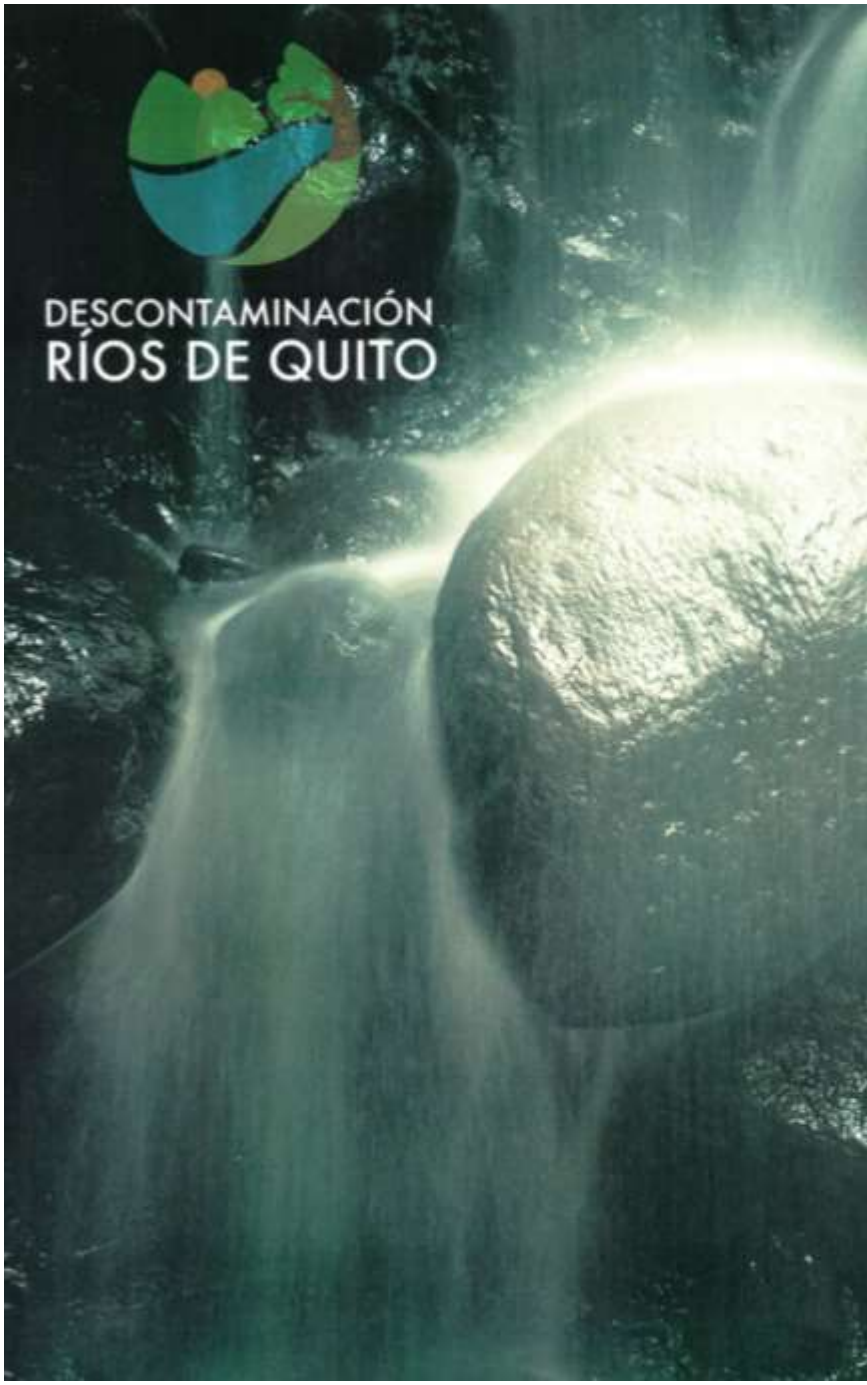
VINDOBONA PROJECT



Executive Summary

EPMAPS
AGUA DE QUITO

VINDOBONA PROJECT
(Executive Summary)

Quito, the capital of Ecuador is home to approximately 2 million people and is located at an altitude average of 2,800 m above sea level. The coverage of drinking water and sewerage in Quito correspond to 99.93% and 95.83%, respectively. At the present, wastewater treatment is very limited. The City currently discharges to its surroundings creeks and rivers an estimated wastewater flow of 128 MGD, which is expected to grow to 180 MGD by 2045. The Quito Water and Sewer Authority, through the Program for the Decontamination of the Rivers of the Metropolitan District of Quito, has formulated an ambitious project to intercept the contaminated discharges before reaching the water bodies, treat the wastewater, and, as a substantial benefit of the project, generate electricity using raw and treated wastewater.

