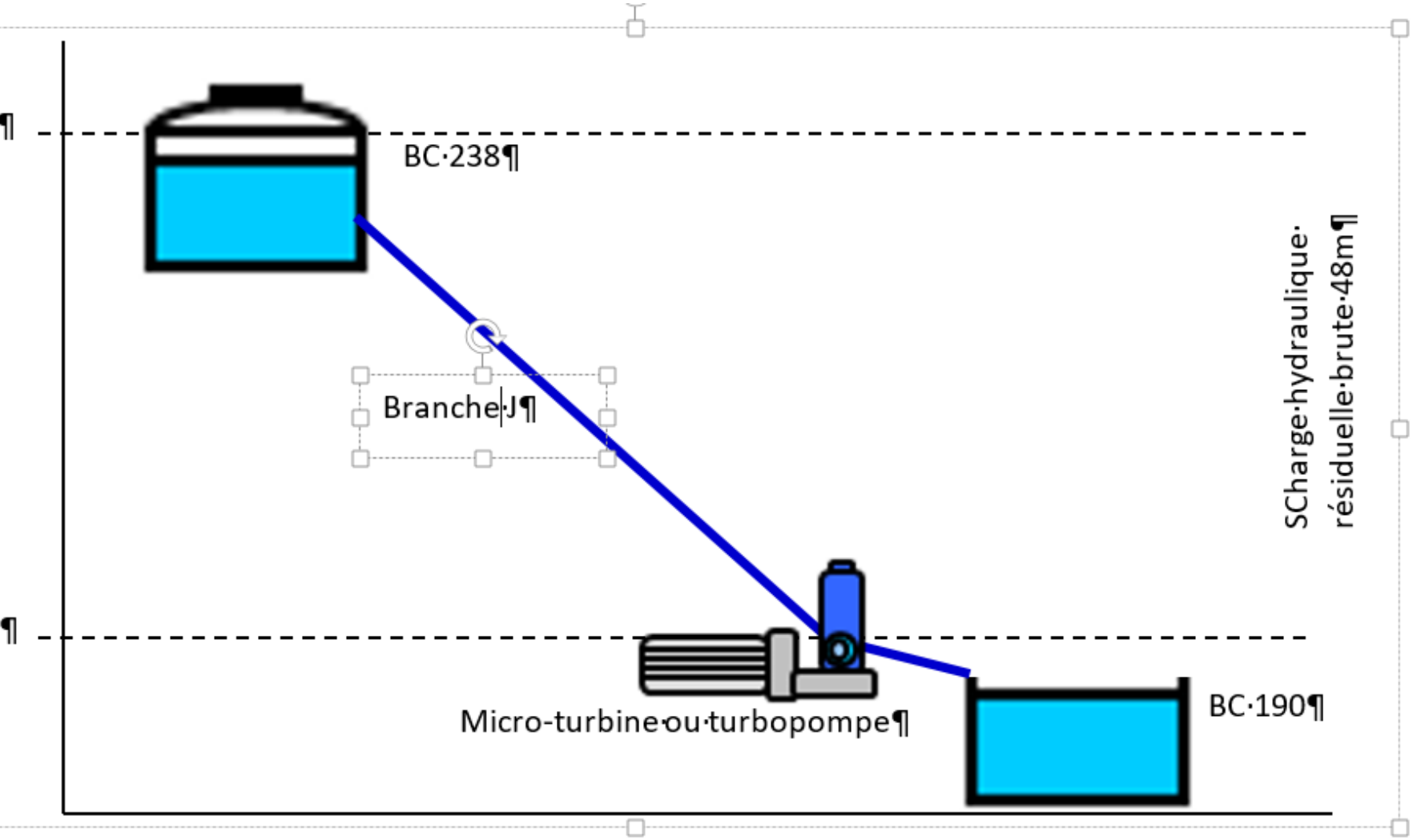
The Chrichira adduction system



The Chrichira system around the BC 238



Energy Recovery



Energy saving by optimization of pumping

- Optimization of pumping consists of modifying the discharge from the El Grine pumping station and the two Grine 8 and Grine 9 boreholes, today discharging from level 177 m to the BC238 reservoir at 238 m, by **connecting them directly to a new basin, (BC190) to be created at level 190 m, in order to reduce the head of the pumping units**.
- This modification allows a significant saving of pumping energy (with a gain of 48 m head height for a flow rate of 200 L / s, or about 130 kW electric gain).

