YMCA- Lebanon

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

WASTEWATER TREATMENT PLANT

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Beirut, Lebanon

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ANNEXES

1- Executive summary

Introduction:

In Rashaya town, Rashaya Caza of Lebanon, wastewater disposal is the main environmental issue that has created unsanitary conditions, odor and mosquito problems within the town, which causes nuisance to the residents and affects their health. This is due to the overflow of the septic tanks on streets and public places.

Therefore, it is planned to establish a Wastewater Treatment Plant (WWTP) in Rashaya town, which will treat the wastewater generated from 60% of the households of the town, or the houses located at the Eastern and Southern sides of the town. Due to gravitational conditions, the Northern and Western sides of the town, which contain 40% of the population, will not be connected to the WWTP. Another WWTP will be established for them in the future. However some of the houses there already have greywater treatment systems that treat 60% of their wastewater.

The Rashaya WWTP will have a capacity of treating up to 600m^3 of raw sewage everyday, achieving a secondary level treatment. After that, the effluents will be discharged into the valley, at a spot next to the plant or 500m far from the plant through a pipe line.

Rashaya town is located 100 km South-East of Beirut, at an elevation of 1250 m from sea level. The proposed WWTP will be established on a site located 3km south from the town.

The present winter population of the town does not exceed 7500 people, which reaches to 10000 people in summer months. Due to the high rate of migration during the last 30 years, it is expected that the population will remain low, increasing slightly within the next 20 years. The projected population of the town for the year 2020 is estimated to be 12500.

A sewer network is being established by a private contractor AL MADAR in the town. Also recently a 3km pipeline has been established which will be connecting the sewer network of the town to the proposed WWTP. Yet none of

the houses are connected to the sewer network. The residents of Rashaya are very keen to have the project implemented as soon as possible. They are suffering from the current situation, which has contaminated the surface and groundwater resources of the area, and is causing odors and unsanitary conditions.

The construction of the WWTP is supposed to start as soon as the Municipality gets the permit from the Ministry of Environment. YMCA-Lebanon is supporting the Municipality technically and financially for the materialization of this WWTP project. YMCA will cover 50% of the total expenses of the WWTP and the pipe network, such as plant installation and pipes and manholes covers. The Municipality will contribute the other 50% towards the total expenses of the project, by supplying the labor force for infrastructural work, and taking charge of excavation and concrete-using activities.

MEEA Ltd. - Consulting Environmental Engineers- undertook the preparation of this Environmental Impact Assessment (EIA) Report of the Project, which will be presented to the Lebanese Ministry of Environment (MoE), for obtaining the license for the establishment of the WWTP.

Brief Description of Project Size, the Process, and Location

The wastewater treatment plant of Rashaya town will be located at a distance 3km from the nearest house. The land to be used for the project is part of a property, belonging to the Municipality of Rashaya. The land lot number is 5575, with an area of 1760 m^2. Wastewater from the town will reach gravitationally the proposed WWTP site.

The wastewater treatment technology to be used at the WWTP is the GROSSIMEX Company's two stage trickling filters technology, which is an aerobic process. This WWTP will consist of a primary separation tank, two trickling filters, a secondary clarifier and sludge drying beds, through which the wastewater flows gravitationally and is treated by the action of aerobic bacteria and to a certain extent by anaerobic bacteria that are found in the wastewater stream, without any specific maintenance and electric power use. Trickling filter

process provides secondary level treatment to wastewater. It significantly reduces the coliform bacteria, BOD, nitrogen, phosphorous, toxic substances and other pollutants found in the wastewater. The filters, tanks and drying beds are designed to site-specific conditions with high loading capacities.

The treated wastewater, the effluent, would be discharged in a narrow valley adjacent to the site. The plant will treat wastewater to a level of BOD less than 25mg/l, phosphorus less than 10mg/l, nitrogen less than 30mg/l and suspended solids less than 60mg/l. This level of treatment will comply with the regulation of the Ministry of Environment, Decision 8/1, 2002. This makes it safe for irrigation, or discharge in the nature.

The plant is self-operational (gravitation flow) and needs minimum maintenance and no mechanical input. The WWTP is modular and can be expanded in the future to meet the wastewater treatment needs of larger populations.

Importance of the Project for the Local Community

Wastewater disposal is the pressing environmental issue for the inhabitants of Rashaya town, which is going to be solved by the establishment of the WWTP, capable of accomplishing secondary level treatment of wastewater.

Currently households discharge their wastewater in septic tanks, which often overflow and create unhealthy conditions in the town. It has already created nuisance and social problems among the inhabitants.

The residents of the town are keen to have an environmentally sound solution to their wastewater disposal problem. Clean environment will improve the health standards of the local people.

The establishment of a sewer network in the town and treatment of wastewater in the proposed WWTP will eliminate the spread of diseases, prevent risks of contamination of their surface and groundwater resources and contribute in the preservation of the quality of the environment. The treated wastewater might be used for forestation and agricultural purposes.

The Municipal Council and most of the residents of the town welcomed the project except for a few that didn't agree with the proposed location of the

WWTP. No households or farmers will be disadvantaged by the implementation of the project since they are located at a considerable distance from the site. There is only one small agricultural land near the site, which is being used for grain cultivation. Since this land it located at a higher level; it will not be affected by the discharge of the WWTP, on the contrary it can use the effluents for irrigation purposes.

Objectives of the Project

The WWTP project of Rashaya town aims at environmentally safe disposal of its wastewater, for upgrading the sanitary and health standards of the inhabitants.

The long-term objectives of WWTP project are to:

- Prevent the spread of diseases, including the limitation of the mosquito population,
- Prevent the prevalence of conditions offensive to sight and smell,
- Control the contamination of water resources,
- Prevent and control soil and groundwater pollution.

The specific objectives of the project are to:

- Establish a dependable WWTP, which is cost effective and requires the minimum maintenance.
- Manage the pathogenic risk inherent in wastewater to meet the effluent discharge standards set by the Lebanese Ministry of Environment.
- Manage the safe disposal of sludge.

Wastewater Treatment Process of the Proposed Project

The treatment technique for WWTP of Rashaya town will be based on the two stages trickling filters (TSTF) technology of GROSSIMEX Co. This is a biological treatment system based primarily on aerobic digestion and to some extent on anaerobic digestion of biowaste found in the wastewater. Both aerobic

and anaerobic fermentation of wastes are natural biologic processes, which are suitable in rural areas.

Description of the Trickling Filter process

60% of Rashaya's houses will be connected to the sewage network after its construction and will be connected to the WWTP by a 3 km long pipeline.

Step 1: Wastewater flows through screens installed at the inlet of the plant to retain large pieces and particles and floating objects.

Step 2: Wastewater is then introduced in a primary separation tank for sedimentation. The tank is roofed and separated in 2 chambers in which sedimentation of sludge is accomplished. In the first and second chambers anaerobic digestion of the organic material takes place. Gases produced by the digestion are escaped through a 3m long vent.

Step 3: Next the effluents of the primary separation tank reach gravitationally the trickling filters (a set of two) that are the main reactors of the WWTP. Trickling filter (TF) is an aerobic treatment system (needs oxygen) that removes organic matter from wastewater. TF are constituted of rock or plastic media, to which microorganisms are attached. Liquid wastewater is sprinkled over the top of the medium, and as it percolates gravitationally through the media, the organic content is digested by the microorganisms. While the microbial layer thickens through microbial growth, some of the microorganisms detach from the media and are collected in an underdrain system.

Step 4: After wastewater passes through two similar trickling filters, effluents reach the secondary clarifier for further separation of sludge. The clarifier is a tank in which effluents are detained for 6 hours to separate flocculated materials from the liquid component of wastewater. The sludge settles at the bottom of the tank, (sloped 45 degrees) and is collected for periodic disposal.

Step 5: Sludge is then transferred to drying beds for dewatering. Drying beds are constituted of a 300 mm sand layer on which sludge is spread. It dewaters by drainage through the sand and by evaporation from the surface exposed to air. A lateral drainage system is installed to collect percolating water from the sludge.

Sludge is completely dried during the summer season, which can be used in agriculture as soil conditioner.

Step 6: The **final effluent** wastewater from the clarifier is discharged in the valley next to the plant. At this stage, it would have undergone secondary level treatment, which complies with the standards set by MOE. For further purification, effluents can be discharged into the nearby forests or they can be discharged in a farther point in the valley by transporting effluents from the plant's outlet to a lower spot in the valley by a connecting pipe.

The local community will not experience any odor problem or any other sort of nuisance, when the WWTP of Rashaya is operated. This is because of the distance (3km) of the WWTP from the town, and the prevailing west-to-east direction of the winds. Even neighboring towns will not be affected by the odor. It is anticipated that no smell from the WWTP will go further than 50 m form the site.

Advantages of the TSTF Process

The TSTF technology is environmentally friendly, and has no negative impact. The system has no mechanical or electrical components. It generates a little bit of odors, but only at the perimeter of the plant. The system operates gravitationally and produces a treated wastewater, which can be safely disposed in nature. Even this might be used for irrigation purposes, provided that the crops are not eaten in raw state.

Moreover, the plant does not need full time attendance, as it is self-operational. However, the only need is to do periodic cleaning of the screen and testing and reporting any changes that might be caused by external factors.

This technology is of particular interest in rural areas, where low-cost technology and minimum maintenance is needed.

Description of the Surrounding Environment of the Project:

The town of Rashaya is located in the Caza of Rashaya, 100 km from Beirut, at an elevation of 1250m above the sea level.

The proposed WWTP will be located on the south side of the town, 3km far from the nearest house. The site is in a narrow valley of about 100m width and has a total surface area of 1760m^2.

There is a main asphalted road passing along the valley. An access road of less than 100m length will be opened to connect the main road to the proposed WWTP site. The Municipality will be involved in asphalting this road.