As part of the Quito's River Decontamination Program, Vindobona Project (Wastewater interception and treatment public works for Quito and annexed parishes) is an integral and optimal solution to intercept, transport and treat wastewater discharge of the City of Quito through a technical, economical and environmentally sustainable plan that meets current standards and regulations with the ultimate goal of resource recovery and decontamination of the receiving water bodies.

The project area covers 21 sewersheds with a total area of 27,000 hectares or about 67,000 acres.

Quito's wastewater sewage collection system consists of approximately 1,550 miles of combined sewers. The raw effluent is discharged through a series of outfalls along four rivers that cross the city.

Water quality data of the surrounding rivers have confirmed that they are not suitable for uses such as water supply, irrigation, recreational use with or without contact and preservation of aquatic life.

The poor river water microbiological quality is of partcular concern with respect to downstream use, which may involve human contact and consumption.

Water quality modeling shows the Quito river flow is of the pipeline type. Dissolved Oxygen, DO, is near saturation. Biological Oxygen Demand, BOD, is below 30-60 mg/l and the bacteriological contamination is very high.

EPMAPS
AGUA DE QUITO

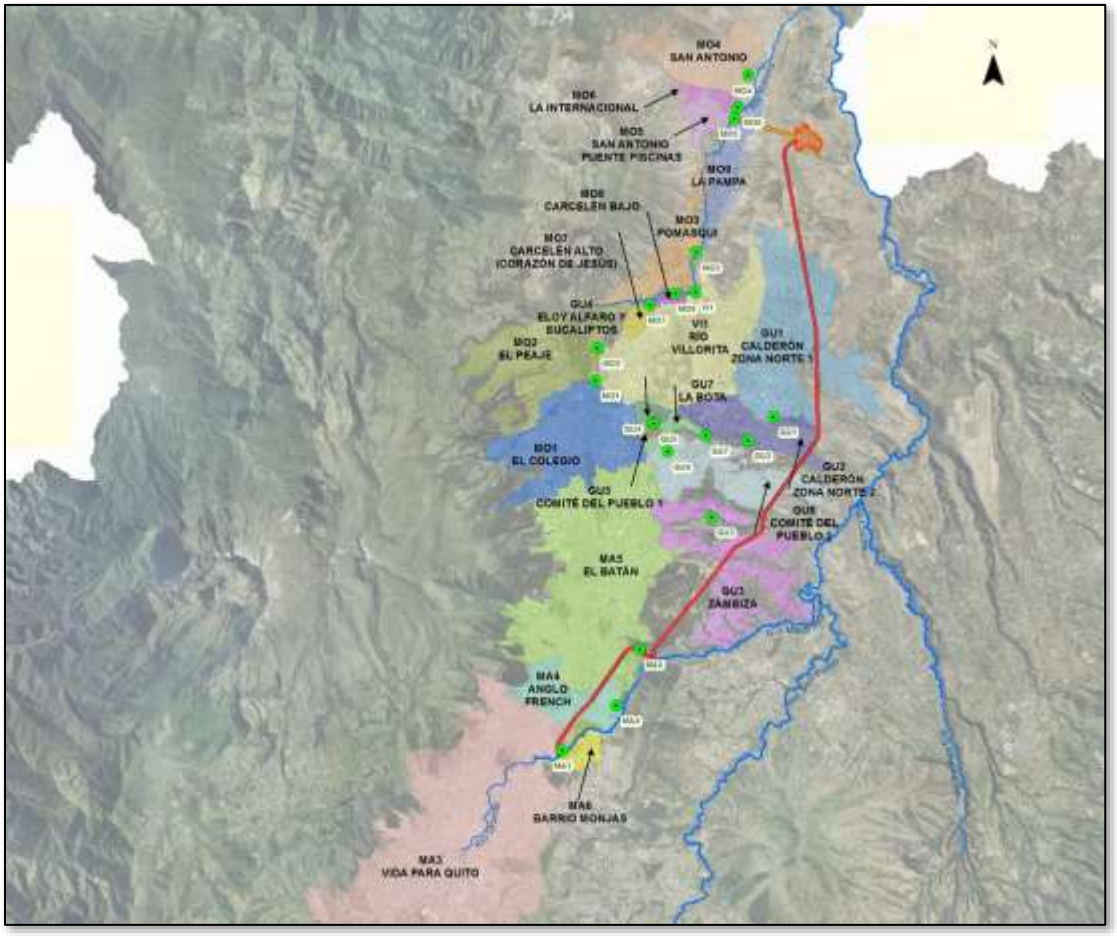


Figure 1. Contribution areas for the Project area

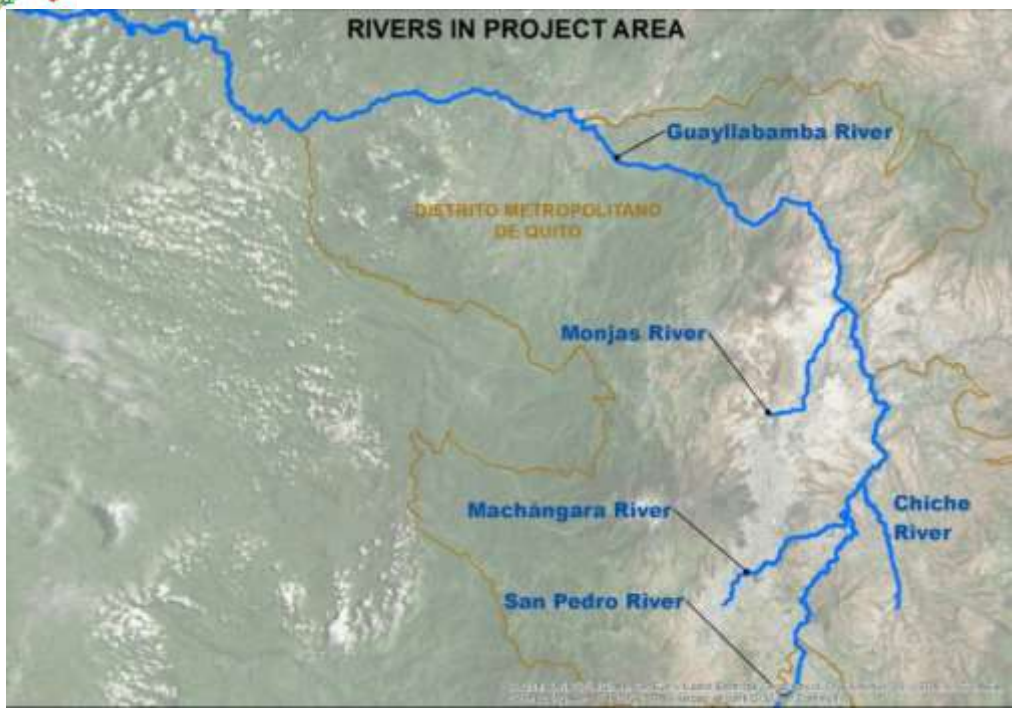


Figure 2. Rivers in Project area

Vindobona Project has the following challenges:

- Conveyance of wastewater through very rugged terrain crossed by several deep gullies and densely populated areas
- Interception of several major combined wastewater system collectors
- Locating a site with sufficient area and suitable geotechnical conditions to install a major WWTP high in the Andes, at elevations around 3,000 meters (9,840 ft)
- Completing surveying work of very large and rugged terrain
- A 900 meters (2,952 ft) elevation difference between the beginning of the interception system and the potential plant site