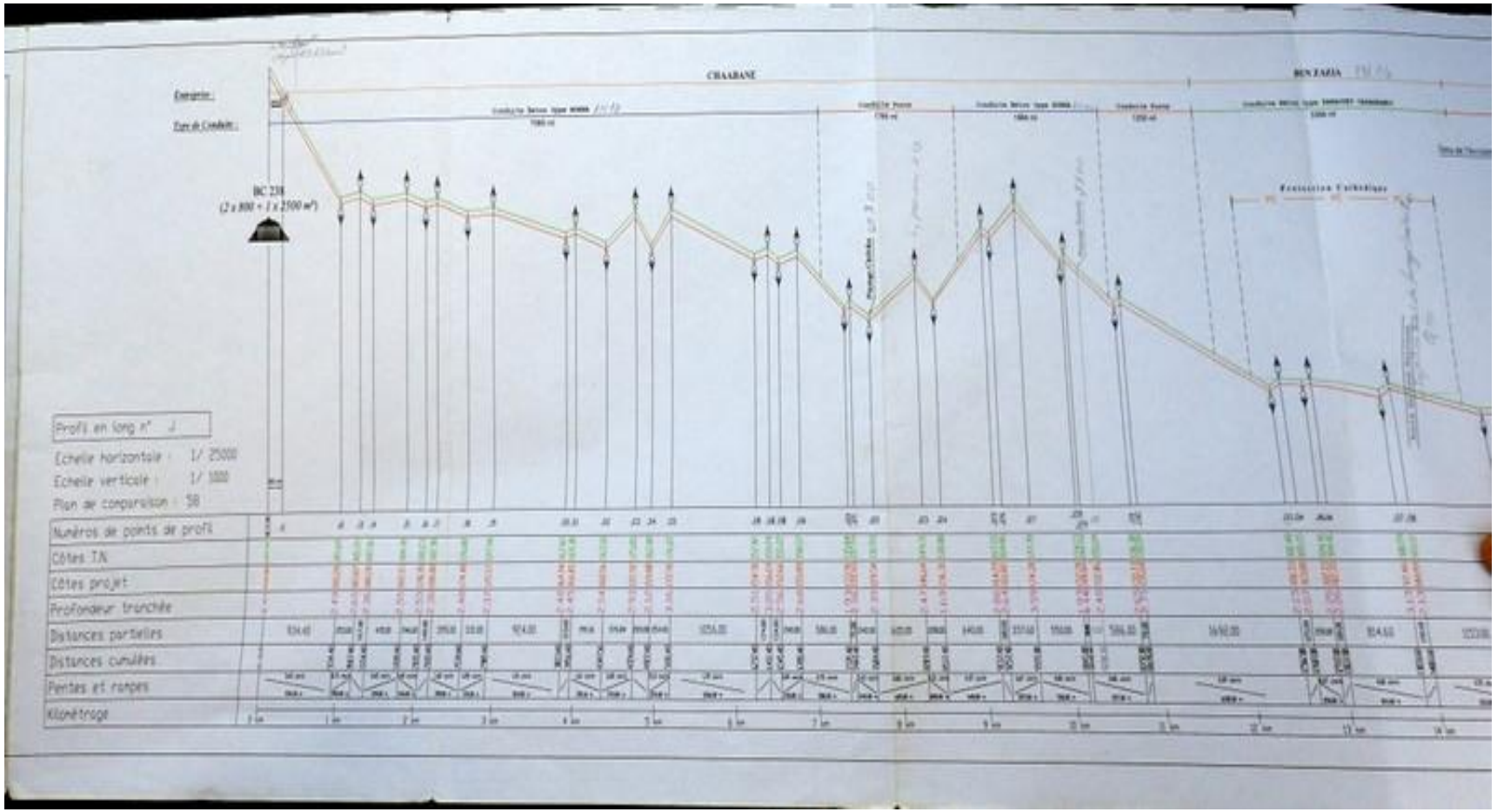
Figure 1 : Station de reprise El Grine

The Chrichira system the BC 238 reservoir

Figure 2 : Départ des conduites J et K

Figure 3 : Brise charge BC 238 m

Profile along the drinking water pipe J until Gontass and further



Choice of the best location

- The Gontass site initially envisaged by SONEDE, located at a distance of 9.6 km from the BC238, at level 180 m, is eliminated
- Too far away, , excessive load losses, in fact the distance from the BC238 causes a significant loss of load, greater than the difference in dimension
- compared to the other site at the level 190m, finally retained (BC 190) for the Hydro turbine