There are no permanent surface water sources in the project area, including the project site. A small spring that emerges every 3 to 5 years (when snow and rainfall are intense) is located at a distance of 1.8 km above the proposed site between Rashaya and the site.

There are no industrial activities in the project area except for 3 grape molasses factories and 2 olive oil presses. However since they do not discharge wastewater in this valley, they will not affect wastewater characteristics arriving to the WWTP. Farming activities near the site are limited to one cultivated land north of the site. The closest fruit farm is located at 1.5km north of the site.

Households of the town get their fresh water supply from 2 artesian wells drilled near the town. They also get intermittent water supply from the public water supply of Chamsine source.

The **climate** of the project area is Mediterranean, with 7 to 8 dry months and relatively wet winters of 4-5 months duration. In winter months, the area might face freezing conditions for some days. The prevailing wind direction in the area is from West to East. The average annual **rainfall** in the area does not exceed 750mm.

The Project area, including the proposed site, has a moderate biodiversity. Oaks, Hawthorn (Zaarour), Sumac, Bellan and annual plants are present at the site and its surroundings. Snakes, lizards, rodents, chacals, foxes and birds and others are the main animals living in the area.

The Project site can be considered as a sensitive spot, since it is located in the vicinity of a natural forest. However there are no trees in the surroundings when a diameter of 100m is taken. The main river of the area, the Hasbani River, runs some 30 km South of the proposed site.

Likely Significant Environmental Effects of the Project and Their Mitigation

Establishment of the WWTP will have positive environmental impacts in the project area. It is unlikely that it will pollute the surface waters, the soil, or contaminate the aquifers in the area. However, if the WWTP is not established, Rashaya will continue discharging raw sewage into leaking septic tanks, which already exerts negative effects on the local environment and will continue to create health problems.

The overall environmental effects of the project will be insignificant. Nevertheless, there is the chance of minor soil erosion incidents, caused by runoff during the wet season of the construction phase. In addition, a minor visual inconvenience can be experienced due to the physical existence of the plant. However, the planting of trees around the WWTP will hide the structures.

Impacts of the project on the environment will consist of four sources namely:

1- Site Specific Factors:

The choice of the site is based on the fact that it is the convenient low spot from the town, where wastewater from all houses can reach gravitationally. Actually, it is the only available single valley where the wastewater can be collected gravitationally. The site is relatively flat where the WWTP can be built and it has been recently purchased by the Municipality.

The treated effluent of WWTP will be discharged in the valley. In here, the effluent will be further purified by natural factors, such as sun, soil, bacteria and

other microorganisms. After that stage, there is no probability that any significant environmental hazards might occur.

2- Process-Technology Related Effects:

The TSTF technology of GROSSIMEX Co. is dependable and environmentally friendly. It is a low-cost technology, which can be applicable in many rural areas where the availability of skilled labor is scarce.

Compared to other similar wastewater treatment technologies, it is dependable, because of absence of mechanical equipments, which often can go out of order. The system operates gravitationally. No water pumping is required in the plant. There are minimal odorous gas emissions from the plant, which cannot be felt at a distance of more than 50 m.

These features make the treatment system easily applicable in the rural areas without significant environmental impacts.

However, there is a chance of flies breeding at the inlet of the plant. This might create nuisance to the people. But screens will be installed at the inlet to avoid access of flies to wastewater.

3- Effects Created During Construction and Earth Moving:

During the construction phase of the project, moderate quantities of earth will be excavated and soil disturbance will take place. If this soil is not utilized for landscaping, during the wet season soil erosion will result at the site. On the other hand, if the excavated soil is haphazardly dumped, this will cover trees and will block canals in the downstream direction and create unsightly scenes at the project site.

4- Effects Created During the Operation of the Treatment Plant:

No significant environmental effects will take place during the operation of the plant. The influent wastewater will be treated to secondary level, as required by MOE standards, and then will be released into the forest for further purification. Sludge will be dried and used as soil conditioner in forestation or agricultural projects. Transparent covers can be installed on sludge

beds for further heating and drying of the sludge by Solarization technique.

Mitigation Measures

The main mitigation means will concentrate on careful designing and use of locally available construction material. For instance, the excavated soil from the site will be utilized in landscaping. E.g. construction of terraces for planting forest trees at the site. The Municipality of Rashaya will undertake tree-planting campaigns around the WWTP, and awareness rising of the community will be done for minimizing biowaste introduction in their kitchen sinks.

In addition, a proper drainage system for the rain runoff will be established at the site. In addition, measures will be taken to buffer shock flows of wastewater, such as accidental entry of rainwater runoff into the sewage network and then to the WWTP.

The caretaker of the plant will practice good housekeeping measures, which will lead into the containment of any incidental pollutant release, proper cleaning of screens and maintenance of drainage system around the plant, optimized wastewater treatment operation and any other related measures that will mitigate the side effects of the overall operation.

Monitoring and Supervision Programmes

MONITORING

The plant does not need full time attendance, as it is self-operational. But it will be subjected to continuous monitoring. Actually, the only need is to clean the screens and do testing for the final effluents and report any changes that might be caused by outside factors.

Monitoring activities will also cover the odor, mosquito and other nuisances that might be resulted at the plant site. This will ensure that all of the mitigation measures are within the safe limit and that they do not have environmental effects.

SUPERVISION

The Municipality of Rashaya will be in charge of the supervision of the WWTP operation. The operational manual of the Plant will give detailed instructions as what to do weekly, monthly and yearly. The operator has to clean screens every 2 to 3 days and check every while the good functioning of the trickling filters. Testing must be done at least once a month during the first year of full operation to check the pH and BOD levels.

The system does not require any power consumption because it relies on gravitational flow.

Once every year, early in dry seasons, the sludge and scum from the primary tank and secondary clarifier will be cleaned and dried onsite and then used for afforestation purposes.

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2- Project Identification

2.1- Project Specifications:

Project Title: Wastewater Treatment Plant (WWTP) in Rashaya Town

Location: Rashaya, Rashaya Caza, Lebanon.

Project Site: Public land lot No.5575, Rashaya town

(See map in Annex 2.3)

Population:

Town	Summer	Winter	Projection 2020
Rashaya	10000	7500	12500

Technology to be used: Two Stage Trickling Filters of GROSSIMEX Co.

(aerobic process)

Size of the Plant:

Total area required for structures:	350m^2
Volume of manual bar screen:	0.1m^3
Volume of primary separation tank:	144m^3
Volume of trickling filter 1:	66.5m^3
Volume of trickling filter 2:	182.5m^3
Volume of secondary clarifier:	198m^3
Area required for sludge treatment:	94.5m^2

Load processed daily: 600m^3/day of untreated wastewater.

Local Stakeholders: Municipality of Rashaya

Sewer Network built by: AL MADAR

Plant to be built by: GROSSIMEX

Plant to be financed by: Joint partnership between YMCA and the Municipality of Rashaya

Plant to be managed by: The Municipality of Rashaya

Construction to start: Immediately after getting the permit from the Ministry of Environment.

2.2- Brief Description of Project Size, the Process, and Location:

The Municipality of Rashaya town of Rashaya Caza has taken the decision to establish a wastewater treatment plant (WWTP) in its southern territories. Only 60% of the population of the town will be connected to the WWTP since the wastewater of the other 40%, located at the northern and western sides of the hill, cannot reach the proposed site gravitationally. Another WWTP will be established for them in the future. However, in this area, 3 greywater treatment systems for individual houses were installed by MECTAT, and funded by IDRC in 2003 to treat 60% of the generated wastewater. In addition to that, one large greywater treatment system serving 4 apartments was installed in the same area as a demonstration project. Therefore, the proposed treatment plant will serve 60% of the population or a maximum population of 7500. The two stage trickling filter (TSTF) method will be adopted from GROSSIMEX, to treat the generated wastewater of the town, which is estimated at 600m^3/day. The WWTP will treat the influent wastewater aerobically to a **secondary level**, that is, equivalent to BOD level of less than 25mg/l. This makes the final effluent compatible with the effluent standards of MOE and therefore, safe for discharging it into nature.

Location of the WW treatment plant:

The WWTP will be constructed on the public land lot number 5575 of Rashaya Municipality, as indicated on the map of Annex. 2.3. The WWTP project site will be located at a distance of 3km south of Rashaya town and at a direct distance of about 3km far from the nearest house of Rashaya.

The plant will have the capacity of treating up to 600m^3 of municipal wastewater everyday. This will guarantee the wastewater treatment of the town for the next 15 to 20 years, the present maximum population being 10000 people. The WWTP would be modular in design, which can be expanded whenever the population increases.

<u>The Project site presents the following characteristics:</u>

- A land area of 1760 m^2 is allocated for the construction of the WWTP.
- The WWTP will be located at a 3km South – West from the nearest house of Rashaya town.

- Once the WWTP starts operating, wastewater from the households will reach the plant gravitationally. After the establishment of the sewage network in Rashaya, all households will be connected to it and a 3km long pipeline will connect the sewer to the WWTP. The site of the WWTP is in a narrow valley of about 100m width. It is an ideal location for wastewater treatment operation. Alternatives of this site would be other points lower in the same valley.
- The site is located at about 100m from the main road. A road will be opened and asphalted, leading to the proposed WWTP site.
- Land leveling and excavation of rocks and soil will take place at the WWTP site. The excavated soil will be used for landscaping and the rocks for construction of retaining walls.
- The secondary level treated effluent of the WWTP will be discharged into the narrow valley next to the WWTP or deeper in the valley through a connecting outlet.
- The site is not surrounded by trees when a diameter of 100m is considered. Therefore, the quality of the discharged effluents of the WWTP would be suitable for planting and irrigating trees around the site.

2.3- Importance of the Project for the Local Community:

In Rashaya, households traditionally dispose of their wastewater in septic tanks, which often overflow resulting in odors, public health problems and tensions among neighbors in the town. Seepage from the septic tanks also contaminate many wells that supply freshwater to the households of the town (Berkat al Nejma, Bir al Dayaa, Bir al Hammam, Ein al kawasba).