The project is mainly made up of the following infrastructure components:

- Interception and transmission of existing discharges through two tunnel outfalls: the Emissary that intercepts and conducts wastewater from the Tola Baja sector to the WWTP (ID = 3.7 m; L = 27,440 m) and the outfall that intercepts and conducts wastewater from the San Antonio sector to the WWTP (ID = 3.7 m; L = 2 391 m). The construction of these outfalls is essential to achieve the decontamination of the rivers adjacent to the urban centers of Quito and is an essential requirement for the future WWTP to have wastewater to treat.

- Treatment of wastewater to achieve an effluent of the appropriate quality for the uses of the river downstream of the discharge. The feasibility design of the WWTP proposes a robust liquid treatment process, which includes preliminary treatment, primary sedimentation, stepped feed activated sludge, secondary clarification and disinfection. The solids handling process incorporates sand removal from primary sludge, thickening of primary and secondary sludge, anaerobic digestion, sludge dewatering, and thermal drying. The WWTP has been planned to gradually increase the level of treatment based on established goals and a final effluent that can be nitrified, with additional nitrogen removal. The WWTP will have an average capacity for the design horizon of 2045 of 7.55 m^3 / s, with a peak capacity of 11.5 m^3 / s and will generate 101 tons / day of Class A Biosolids for beneficial reuse through application to the soil and / or single-fill arrangement.

- Treatment of a portion of “first-flush” stormwater at the preliminary treatment level. Quito's sewer system is a combined system, so the waters from the first wash, considered the most polluted, will receive treatment and disinfection before being discharged to the receiving body.

- A pilot plant was operated to collect information on the wastewater properties, aeration efficiency, and treatment process kinetics. The information collected in the pilot plant was used to optimize the full scale plant design.