The Gontass site eliminated

- For an instantaneous maximum flow rate of 600 l / s transiting in conduct diameter 800 mm, the linear pressure drop for a roughness coefficient of 1 is 1.87 m / km, the length of the pipe between BC 238 and the new BC 180 is 9.6 Km, the total linear pressure loss is = 1.87 m / Km * 9.6 Km = 18m).
- In addition, the Gontass site would require loading the entire length oc conduct J, which is currently free flowing from the BC238, for 9.6 km with a load in the low points of line J to 130 m high, reaching nearly 12 bars compared to BC238. There is therefore a greater risk of breaking the conduct J, and an increased risk of incidents (transient, water hammer ...).

Which Turbine type, for tender ?

- One can envisage for the Hydropower microplant several possible solutions:
- **a hydroelectric turbine,** (Francis type or flow-through-Brook flow or Banki- or Pelton, all technologies and providers considered)
- **or a pump used as a turbine** (PAT, Pump as turbine)
- Pump as turbine offers the greatest benefit in terms of cost and simplicity,

Choice of variant for Chrichira

Variant 1 Constant flow turbine

- Variant 1: A turbine with constant flow, (taken at 600 l / s, passing through the pipe J under load, the upstream part of the pipe K being just kept moist), bypassing the excess flow.
- This solution makes it possible to have a simple turbine (of pump type used in turbine) and thus less expensive in investment and maintenance, a better profitability, and also a quicker construction and commissioning,

Variant 2 Variable flow turbine

- Variant 2: - A variable flow turbine, which can adapt to the total flow from the BC 238, from 600 l / s to 800 l / s. With a four quadrant speed controller.
- This solution allows to valorize more electrical energy, but this technical equipment is more sophisticated and more expensive, probably longer to implement by SONEDE

Variant 3 : decomposing into two turbines

- Variant 3: One can also think of decomposing into two turbines: A turbine with constant flow, (taken at 600 l / s), and in parallel bypass, a second small turbine to use the variable part of the flow, (100 to 200 l / s).

Design of the Chrichira turbine

- **Recommendation:**
- **a *pump used as a turbine (PAT Pump As Turbine*)** is the recommended solution, in agreement with SONEDE, for the Chrichira site
- And **constant flow, around 600 l/s (optimized at 680** l/s after exchange with the manufacturer KSB))

- **The necessary hydraulic protections** will be installed.
- The bidder will propose protections for the micro-central (risk of surpression and overspeed, in order not to reach the speed of runaway of the turbine, and not to cause water hammer).

Benchmarking in RODEZ drinking water production plant, with hydropower PAT installed