Therefore, the local community is keen to have an environmentally sound solution to their wastewater disposal problem. Clean environment will improve the socio-economic and health standards of the inhabitants of the project area, as well as their relation with their neighbors.

The establishment of the WWTP will enable proper treatment of wastewater and will significantly limit the spread of diseases, reduce the mosquito problem of the town and preserve its environmental quality. In addition, the treated effluent wastewater can be safely discharged and used for irrigation.

2.4- Objectives of the Project:

The WWTP project of Rashaya town aims at environmentally safe disposal of its wastewater, for upgrading the sanitary and health standards of the inhabitants.

The long-term objectives of WWTP project are to:

- Prevent the spread of diseases, including the limitation of the mosquito population,
- Prevent the prevalence of conditions offensive to sight and smell,
- Control the contamination of water resources,
- ? Prevent and control soil and groundwater pollution.

The specific objectives of the project are to:

- Establish a dependable WWTP, which is cost effective and requires the minimum maintenance.
- Manage the pathogenic risk inherent in wastewater to meet the effluent discharge standards set by the Lebanese Ministry of Environment.
- Manage the safe disposal of sludge.

2.5- The EIA Study Executing Company:

The Environment Impact Assessment (EIA) study of the project and the preparation of the EIA Report have been carried out by the Middle East Engineers and Architects (MEEA) Ltd., Consulting Environmental Engineers, based in Beirut since 1979.

Detailed Address:

Echmun Bldg., Damascus Rd.
P.O. Box 113-5474
Downtown Beirut, Lebanon
Tel: 961-1-321800, 961-1-742043
Fax: 961-1-321900
E-mail: mectat@mectat.com.lb
Website: www.mectat.com.lb

For further information on background of the executing company and the research and study team, please refer to Annex-4

3-Legal and Administrative Perspectives and Policies:

In Lebanon, policies of wastewater management is centrally planned in cooperation between the Council for Development and Reconstruction (CDR), Ministry of Environment (MOE) and Ministry of Energy and Hydraulic Resources (MEHR).

Ministry of Environment of Lebanon is the highest authority in charge of environmental matters in the country. Already the Law #444 for the Protection of the Environment is promulgated in 29/7/2002. Chapter 4 of this Law, in items # 21-23, refer to the need for conduction of EIAs for development projects, including wastewater plants.

Since 1995 activities are being carried out by MOE for establishing the EIA procedure in Lebanon. Already now an EIA Unit operates at MOE. A separate draft EIA Law has been prepared by MOE and adopted by the Council of Ministers on 25/7/2000. This EIA law awaits ratification by the Lebanese Parliament. Draft EIA Law stipulates that, establishment of wastewater treatment plants is subject to full EIA studies.

On the other hand, the Decision 8/1, 2002 of MOE has set National Standards for water, air and soil, standards for urban wastewater and set standards for discharging liquid waste in surface and underground water bodies, and into the sea. The table here below describes the effluent specifications of wastewater treatment plants based on MOE Decision 8/1, 2002.

Effluent specifications of wastewater treatment plants based on MOE Decision 8/1, 2002.

pH	6 to 9
Temperature	< 35ºC
Salmonellae	Absent (Zero)
BOD_5	< 25 mg/l
COD	< 125 mg/l
Total Phosphorous	< 10 mg/l
Total Nitrogen (TN)	< 30 mg/l
Suspended Solids	< 60 mg/l
Oil and Grease	< 30 mg/l
Total Organic Carbon (TOC)	< 75 mg/l
Coliform Bacteria 37ºC in 100ml	< 2000
Ammonia	< 10 mg/l
Odor	Absent (Zero)

Address of Ministry of Environment of Lebanon

Al-Azarieh Building,
Beirut Central District, Beirut, Lebanon .
Tel: 01-976555, Fax: 01-976534

4- Public Contribution/ Cooperation:

4.1- Public Agencies:

The Ministry of Energy and Water of Lebanon is in charge of water and wastewater management issues in the country and Ministry of Environment is in charge of setting environmental standards and guidelines for proper treatment of municipal wastewater. The general issue of wastewater management is centrally planned in cooperation between the Council for Development and Reconstruction (CDR), Ministry of Environment and Ministry of Energy and Water.

Wastewater management in Lebanon is still in its early phases. In 1995, a Damage Assessment Report was prepared to formulate a policy framework for the wastewater sector (Khatib & Alami, 1995). Implemented over three phases, the resulting National Emergency Response Program (NERP) launched two major programs:

- Coastal Pollution Control Program (CPCP); and
- Water Resources Protection Program (WRPP).

CPCP is proceeding with alternative funding from various sources. Works under the WRPP include the rehabilitation of wastewater treatment plants and water sources (springs and wells), as well as the rehabilitation and construction of transmission and distribution networks. 35 wastewater treatment plants of various sizes have been planned for 2001 or were already under construction. 9 big plants are planned for the coastal cities.

In the field of wastewater management, so far little has been implemented in **rural areas** of Lebanon. Less than 10% of rural areas have sewerage systems, but very few municipalities in those areas have and operate wastewater treatment plants. Most of the municipalities that have already installed sewerage networks in their towns dispose of their raw wastewater directly to nature, without any treatment. This practice contaminates the fresh water resources and creates other negative environmental impacts. A case in point is the pollution of Litani River by raw sewage. In general, surface and ground water are being polluted, lands are being contaminated by sewage, unsightly conditions are created and deterioration of health is taking place because of the irrational disposal of the untreated wastewater.

Since 1998 municipalities in rural areas have taken the initiatives to establish sewerage networks and treatment plants. At least 20 small-scale wastewater treatment plants

were supported by the USAID by 2005. Currently more than 30 plants are being supported by USAID in rural areas. The WWTP of Rashaya is one of these.

In case of Rashaya WWTP Project, the Municipality has asked for the establishment of the WWTP. This plant will achieve a **secondary level** treatment for the wastewater generated from the households of the town.

The contribution of the Municipality towards the establishment of the WWTP is 50% of the total cost of the project.

4.2- Groups Disadvantaged by the Project:

There are no groups that are disadvantaged by the project. Everybody welcomed the project except very few that rejected the location of the site claiming that the plant will be an eye sore. However, since the alternative site which they proposed was found to be not suitable for the installation of the WWTP, they all agreed at the end on the present proposed location. There are no houses or farms in the vicinity of the proposed WWTP site. The only agricultural land that is close to the site is located above it hence won't be affected by its effluents. The nearest house of Rashaya is more than 3km far from the plant.

All of the householders of the town are happy about the project, because this will bring a real solution to their wastewater disposal problem. Households currently discharge their wastewater in open bottom septic tanks, which often overflow and create unsanitary conditions in the town and create breeding sites for mosquitoes and exert tensions among neighbors.

MEEA/MECTAT expert visited the Project site on the 25th of October 2005 and assessed the local conditions at the proposed site. They met with the Mayor of Rashaya and some citizens and discussed with them issues related to the WWTP and the local environmental issues. No serious objection or criticism was raised on the project. On the contrary, most of them have welcomed and praised the project.

5- Project Description

5.1- Status of Wastewater Management in the Project Area:

Disposal of wastewater:

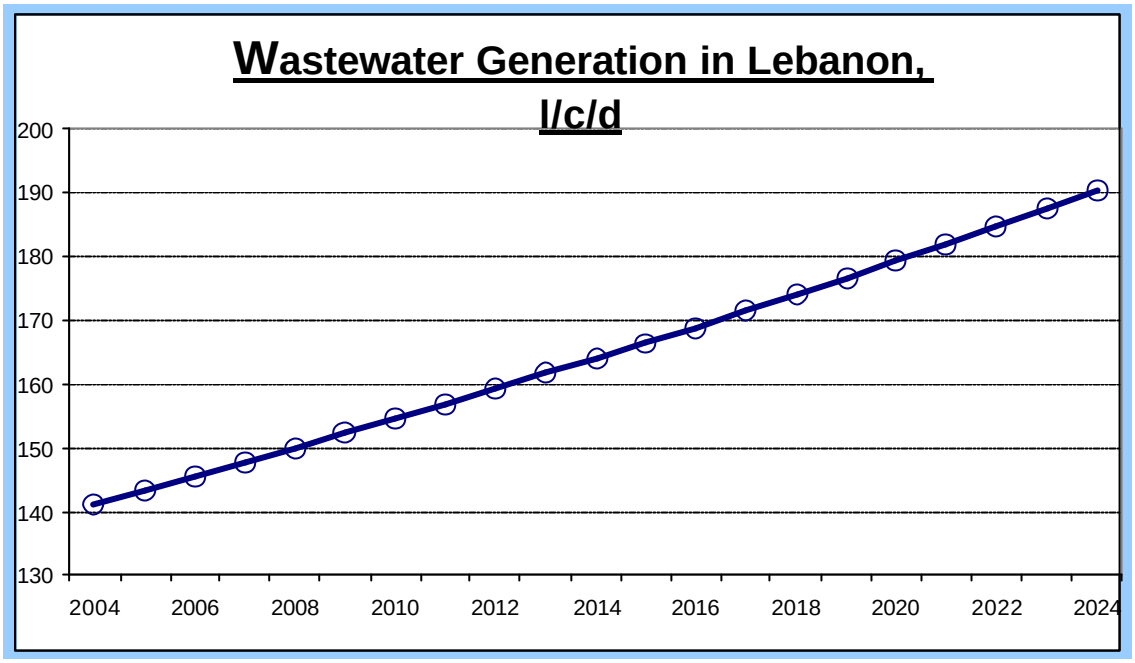
The state of wastewater disposal in Rashaya presents the following situation:

- In Rashaya, wastewater disposal is the main environmental issue that has caused unsanitary conditions, odor and mosquito problems within the town, which causes nuisance to the residents. They also pollute the scarce water resources that are available in the town. This is due to the overflow of the septic tanks of houses.