- Three (3) hydroelectric generation plants, two (2) in line that will use raw water and one (1) located at the discharge of the WWTP that will use the treated water, the plants will have a combined generation capacity of 40 MW, which is equivalent to enough energy to self-supply the operation of the treatment plant and additionally produce surpluses for the benefit of the project.

In summary, the project has the following main infrastructure components:

- A 12-feet diameter, 20-mile long wastewater tunnel interceptor.
  - Tola - Vindobona with a length of 27.6 km (17.14 miles)
  - San Antonio - Vindobona with a length of 2.4 km (1.5 miles)
- A 180 MGD secondary wastewater treatment plant to an effluent standard fit for downstream use.
- Three strategically located power generation facilities on the raw wastewater collection tunnels and on the treated wastewater discharge tunnel, with a total
- power generation capacity of 40 MW.

- **Batan** and **Nayon** located along the tunnel Interceptor Tola – Vindobona, and
- **Vindobona**, located at the effluent of the WWTP

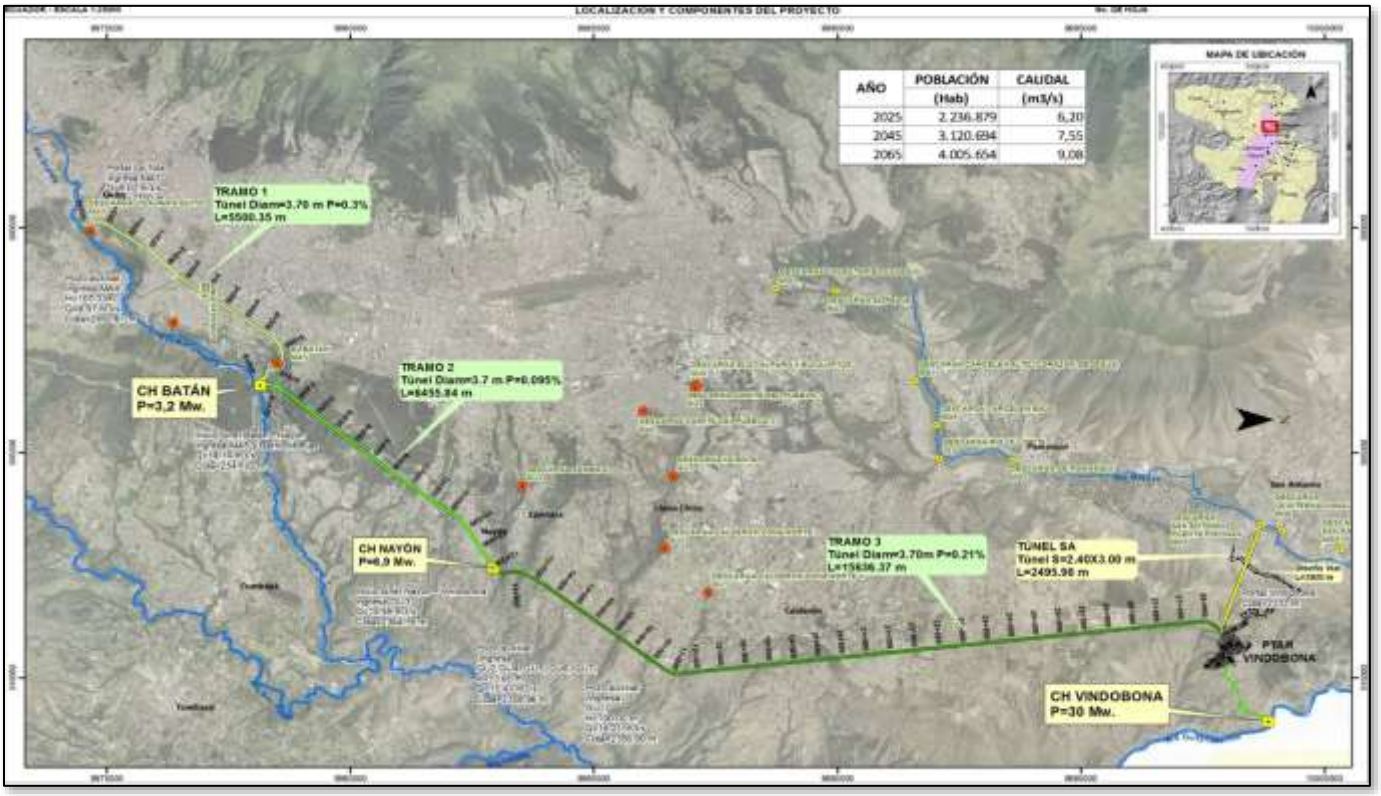


Figure 3. Main components of the project

EPMAPS
AGUA DE QUITO

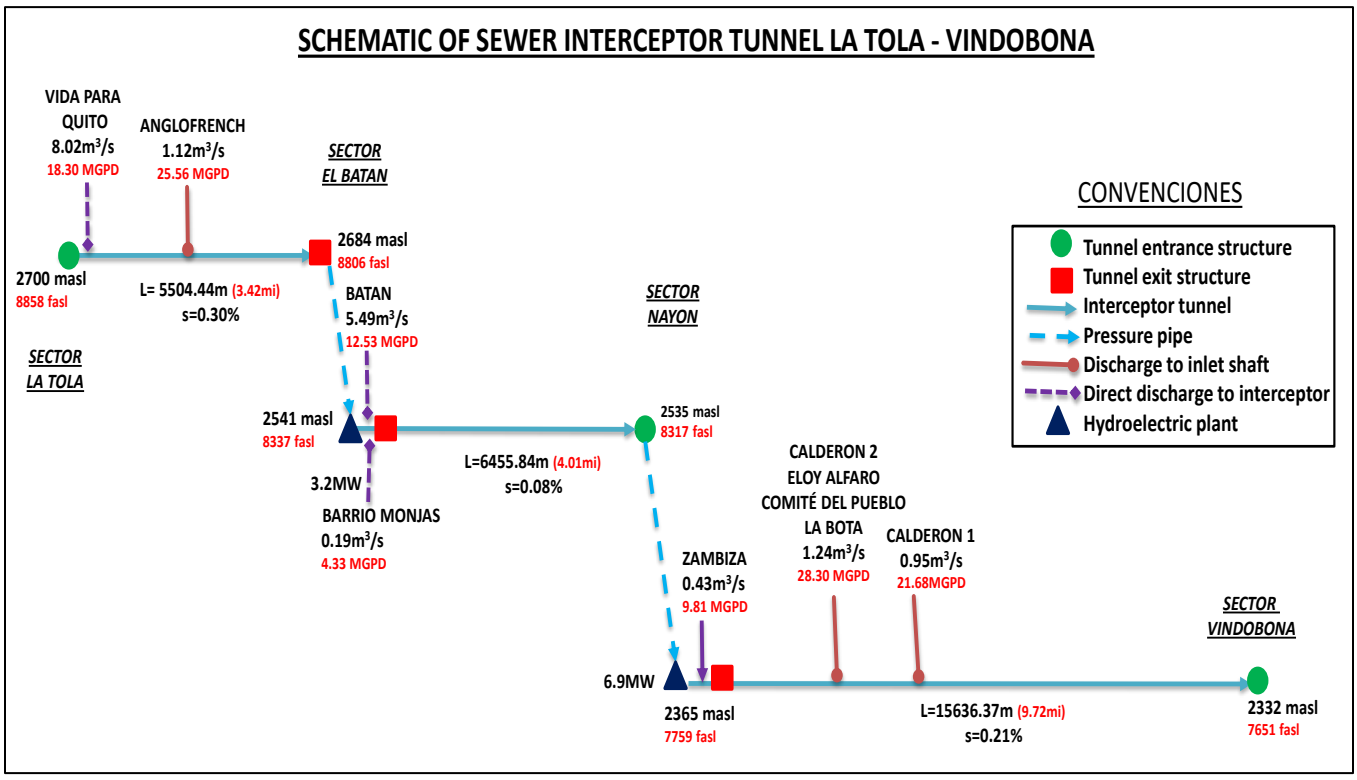


Figure 4. Schematic of sewer interceptor tunnel La Tola - Vindobona

EPMAPS
AGUA DE QUITO

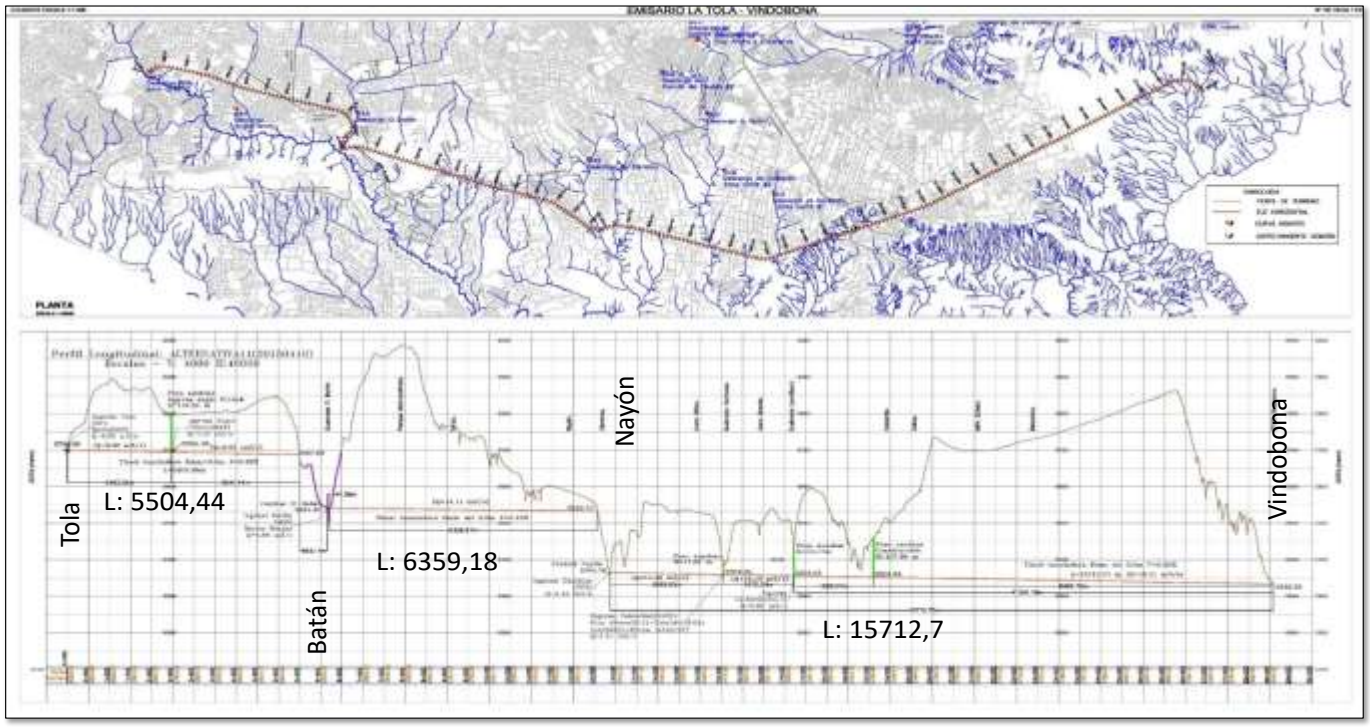


Figure 5. Layout and cross section views of sewer interceptor tunnel La Tola - Vindobona