Benchmarking Rodez La Boissonnade

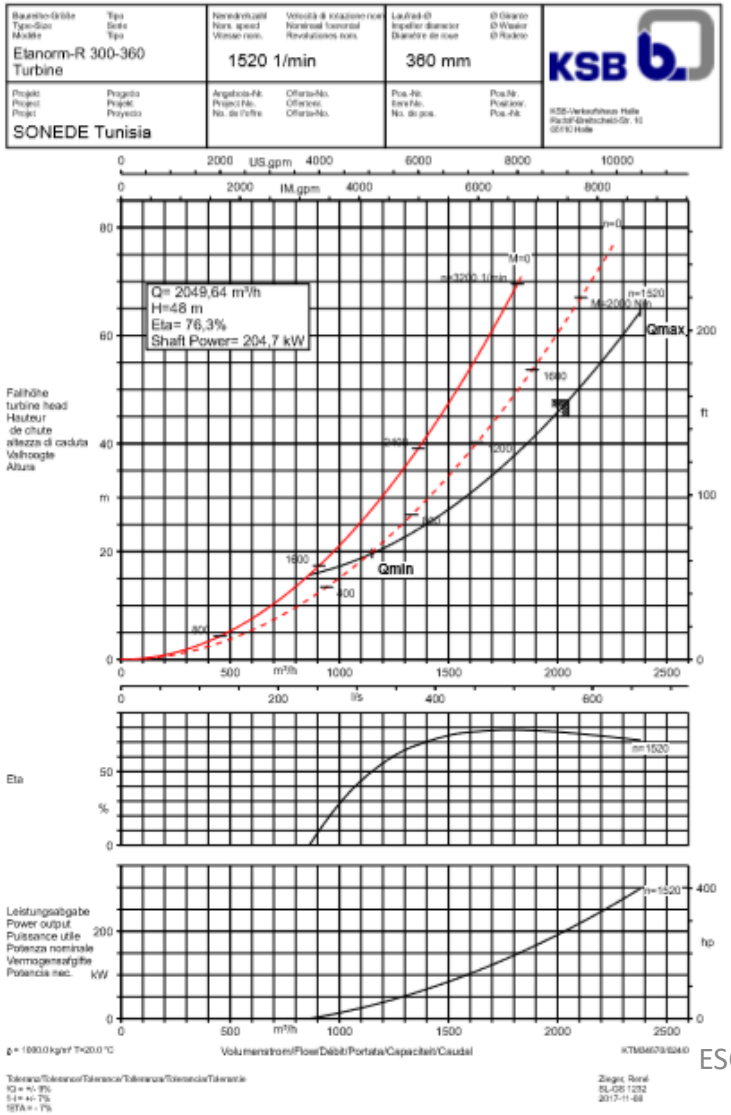
- At RODEZ le 24 aout 2017
- Drinking water production plant in Rodez, operated by Veolia for the City of Rodez
- Using a Pump as turbine KSB, power 40 KW,
- Good return of experience, useful for SONEDE

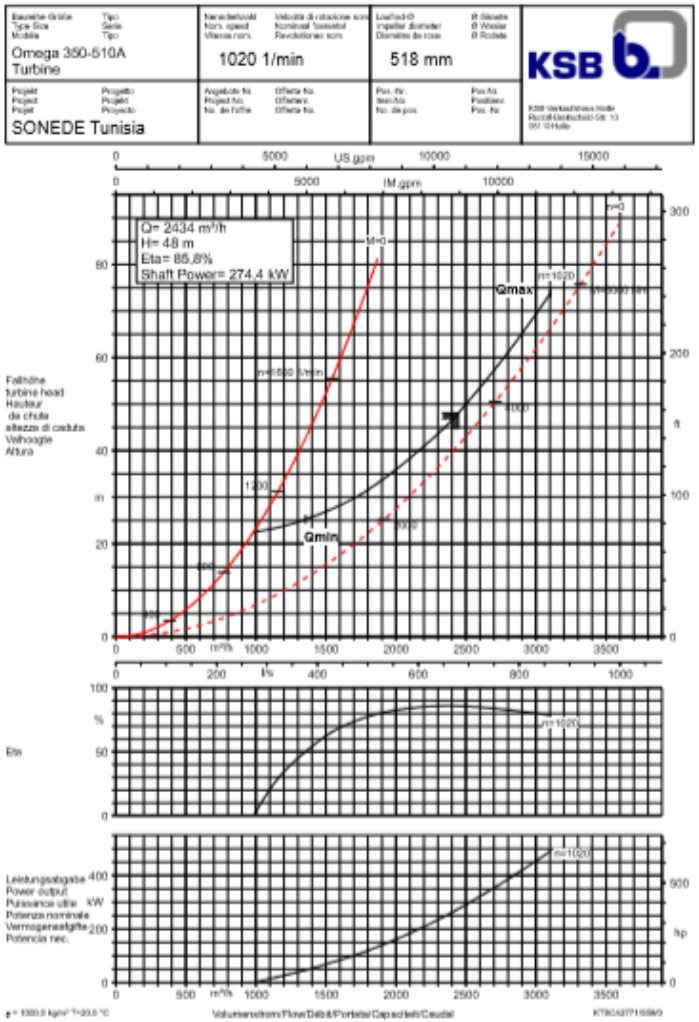
Dimensioning and Optimization

- **Optimization Adapt the turbine to the flow of water, or adapt the flow of water to the turbine ?**
- Around the flow of 600 l/s, KSB have a choice between two optimum Pump as Turbine (PaT),
- KSB proposed to increase the flow, The PaT more productive in terms of yield would require a steady flow of 2450m3 / the proposed flow at 680 l/s instead of 600 l/s, in conduct J.
- the second solution goes through a reduced flow, a pump with bypass 570l / s going through the pump and 110 m3/h going through the bypass).