- There are two artesian wells in Rashaya that supply freshwater to the town. They may soon be contaminated by the overflowing septic tanks since the soil is calcareous and very permeable.

***Wastewater generation rates in the Project area**:*

For estimation purposes, the present average rate for wastewater generation commonly used for all Lebanon is about 140 liter/capita/day. This average is expected to increase with time. A likely increase rate of 1.5% will bring the average wastewater generation rate to 190 liter/capita/day for the year 2024. Nevertheless, in rural areas the current water consumption rates is estimated to be 100 l/capita/day, including irrigation of the gardens. Consequently wastewater generation rate is estimated to be 80 l/capita/day. The daily per capita average generation rates can vary according to seasons of the year.



Source: MoE, Climate Change Report

It is not easy to predict the demographic behavior of the population of the town, since most of the towns in the Rashaya Caza experienced immigration during the years of war in Lebanon and the Israeli occupation. During this period, many people were either relocated in other regions of Lebanon or migrated to other countries.

The current population in Rashaya is estimated at 7500 people in winter and 10000 in summer. The population is not likely to grow as in the case of most rural areas in Lebanon where lack of services and high unemployment rate push the youth to seek jobs and settle in large urban areas in Lebanon and foreign countries. Therefore the maximum population of Rashaya town, for the next 20 years is estimated at 12500 people in summer. However the proposed WTTP will only serve the households located at the eastern and southern side of the town, which constitute 60% of the total population. Therefore, the considered maximum served population is estimated to be 12500 x 0.6 = 7500.

Therefore, the maximum quantity of wastewater generation in the project area by year 2020 is estimated as follows:

7500 person x 80 l/person/day = 600,000 l/day

$$=\boldsymbol{600\ m^3/day}$$

The actual capacity of the proposed WWTP is 600 m^3/day. It would be modular and can be easily expanded in the future, to meet the wastewater treatment needs of larger populations.

It should be noted that, the industries of the town (grape molasses factories and olive oil presses) do not discharge any wastewater in this valley. Therefore, influent wastewater stream of the WWTP will just contain wastewater from domestic origin.

Composition of Wastewater influent:

Tests performed by YMCA on samples of wastewater from various rural towns of Lebanon and particularly in the project area have revealed the following characteristics of the influent wastewater.

Influent wastewater characteristics

pH (pH Units)	7.5
BOD	240 mg/l
COD	400 mg/l
Total Suspended Solids	1000 mg/l
Total Phosphorous	15 mg/l
Total Nitrogen	30 mg/l
Ammonia	40 mg/l
Grease and oil	40 mg/l
Total Organic Carbon	120 mg/l
Coliform Bacteria	1000000 per 100 ml
Average Temperature	18ºC

The wastewater treatment plant in Rashaya will deliver final effluents that comply with Ministry of Environment Decision 8/1, 2002. Effluent specification list of MOE is presented in Chapter 3 of this Report.

5.2- Proposed Wastewater Treatment Process of the Project:

The selected wastewater treatment process is a two stage trickling filters technology delivered by GROSSIMEX. The central units of the process are the trickling filters, where biowastes are digested aerobically.

Detailed explanations of the WWTP components and the treatment process are described as follows:

1- Screens: wastewater arrives from the town to the treatment plant trough a 3km long PVC pipeline. The first stage of treatment is screening where big particles and floating objects can be retained.

2- Primary separation tank (or watertight and covered septic tank): after screening, wastewater reaches this primary separation tank. This tank is divided into 2 chambers, in which sedimentation is accomplished. In the first chamber about 90% of the settleables are settled, and in the second about 10% of the solid settlement is accomplished. The organic components of settled solids are digested by anaerobic bacteria and gases are produced.

The tank will allow an average of 3 hours for settling, reducing 25-40% of the BOD content and 50-70% of TSS. The tanks are simple to maintain and do not require highly skilled supervision. There is no mechanical equipment for desludging. This takes place gravitationally once or twice in every year, in the dry season.

2- Trickling filters: wastewater next flows gravitationally to reach the first trickling filter. A trickling filter consists of a bed of highly permeable medium (stones or PVC pieces) to which microorganisms are attached and through which wastewater is percolated or trickled. The liquid is distributed and sprinkled gravitationally by over the top of the medium. The organic material present in the wastewater is degraded by a population of aerobic microorganisms attached to the filter media. Wastewater percolates to reach an underdrain system that transport it, in addition to any biological solids that have become detached form the media, to the next stage of the treatment i.e. trickling filter #2. The collected liquid is then transported and sprinkled gravitationally on the second trickling filter in which organic matter is digested in the same way, to ensure further decomposition and neutralization of organics.

3- Secondary clarifier: In this tank, 6 hours of detention time is allowed for the treated wastewater of the trickling filter, where the flocculated sludge separate and settle to the

bottom of the tank. The settleabe sludge is then collected from the 45-degrees sloped floor of the clarifier, and is transferred gravitationally to the sand drying beds.

The final effluent wastewater, having the characteristics of secondary level treatment and complying with the standards of MOE, will be discharged in the valley next to the treatment plant.

4- Sludge drying beds: Drying beds are used for sludge dewatering. The sludge from the primary separation tank and secondary clarifier is placed on a 300 mm sand bed and allowed to dry. Sludge dewaters by drainage through the sand and by evaporation from the surface exposed to air. Drying beds are equipped with lateral drainage and the resulting dried sludge is either disposed in a landfill or used as a soil conditioner, after solarization which will disinfect the dried sludge. Drying beds have low costs and do not require frequent attention.

The Operation and Maintenance of the WWTP is very simple. It is based on gravitational flow without any use of electricity and pumps. The system as designed is self-operational. However, it needs continuous testing of the final effluents. These samples must be tested for pH, BOD and other parameters as required.

For additional information and drawings on the wastewater treatment process, please refer to Annex-3.

The proposed WWTP will be managed and operated by the Municipality of Rashaya. GROSSIMEX will provide to local employees with the adequate trainings for proper operation and maintenance.

Environmental Pollution Issue:

The outputs of the plant would be **effluent wastewater**, **sludge**, **scum, gases** and **solid waste** from the screens.

The effluent wastewater will have the characteristics that comply with the Ministry of Environment Decision 8/1, 2002. Therefore, the WWTP will not create water and soil contaminations. It will neither create health or nuisance problems. This implies that the project will not have an impact on the surface and ground water resources. Forest trees can be planted to receive the effluent and further purify it.

The plant will generate minimal amounts of **sludge** (maximum of 1.05 m^3 per day) and **scum,** which will be emptied once every year through connecting valves and it will be dried properly at the site and used in afforestation projects. During the dry period, solarization of the sludge, can be also done by covering the drying beds with transparent plastic sheets , which will allow increase in temperature to 60^oC and above, which will sterilize the drying sludge.

The **gases** generated will be released through vents and the **solid wastes** piled from the screens will be collected periodically by the operator and disposed of in the municipal solid waste collector of the town.

5.3- Required Equipment and Construction Work:

Equipment to be used at the wastewater treatment plant:

The plant will not have any mechanical equipment except its concrete structures. Hand implements will be available for manual works.

Required Construction Work:

The plant will be established on a land area of 1760m^2. It will occupy part of land lot No. 5575, which is a owned by the Municipality.

The principal structures will include:

- One receptacle where a 20mm manual screen is installed
- One Primary separation tank, which will be a double chambered septic tank.
- One or Two dosing siphons for first distribution network
- One rock media trickling filter for roughing
- One or two dosing siphons for second distribution network
- One rock media trickling filter for polishing
- One clarifying unit
- One drying bed for the sludge
- One tree plantation

Required construction work involves the following:

1. Leveling of the ground

2. Construction of the primary separation tank of size 144 m^3, in an area of 36m^2.

3. Excavating an area of 36m^2, for building the first trickling filter with a volume of 66.5 m^3. Underdrain is made of concrete block forms.

4. Excavating an area of 100m^2, for building the second trickling filter with a volume of 182.5 m^3. Underdrain is made of concrete block forms.

5. Construction of the clarifier of size 198m^3 that will occupy an area of 36 m^2. The clarifier will be on the static type with a conical hopper at 45^o.

6. Planting trees at the effluent location.

7. Clearing an area of 94.5m^2 for the installation of the sand drying beds for sludge.

8. Putting a fence around the plant.

9. Putting a main gate at the entrance of the site.

10. Planting trees around the site.

11. Make arrangements against fires.

12. Landscaping with excavated soil and sand.

Maps of Annex- 2.1 indicate the details of construction work to be carried out at the site. Proper canalization will be done in order to avoid water flooding, erosion and pollution around the plant. These measures will be completed during the construction of the treatment plant.

5.4- Advantages of the Two Stage Trickling Filters Wastewater Treatment

The aerobic process of trickling filter technology is found suitable for the project. It presents the following advantages:

- It is a simple and reliable process that is suitable in areas where large tracts of land are not available for other types of biologic treatment systems.
- It can attain a treatment level to secondary discharge standards for the final effluents.
- Effective in treating high concentration of organic material depending on the type of the media used.
- Appropriate for small to medium –sized communities and on site systems.
- High degree of performance reliability.
- Ability to handle and recover from shock loads (by shifting to plastic media in the filters).
- Durability of process elements.
- No power requirements.
- Level of skill and technical expertise needed to manage and operate the system is moderate.

However, the only need is to clean the screens and do testing and reporting on any changes that might be caused by external factors.

6- Description of the Environment

6.1- General Setting

Two parallel mountainous ranges, Mount Lebanon and Anti Lebanon, separated by the Bekaa plain are the dominating topographic features of Lebanon (Figure 6-1). These topographic features extend in a NNE-SSW direction. The study area is located in the Caza of Rashaya, on the Eastern slopes of South-West Bekaa. The territories of Rashaya town have elevations ranging between 1200m and 1300m above sea level.