EPMAPS
AGUA DE QUITO

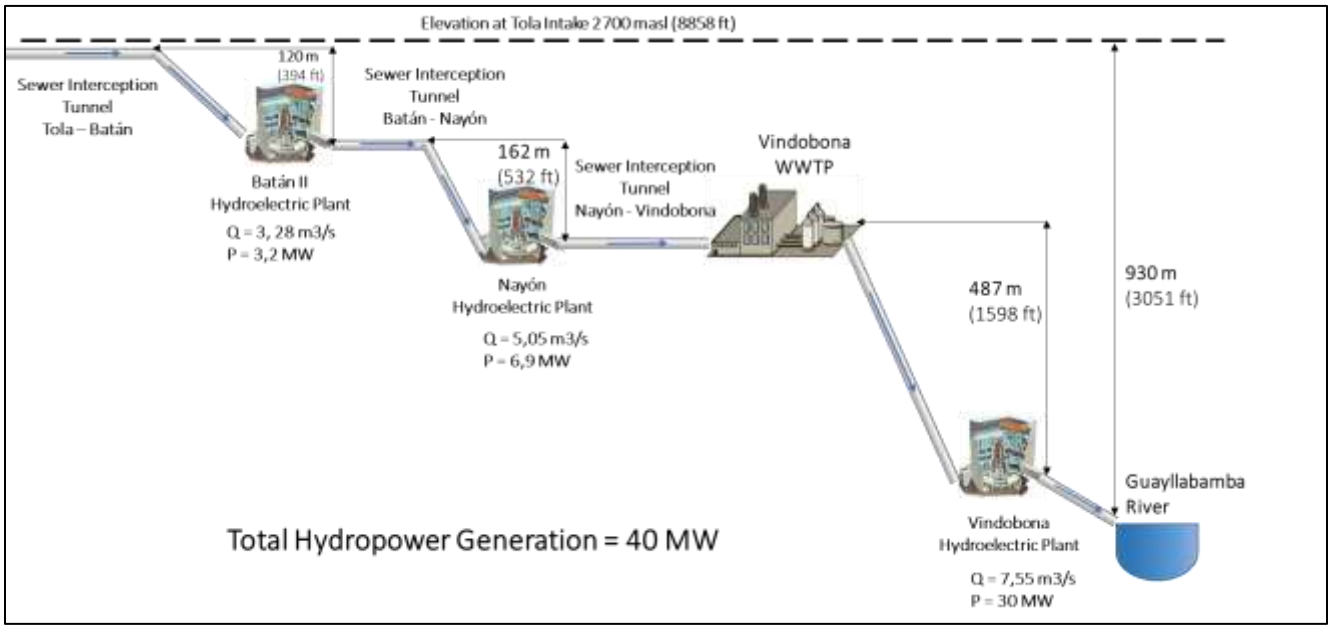


Figure 6. Schematic Diagram of Hydropower Generation System

PROJECT INVESTMENTS COSTS*

Interception and Treatment Public Works of the City of Quito and Adjoining Parishes						
Designer:		Hazen and Sawyer				
Location:		Quito- Ecuador				
BUDGET						
Ítem	**Code**	**Description**	**Unit**			**Costs**
001		**EMISSARIES IN TUNNEL**				**303.411.403,95**
1.001		**SECTION LA TOLA - BATAN**				**61.176.625,93**
1.002		**SECTION BATAN - NAYON**				**61.735.315,67**
1.003		**SECTION NAYON - VINDOBONA**				**151.747.641,07**
1.004		**SECTION SAN ANTONIO - VINDOBONA**				**28.550.829,15**
002		**RESOURCE RECOVERY FACILITY (WWTP)**				**399.632.096,30**
003		**HYDROELECTRIC STATIONS**				**89.398.120,52**
3.001		**HYDROELECTRIC STATION EL BATÁN**				**16.070.673,72**
3.002		**HYDROELECTRIC STATION NAYON**				**20.063.773,29**
3.003		**HYDROELECTRIC STATION VINDOBONA**				**53.263.673,51**
SUBTOTAL						**792.441.620,77**
value added tax					12%	**95.092.994,49**
TOTAL						**887.534.615,26**
They are:						
	EIGHT HUNDRED EIGHTY-SEVEN MILLION FIVE HUNDRED THIRTY-FOUR THOUSAND SIX HUNDRED FIFTEEN WITH 26/100 DOLLARS					

*** Item 1.005 (not included) corresponds to the Access Road to WWTP Vindobona (USD 200.992.13)**

ECONOMIC FINANCIAL ANALYSIS

The scope of the economic and financial evaluation includes the three components of the Project:

- Emissaries;
- WWTP;
- Use of wastewater through three hydroelectric plants.

However, for methodological purposes, the outfalls and the WWTP have been considered as a single component associated with the decontamination of rivers, and the hydroelectric plants as a second component.

The project will be built in two stages: Construction stage 1 (years 0 to 5) consists of the execution of all construction works and approximately 80% of the WWTP; Constructive stage 2 (years 8 to 10) applies to the execution of the complementary works of the WWTP to serve the projected population until the year 2045.

EPMAPS
AGUA DE QUITO

The total investment cost of the wastewater interception and transportation system amounts to USD 303,411,403.95, of which 75 % corresponds to direct costs and the difference (25%) to indirect costs.

The investment cost of the WWTP amounts to USD 399,632,096.30, of which USD 299,724,02.26 correspond to direct costs and the difference (25%) to indirect costs, distributed in two construction stages.

The direct investment cost of the Hydroelectric Power Plants is USD 71,051,863, and the total indirect cost is 25%. Therefore, the total cost is USD 89,398,120.52.

For the economic evaluation, the contingent valuation method and costs were used at an efficiency price.

For the financial evaluation, the long-term free cash flow method was used, with a period of 25 years. The discount rate considered in the calculation of the present value is 6.80. For the application of the free cash flow method, it was necessary to estimate the cost of the financing that this project would adopt, through a loan to finance 80% of the total investment.

The flow of future net economic funds (benefits - costs) calculated at a discount rate of 12% as opportunity cost, yields a positive net present value, that is to say, the project throughout its useful life will present net flows of economic benefits, which proves its economic viability.

This project, evaluated in its entirety, shows that, for every dollar of investment (costs), it obtains USD 1.28 of economic benefits, with an internal rate of return of 15.67%, which is higher than the rate assigned as opportunity cost of 12% required in the present value, therefore this project is economically feasible.

Relevance of the Quito Resource Recovery Project

- The Vindobona Project is part of a major undertaking by the Quito Water and Sewer Authority (EPMAPS-Q) to decontaminate the rivers surrounding the capital city of Quito.
- Currently, none of Quito's wastewater is treated, causing contamination of the city's four major rivers. When the Vindobona plant comes online around 96% of the city's wastewater will receive treatment.