PUMP AS Turbine KSB optimization between two pumps

Adapt the flow of water to the pump as turbine





Economic Evaluation in Chrichira

Detailed consistency of the works ,

Estimate of all the costs and the profits

Economic Calculation of Pumping Optimization
from the Grine pumping station,
the estimated return time is three years

Economic calculation for the Chrichira hydroelectric power plant with an overall turbine efficiency (pump as turbine) of 0.7 and an annual availability factor of 0.95, the electrical energy generated is 1.65 GWh per year.
When compared to the investment of the only micro-station in PAT (Pump as Turbine) estimated at 500 000 DT,
this gives **a payback period of two years.**

Deliverables and outcome

- Meetings with all stakeholders in Tunisia (STEG, ANME, AFD, SONEDE…)
- Visit on field, Tunis, Kairouan, Sousse (including the Tunis Montfleury Mounabia Bas project)
- Benchmarking (Rodez La Boissonnade, KSB Pumps)
- Feasibility technical and economic study
- Technical specifications for Chrichira
- and Montfleury Mounabia Bas in Tunis
- **Recommendations for energy saving policy in Tunisia and in ESCWA countries**

The Montfleury Manoubia Bas project in Tunis

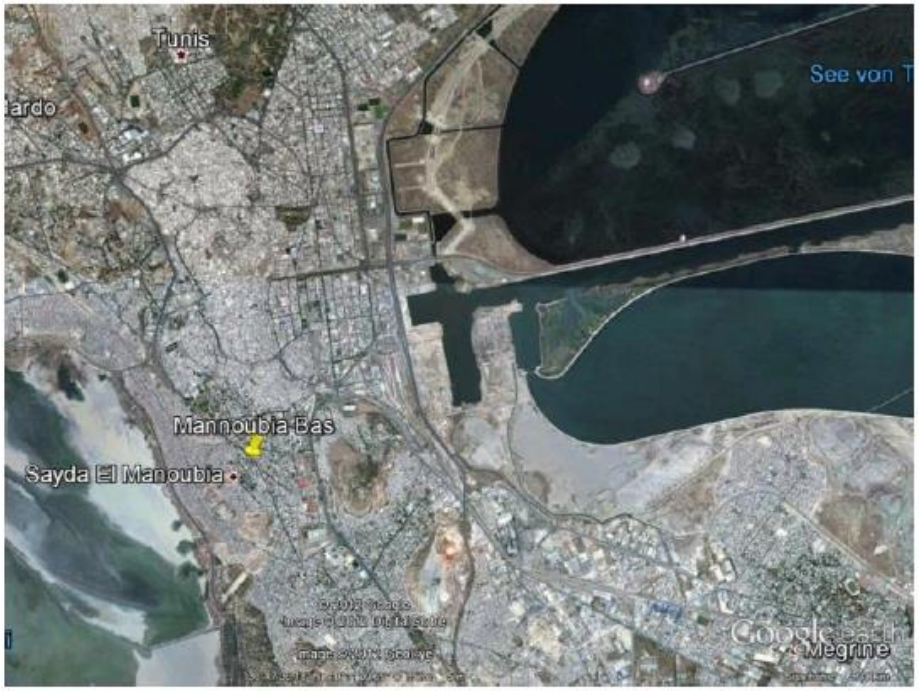
The MANOUBIA load breaker site, located at Montfleury in the city of Tunis, was also studied, at the request of SONEDE, and the technical specifications for an extended call for tenders to MANOUBIA were developed.

The first feasibility study of the Montfleury Manoubia Bas project was in 2012, by SKAT, Switzerland, in partnership with GIZ.
About 40 kw power,
with variable flow (between 110 to 150 l / s),
And variable head –Maximum 51 m, Net head: between 35.5m and 45.0 m, as the water comes from two different tanks, whose water level is variable.