The town of Rashaya is located in the southern edge of the Bekaa Province. A generally good road network exists in the region (Figure 6-2) connecting the towns and villages to each other. There is a main asphalted road passing along the narrow valley of the project site. A 100m long access road will be opened to connect the main road to the WWTP. This road is to be asphalted in the future.

Figure 6-1. Topographic Map of Lebanon

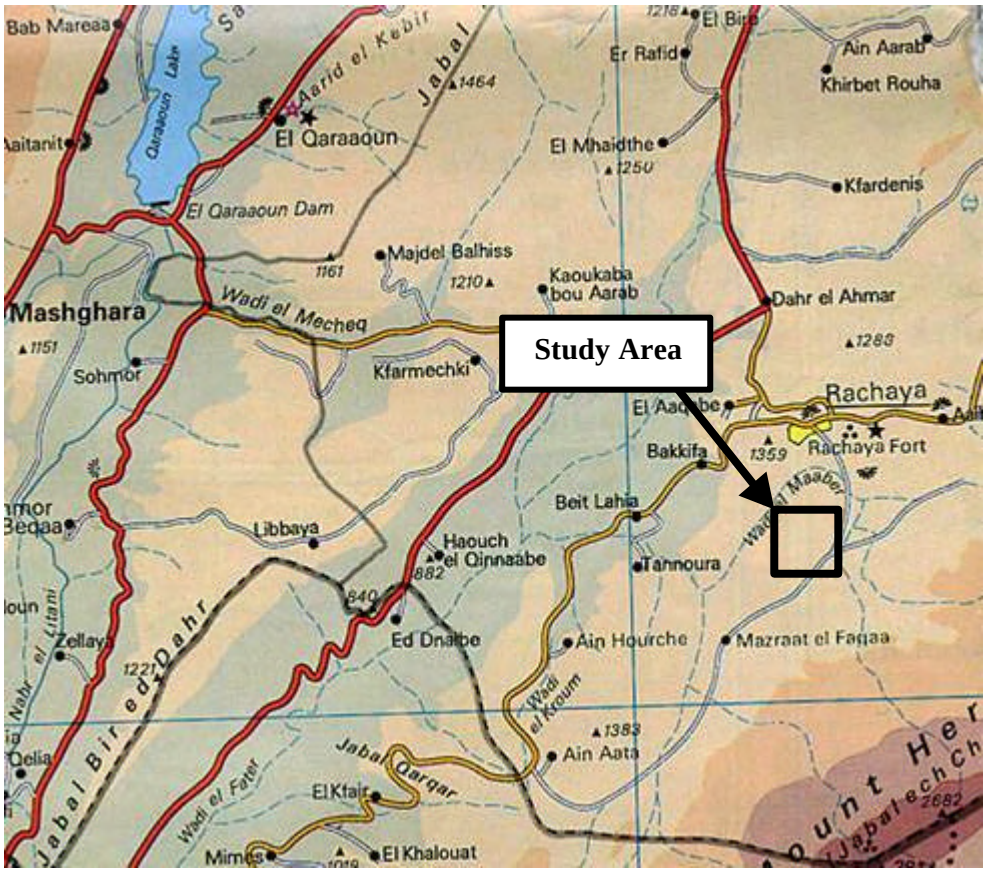


Figure 6-2. Map showing the road network of the project area

Rashaya town is located on a hill, and houses are distributed on its top and sides. The project site is located 3km south of Rashaya town, in a narrow valley of about 100m width. Trees are located on its eastern direction, and the forest of Faqaa, classified as a protected area, is located 2km south of the project site.

Air Quality

Given the fact that forest trees are present in the vicinity of the project area and that the existing industries in Rashaya Town do not emit any air pollutants, and there is no large-scale agricultural projects and no heavy car traffic in the area, the air quality in the town and its surroundings is good.

Soils

At the project site, the soil cover is very thin. In general the project area is rocky with thin layers of soil. It is obvious everywhere that heavy soil erosion has taken place and the region is prone to desertification. Soil is red in color derived from calcareous parent rock material. It is considered not fertile and poor in organic material.

6.2- Meteorological Setting

The topographic features of Lebanon, in general, influence largely the climate of the country. The climate of the Lebanese coast is of Mediterranean subtropical type, where summers are hot and humid; and winters are mild and wet. On the other hand, snow covers the mountains of the two ranges at times for several months per year. The two mountain ranges tend to have a cool and wet climate in contrast to that of the coastal zone.

Meteorological information including precipitation, ambient temperature, as well as wind direction and speed, are essential data for adequately assessing environmental impacts. Unfortunately, meteorological records are seldom available, except for a few locations in the country where stations were operating, in particular a couple of stations of the Service Meteorologique and the American University of Beirut (AUB) stations.

Precipitation

The two mountain ranges of Lebanon intercept humidity and receive high rainfall compared to areas with similar locations. The project area has annual precipitation ranging from 650 to 750mm. More than 80 percent of the annual rainfall occurs between November and March. The average number of rainy days range from 60 to 70 per year. Mount Hermon, (2,814m in elevation), which is at a distance of 10km east of Rashaya, receives more than 1000mm of annual rainfall.

Temperatures

The annual average temperature in the project area is 15 °C. The warmest months are July and August, when mean daily temperatures in this period can reach a maximum of 33 to 35 °C, while the minimum temperature falls to -5 °C for a couple of days in winter. Figure 6-3 depicts average temperature distribution for the project area by the Service Météorologique du Liban (1977).

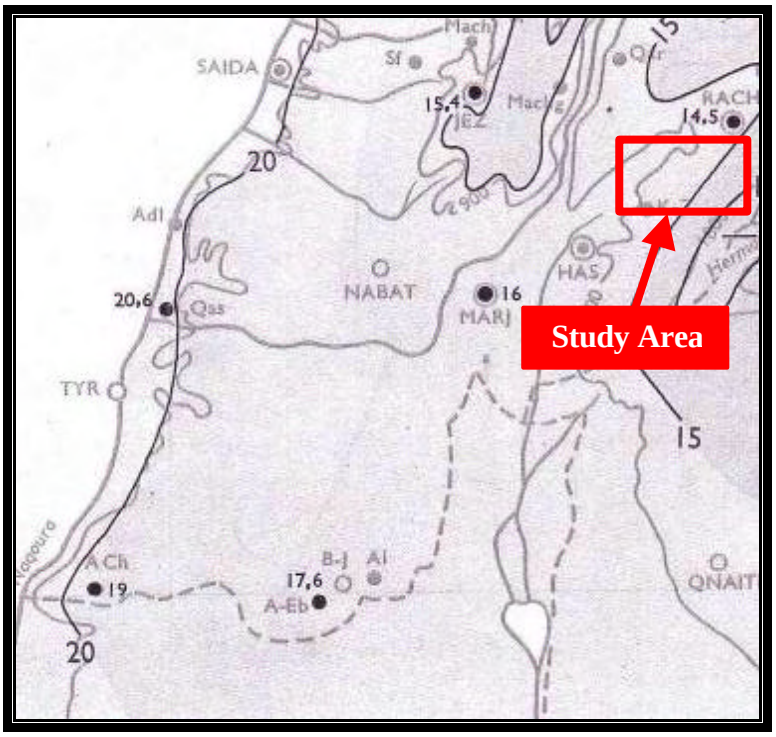


Figure 6-3. Temperature Distribution Map

Winds

Dominant wind directions are West to east. The two mountain ranges have a major impact on wind direction, and contribute to reducing the incidence and strength of the southeasterly and northwesterly winds in the Bekaa valley. Strongest winds are generally observed during the fall and winter seasons. Dominant wind direction is oriented in the SW and SWW.

6.3- Site Setting

The location of the WWTP was proposed by the Municipality of Rashaya town, which is in the narrow valley south of the town. No other suitable valley is available in the periphery of the town. The data presented in this section was either collected through field visits, location assessments, research, and/or in consultation with the Mayor he Municipality Council members of Rashaya.

A piece of land of 1760 m² area from the public land lot No. 5575 is allocated by the Municipality for building the WWTP. The site is located at the southern side of the town, at a distance of 3km from the nearest house. The location is in a semi agricultural/semi natural zone. There is only a small farm land near the site that is being used for grain cultivation. The proposed site is adjacent to a small forest on the east (photo 6-2); however on the western side, it is dry rocky soil, with few scattered

shrubs (photo 6-3). There are no orchards in the vicinity of the site and the closest fruit farm is located at 1.5km far form the WWTP. There are no rivers, streams, and surface water bodies in the vicinity of the site. However, there is a small spring located at 1.8 km from the project site (photo 6-4). This spring does not have a continuous flow, it just shows up once in every 3-5 years when heavy snow falls and when the area of Mount Hermon (Jabal el Sheikh) receives >1000 mm rainfall. The groundwater is at a depth of 400m.

The main asphalted road passes 100m from the site. An access road will be opened to connect the WWTP to he main road.

Appendix B presents a Topographic Map of Rashaya area showing the proposed location of the WWTP.