- The project, by taking advantage of substantial differences in ground elevations, is improving its financial feasibility through generation of electricity in excess of its internal demands.
- This is one of the largest greenfields wastewater treatment projects in South America, which affords Quito the opportunity to develop a project based on sustainability principles of **energy neutrality** and **resource recovery** while improving the quality of life of its inhabitants though an integrated water recovery solution, which results in an emblematic project for Quito and its residents.

PROJECT BENEFITS

The Vindobona Project is an indispensable component of the Quito Rivers Decontamination Program and constitutes the main component for its achievement.

Due to the location of the City of Quito in the Andean highlands and the complicated geomorphology of its location in a mountain area, the project integrates several components to collect, transport and treat wastewater while taking advantage of the unevenness from the beginning of collection until final disposal to build three hydroelectric plants, which will provide enough energy for the requirements of the WWTP and will produce a surplus for the benefit of the project. In addition, the combined wastewater and rainwater collection system allows the reception and treatment of first flush waters resulting from surface runoff in times of rain.

The project itself is ambitious and emblematic, it faces all the hydrogeological and topographic challenges of the area and is economically feasible; however, like most sanitation projects, it is not financially feasible, requiring considerable subsidies during project implementation. These subsidies can be reduced according to the strategy of construction in stages and the negotiations of the water company regarding the policy of buying and selling energy with the public companies of the energy sector.

The Project, as a whole, offers a series of benefits for the city of Quito, for the natural habitat in the area of influence and for those who live in the vicinity of the project. The benefits can be grouped as follows:

- Recovery of the quality of rivers and banks

One of the main benefits of the project is the recovery of the rivers of Quito, through the sanitation of the water bodies, the riparian zones of the rivers, the improvement of the

conditions of the aquatic and wild life and the opportunity to increase the uses of the water body downstream of the treated effluent discharge.

In effect, by conducting the wastewater to a remote site, such as Vindobona, the contamination of the San Pedro, Machángara and Monjas rivers is eliminated, which receive all the impact of municipal and industrial raw waters.

The project also offers the opportunity to collect and treat the first wash waters, which concentrate the solids, garbage and organic matter produced by runoff. In this way, these polluting discharges to the receiving bodies are avoided, contributing directly to the preservation of the quality of said bodies.

The environmental benefits can be summarized as follows:

- Decontamination of the rivers of Quito
- Improvement of riparian zones
- Improvement of aquatic and wildlife conditions
- Generation of opportunities for new uses of the body of water

- Social benefits

The discharge of treated wastewater will contribute to improving the living conditions of the inhabitants of the entire city, since the disinfected water eliminates the risk of infection by contact with water highly contaminated with pathogenic organisms. The benefit is greater for the population that lives in the vicinity of the river that is used for recreational purposes or for fishing and irrigation. In particular, the few farms that grow raw consumer products using wastewater or discharged into rivers are at imminent risk, not only for farmers, but for the population that consumes the food thus harvested. Another social benefit is the generation of employment not only in the operation of the entire collection and treatment system, but also in resource recovery activities such as irrigation and use of sludge in agriculture.

The social benefits can be summarized as follows:

- Improving the health of the population exposed to contact with water
- Better environmental conditions for the inhabitants who live on or near riverbanks
- Minimizing the risks of consuming raw food irrigated with untreated or disinfected wastewater
- Generation of jobs during the construction and operation of the system.

- Recovery of the water resource and generation of clean energy

The collection and treatment of wastewater can be viewed as a water resource recovery project. Indeed, the Project makes it possible for wastewater to be purified and recirculated to the environment in a safe way. Additionally, the unique characteristics of the project make it possible to generate clean energy with currently waste resources or with treatment by-products. Finally, the production of processed sludge allows its possible use in agriculture, thus taking advantage of the organic and nutrient content present in wastewater. These opportunities translate into economic and environmental benefits.

The following summarizes the benefits of resource recovery:

- Recovery of wastewater, which generates benefits in the receiving bodies and in irrigation
- Use for agriculture of the organic and nutrient content of the processed sludge
- Generation of clean energy with which a project with a positive net energy balance is achieved
- Future opportunities for cogeneration of energy from biogas produced in anaerobic reactors
- Public perception and opinion

An intangible benefit, but of great importance, has to do with the positive perception and feeling that the fact of living in a clean city that is committed to protecting the environment generates in people. Indeed, the concept of a modern and clean city attracts tourism and is a source of pride for the entire population and city authorities. It is so so, that the surveys have shown the high degree of acceptance of the population with respect to the decontamination of the rivers of Quito.

Finally, considering that the project has already obtained its **Technical Viability** and the **Environmental License**, it should be noted that the project will be implemented on the Equator, at an elevation of about 9800 feet above-sea-level, on a topographically challenging terrain, which presented opportunities for maximizing project benefits and substantial challenges in its design and construction.