The opinion of the consultant, in agreement with SONEDE, is to retain for the design of Manoubia Bas, a turbine with variable flow, preferably a pump as turbine, with speed variator with four quadrants

Montfleury Manoubia Bas site in Tunis

The site is located in the city center of Tunis, in Sayda El Manoubia, next to an administrative building of SONEDE (Montfleury) and on land belonging to SONEDE



Photographie 1: Emplacement du site, sur GoogleEarth

Location of the site on google Earth

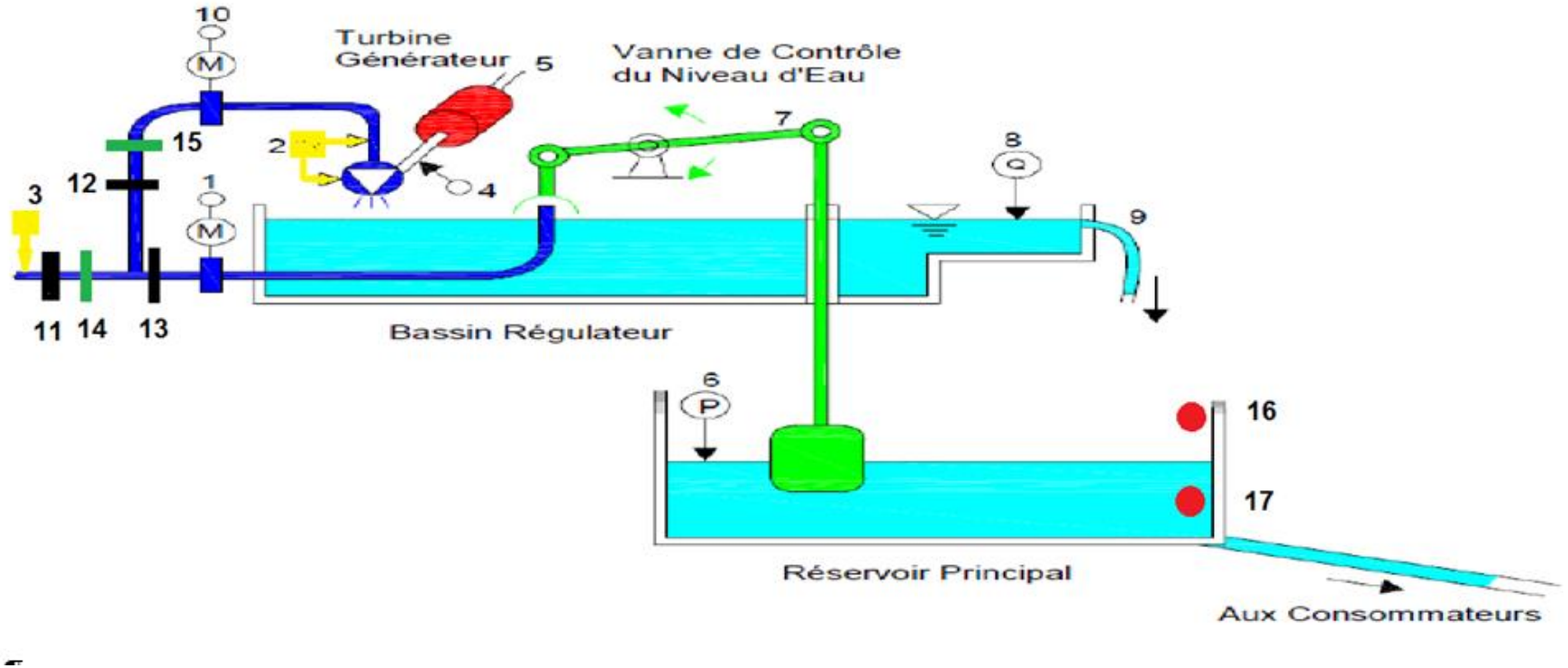
Photographie 2 : Lieu du site, vue de l'entrée

the Site seen from the entrance

Manoubia Bas Arrival of the water, dissipation of energy at the load breaker

Arrival of the water, dissipation of energy at the load breaker

Manoubia Bas operating diagram



Manoubia Bas : for SONEDE, a first demonstration show case in Tunis

The micro hydropower plant of Manoubia Bas, located in Tunis itself, is to be realized quickly, and will be a demonstrative showcase of hydroelectric energy recovery on drinking water network.

Its centralized location is ideal for its use as a pilot power station and a demonstration show case.

Technical specifications (CCTP) have been drawn up by SONEDE, with the consultant.

Thank you for your attention

Henri Boyé

ESCWA energy expert consultant

hboye@free.fr