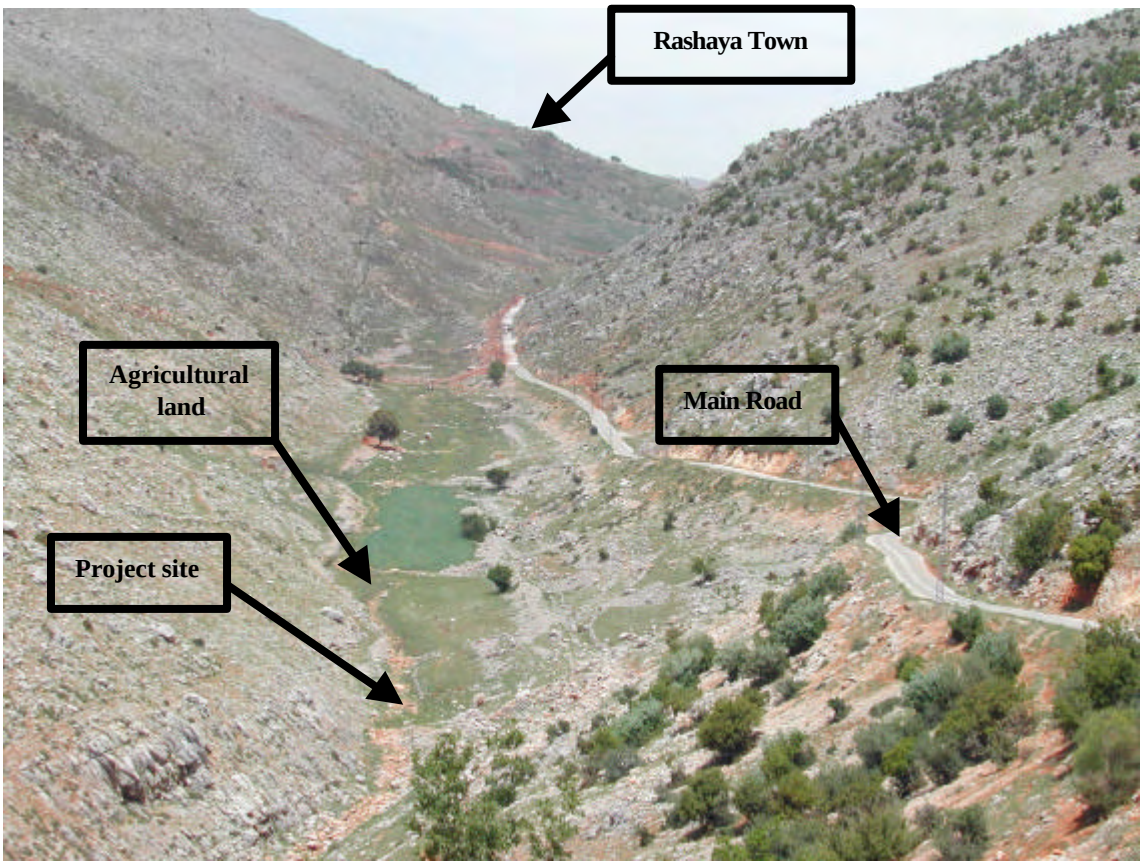


Photo 6-1. General view of the project site

Photo 6-2. View of the natural vegetation at the East direction of the site

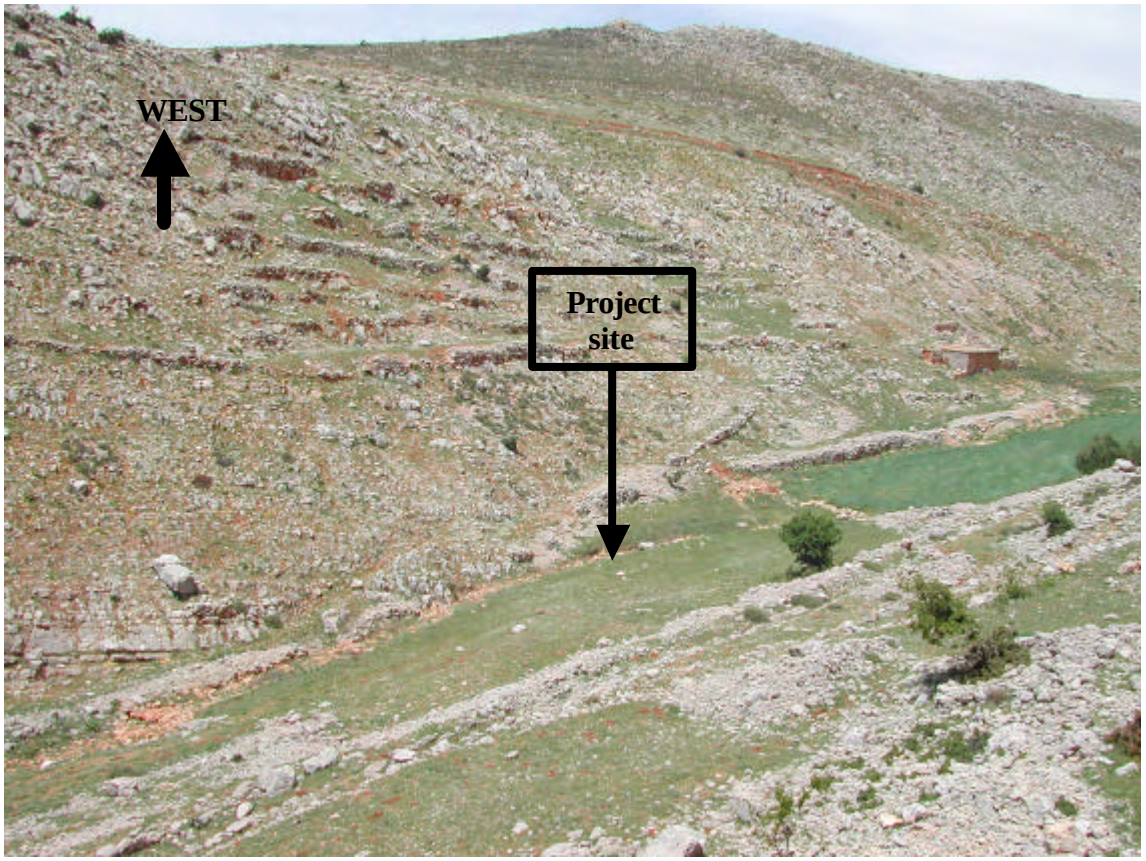


Photo 6-3. View of the West Side of the proposed location

6.4- Tectonic Setting and Seismicity

Lebanon is located along the Dead Sea Transform fault system, which has several surface expressions, represented in major faults (Yammouneh, Roum, Hasbaya, Rashaya and Serghaya faults), in uplifts as high mountainous terrain (Mount Lebanon and Anti Lebanon), and from the seismic activity record. Recent research work has categorized the Lebanese section of the Dead Sea Transform fault as being a strong seismic activity zone (Khair *et al.*, 2000). Geographically the project site is in Rashaya town, situated to the S-SW of Rashaya town. This site is 3km far from the town and is located in a narrow valley.

The studied area lies east of the Rashaya fault which is trending NNE-SSW and to the East of the Yammouneh and Hasbaya faults, where both of them trend NNE-SSW. (Figure 6-5).

The Rashaya fault has a higher influence on the region than the Yammouneh fault being closer to it. The Rashaya fault is still active which makes the region tectonically active.

The danger of earthquakes is not high regarding that no large earthquakes have been recorded on that fault.

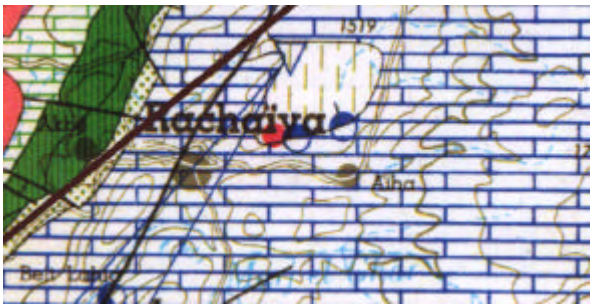


Figure 6-4. Rashaya's Fault

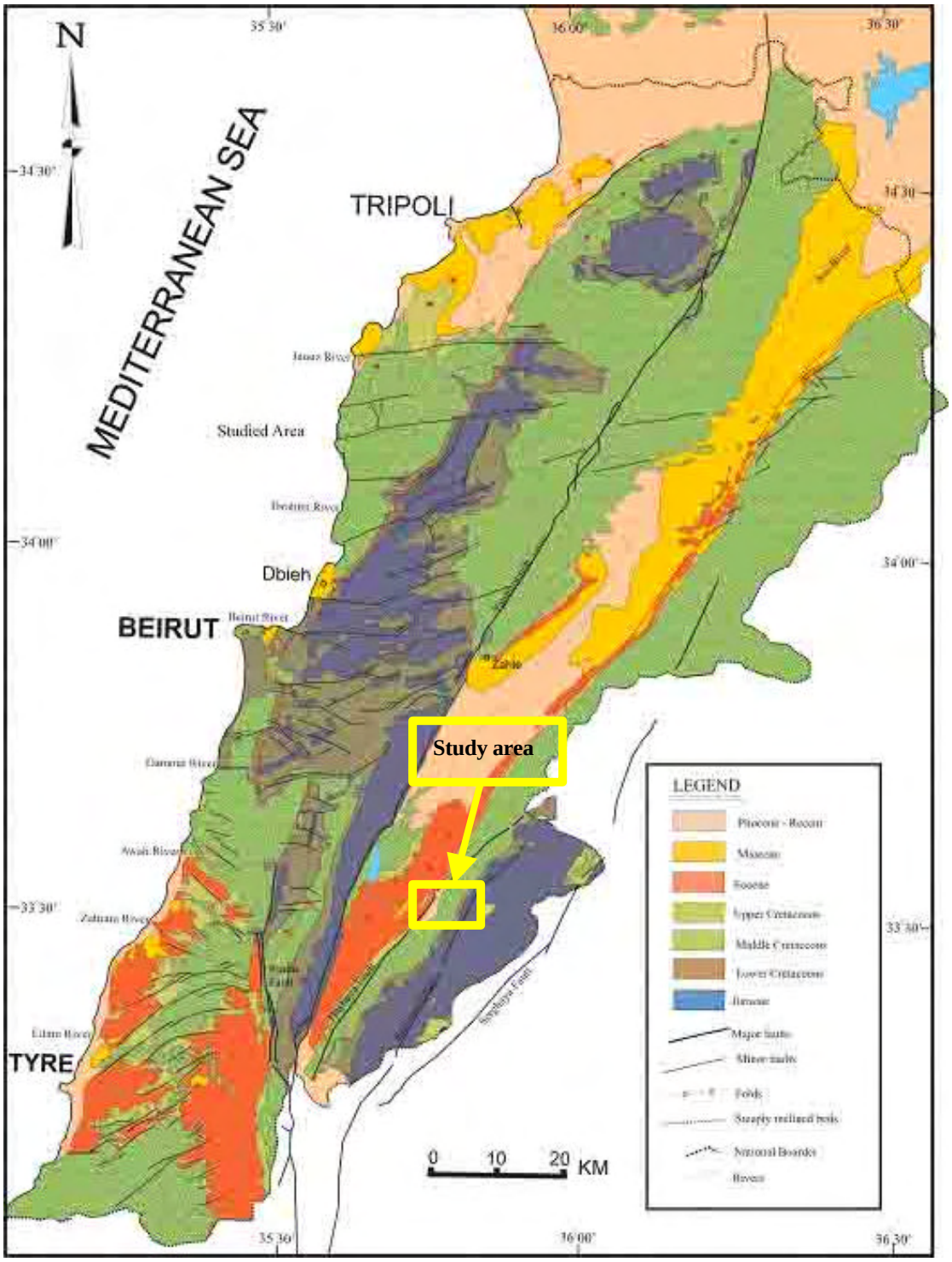


Figure 6-4. Tectonic Map of Lebanon modified by Dubértret (1966), showing the studied area.

6.5- Geologic setting

Rashaya town is located on a geological setting formed in the Jurassic period characterized by a Karstic formation. The site's limestone is composed of massive limestone with thicknesses attaining 1 km. Its color varies between creamy white to grey. It is found in the valley where the construction site is established. It is composed of carbonates that have deposited in a marine environment.

6.6- Hydro-geological setting

As mentioned before, the town of Rashaya uses two nearby artesian wells to supply water to the households. The calcareous formation of the town makes soil very permeable with the ability to infiltrate water. The groundwater of the area has a high storability and a high transmissivity. However Rashaya's wells are far from the project site. Only one small spring is located in the surrounding of the project site, at 1.2 km from the town. This spring emerges only once in every 3-5 years when snow and rainfall are heavy. The spring is located at 1.8km north of the site, so it will not be affected by the plant effluents. (Photo 6-4.)

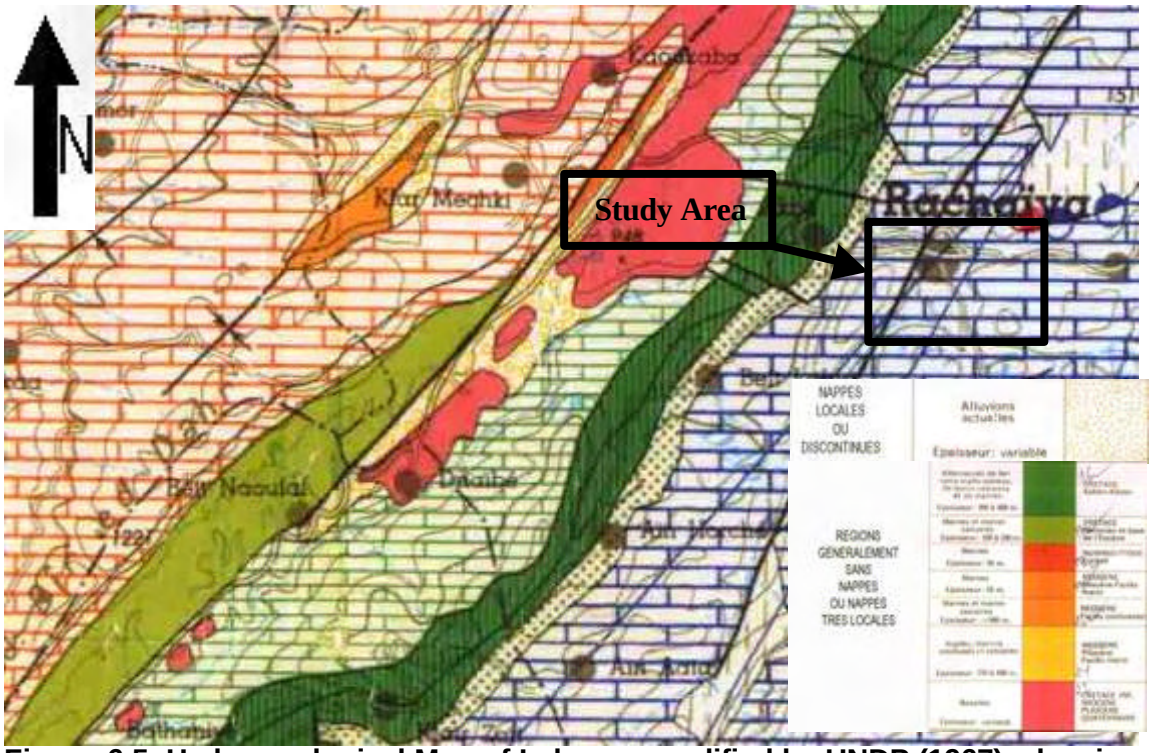


Figure 6-5. Hydro-geological Map of Lebanon modified by UNDP (1967), showing the studied area.

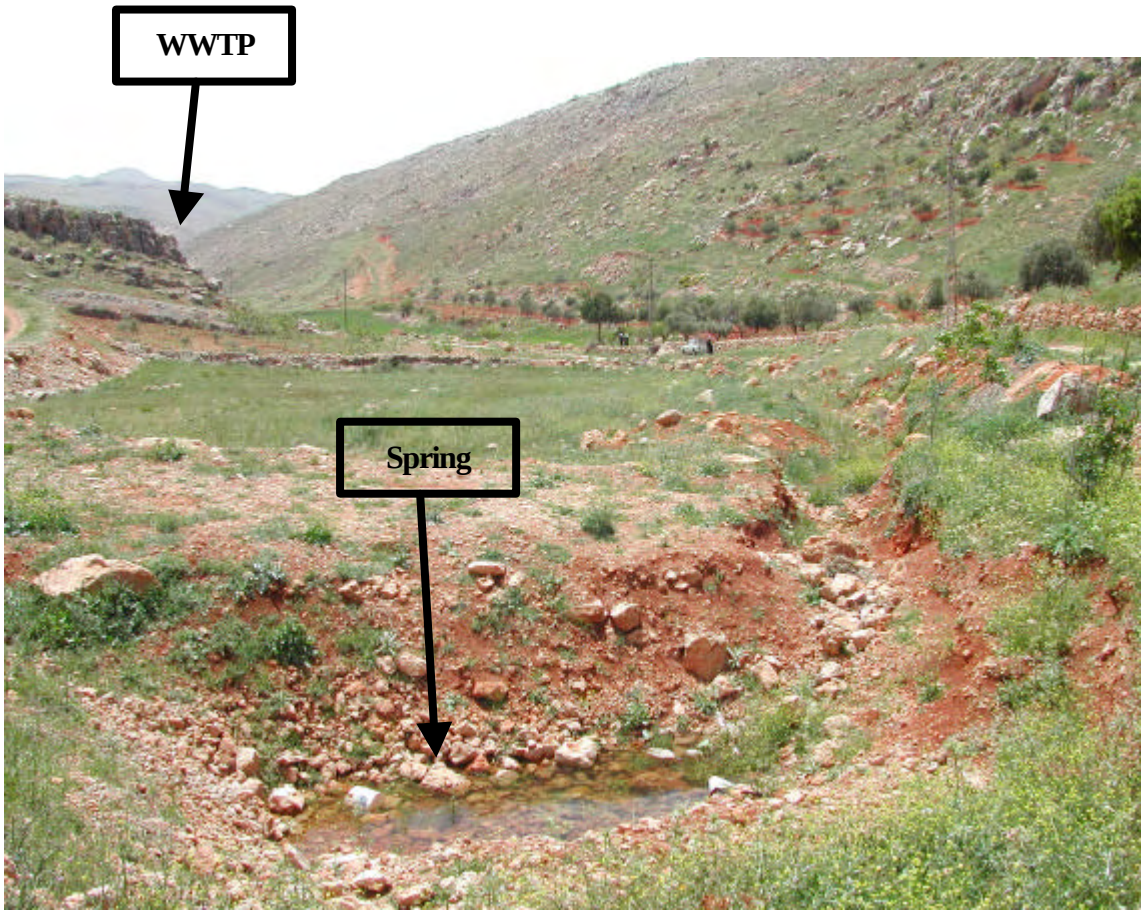


Photo 6-4. View of the spring at 1.8 km from the site.

6.7- Ecological Context (Biodiversity)

Ecologically, the proposed location is not in an area of special concern, such as areas designated as having national or international importance (e.g. world heritages, wetlands, biosphere reserve, wildlife refuge, or protected areas). It is located at 2 km from Faqaa forest, which is classified as a protected area. The project will not lead to the extinction of endangered and endemic species, nor the degradation of critical ecosystems, and habitats. The project site is a rocky land, with a normal biological diversity. Due to overgrazing, neglect and unfavorable climatic conditions, there are no natural forest tree species at the site. The main river of the area, Hasbani River, originates some 30 km south of the proposed site, separated by several mountain ranges.

Flora:

The Project area, including the proposed site, has normal **biodiversity**. There are a few tree species such as oak, sumac, Zaarour, wild pistachios (butum) and the perennial plant “bellan”, which has high potential to control soil erosion (Photo 6.5).

Photo 6-5. Natural Biodiversity at the eastern direction from the Proposed WWTP Site

Photo 6-6. Seasonal vegetation

Fauna:

The wildlife in the project site consists of some species of migratory birds and some rodents , lizards, snakes, chacals and foxes . Many species of local and migrating birds are available in the Project area.

6.8- Infrastructure Status

Infrastructure within the towns is mainly limited to road network, telephone, electricity, and water supply, which are in satisfactory condition.

Wastewater treatment plant is not available in Rashaya town; in the near future they will establish one with the cooperation of YMCA. Also, a wastewater collection network will be established by a private contractor, AL MADAR. But there are such plants (WWTP) in the neighboring towns of Al-Housh, Ain Hersha and Marj El-Zouhour (Ad-Dnaibe) of the project area. In Rashaya, the domestic sewage is generally disposed of into primitive and substandard septic tanks.

In spite of the fact that Hermon Mountain (Jabal El-Sheikh) with an altitude of 2800m, with all year round snow cap, is very near to Rashaya, there are no natural springs (except the small intermittent spring down in the valley) in the area and the water table is at a depth of more than 400m. However, all the residents have permanent access to water through the drilled artesian wells or through the municipal water supply network of Chamsine (intermittent supply, 2-3 times per week).

Regarding the municipal solid waste (MSW) issue, a Solid Waste Treatment Plant (SWTP) is being established in 2004 with the support of YMCA. The SWTP is located between the Kawkaba and Mhaidseh towns, which will treat the generated solid waste of 17 neighboring towns. The technology used is the Stationary In-Vessel Composting technology for aerobic digestion of organic material with recyclable material recovery. The SWTP is under construction, and currently SW of the 17 towns are being open dumped.

6.9- Socio-Economic Status

Socio-economic information about Rashaya was obtained during informal meetings with the Mayor and the Municipal Council members during the field visits.

***Demography*:**

The present winter population of the town is around 7500 people, which reaches to 10000 people in summer months.

It is not very easy to predict the demographic behavior of this population since for the last 30 years most of the inhabitants were either relocated in other regions of Lebanon or migrated to other countries. During the last decade some families returned to resettle in the town. Within the next 20 years the summer population of the town is anticipated to reach a maximum of 12500 people.

Development Activities:

Based on a survey carried out by the World Bank in 2002, all over Lebanon, the project area is designated as one of the nine poverty areas of Lebanon. World Bank is now financing a community development projects for the Rashaya and Hasbaya Caza.

YMCA and some other NGOs were able to achieve some development projects in the area. YMCA concentrated in building agricultural roads, water storage ponds, wastewater treatments plants and food processing centers in the town clusters of the area.

The economy of the area is mainly driven by agriculture and services. There are few industries in the town and tourism is quite significant in this area.

***Agriculture*:**

Rainfed agriculture is the main economic activity of the farmers of the project area. All of the adequate land lots are already being farmed. Common plantations are grapes, olive, cherries, and to a lesser extent apricots. Vegetable growing is less common in the area, due to the scarcity of water. However wild cucumbers (meqta) are farmed with dry farming techniques.

The main animal husbandry is goat rearing. The goat Labneh is an appreciated basic food in the project area.

Soils of the project area lack organic material, which is essential for building the soil fertility of the farmlands. Therefore the dried sludge that will be produced from the WWTP can be utilized by the farmers of the area.

Industries:

The industrial activity of the town is limited to 3 grape molasses factories and 2 olive oil presses. However these industries do not discharge wastewater in the valley where the WWTP will be established. Hence this will not affect the characteristics of the overall wastewater generated by the town.

Public Health:

A major public health concern of the project area is the problem created by the sub-standard septic tanks, which are often overflowed and create unsanitary situations on the streets.

Heritage:

Rashaya is known for its 18th century citadel where several prominent politicians were imprisoned in 1943 by the French mandate. They were struggling for the independence of the country. Rashaya is also known for its old paved souks and its red roofed typical Lebanese houses. In the vicinity of Rashaya, there is also the Faqaa forest which is classified as a protected area.

7- Likely Significant Environmental Effects of the Project and Their Mitigation

This section describes the probable or likely environmental impacts that might occur because of the implementation of the WWTP project, of Rashaya town.

If the WWTP is **not established**, the pollution created by the current practice of raw sewage discharge in septic tanks will continue. This will exert negative effects on the local environment and intensify the existing public health problems and intensify the social tensions.

7.1- Sources of Environmental Impacts and their Mitigation

Impacts of the project on the environment will consist of three sources namely: **site** specific factors or the location of the project, the **process** or the technology that is selected, and the **activities** during the construction and the operational phases.

7.1.1- Site- Specific Factors:

The proposed site is a 1760m^2 piece of land within the land No 5575 in the territories of Rashaya town, which has been purchased by the Municipality. It is located at a distance of about 3km from the nearest house. It is a low point, below the level of all houses of the town, where the wastewater can be collected gravitationally. A sewer network and a 3km pipeline are being established, connecting the town to the WWTP. Yet none of the houses are connected to the sewer network.

The site can be subject to erosion caused by rainfall if proper canalization, landscaping, and land leveling are not done at the site and its surroundings. Moreover, if the construction work takes place during the wet season, high rates of soil erosion will result from the exposed surfaces. The 100m long earthen access road to the WWTP, if not asphalted during the dry season, soil erosion will take place during the following wet season and the road will be deteriorated.

7.1.2- Process-Technology Related Effects:

The proposed wastewater treatment plant will treat the wastewater and achieve a **secondary level** treatment. The two stage trickling filter technology of GROSSIMEX which is an aerobic process and to a certain extent combined with anaerobic digestion. The wastewater will reach and move through the plant gravitationally. There are no mechanical or electric equipment involved in the system.

The basic reactor of the plant is the trickling filter, in which aerobic digestion will take place and the organic material present in the wastewater will be digested. To a lesser extent, anaerobic digestion will take place in the primary separation tank which precedes the trickling filter, and **biogas** will be generated which will be collected and released through vents. Emissions are minimal and do not require flaring.

The other regular outputs of the plant are **treated wastewater**, **scum** and **sludge** (both from the aerobic and anaerobic processes). Once every year, the accumulated **sludge and scum** in the primary separation tank is emptied through valves and transported directly through pipes to the sludge drying bed. As for sludge produced by the final clarifier, it will be wasted whenever it reaches 60-70% of the capacity of the clarifier. Collected sludge will be dried at the site and then used in afforestation projects. Also solarization technique can be applied for sterilization of the sludge. This would be done during summer.

According to the design parameters of the plant, GROSSIMEX assures that the final effluent will comply with the standards set by MoE for **secondary level** treatment. These standards are indicated in Section 3 of this report.

Mitigation

In order to avoid environmental impacts, YMCA has done detailed search and then selected the two stage trickling filters technology, as one of the best available and dependable small-scale wastewater treatment technologies for this specific site. It is made sure that at all stages of the process, proper control measures are applied in order to avoid the creation of environmental problems. During the operational phase, regular testing of the plant's effluents will take place to monitor its quality.

7.1.3- Effects Created During Construction and Earth Moving:

During the construction phase of the project, soil and rock excavation and soil disturbance will take place at the site. If this work coincides with the rainy season soil erosion will result at the site. On the other hand, haphazard dumping of excavated material will create soil erosion and aesthetic disturbance.

There will be **emissions** from vehicles of VOCs, NOx, SOx, CO_2 and particulate matter to the atmosphere and thus contribute to air pollution, greenhouse gas production and global warming. Nevertheless, these emissions will be minimal because they will not occur in high frequencies or for long periods of time.

Excavating vehicles use hydraulic oils, lubricants and greases, which might be spilled accidentally. Their haphazard discharge on the ground can contaminate the natural environment.

The **noise** of the vehicles and workers at the site will cause disturbance for the wildlife, especially birds, but for a limited period.

Noise will be also generated due to traffic created during the delivery of construction material. But this will not create a problem given that there are no houses in the vicinity of the project site.

Dust generated during the construction phase can contribute to air pollution directly and indirectly as synergists or carriers of other pollutants. Dust can be generated at the project site because of excavations and vehicular movements, and also during the transport of material and equipment to the plant, when using the 100m long road, Due to the distance, dust cannot affect the plants and crops of farmers that are more than 1km away. However, the dust might reach the natural forest and cover the leaves of the trees, which hinders their regular growth.

Concrete structures of the WWTP and pavements at the site can cause soil erosion due to runoff from these surfaces.

The existence of the plant will be an eye sore at the site, unless it is curtained with a tree fence.

Mitigation

Environmental impacts of the construction phase will be kept to a minimum by taking adequate measures at the planning and design stage. The residual impacts of the operation will be mitigated by the following measures:

- Spraying water during excavation will minimize dust generation.

- The earth moving operation will be carried out during the dry season and the piled soil will be properly used for landscaping and the excavated rocks in construction of retaining walls and terraces. Proper landscaping will lead into tree planting around the site.

- Proper drainage canals will be constructed around the project site, in order to avoid flooding and soil erosion (by runoff).

- Decreasing the number of trips carried out by the vehicles will minimize disturbance of wildlife and minimize air pollution.

7.1.4- Effects Created During the Operation of the Treatment Plant:

Because of its wastewater treatment potential, the plant will have a **positive impact** on the environment. In other words, significant positive impacts will occur on the quality of surface and ground water, on public health, and on socio-economic development of the Rashaya town and the project area, taking into consideration that the current practices of wastewater disposal, at household and community levels, will be replaced with one controlled treatment plant. However, it will have some negative impacts, which may be seasonal or permanent, if the plant does not operate properly, as it is designed for.

Impacts

- The treated effluents will not generate significant impacts, if the plant operates according to the designed standards for the treatment of wastewater of domestic origin from the Rashaya town. Discharge of improperly treated effluents from the plant can cause surface and groundwater contamination. The plant may also not be able to perform effectively if it is **overloaded**.

- Rainwater run-off from the hard surfaces of the plant may create localized soil erosion problem.

- If the accumulated **sludge**, is dumped haphazardly in the valley, next to the plant, this might create contamination of local water resources and the soils. Also if sludge drying is not done during the dry season, there is the possibility that part of the sludge may be driven with the runoff, which can result in the contamination of the surface water resources.

Mitigation

Implementation of the following measures will mitigate the impacts of the project during its operational phase:

- Effluent wastewater quality will be tested by the Municipality on a regular basis to ensure that its characteristics are within the set standards of MoE.

- In case of non-compliance with MoE standards, effluents can be pumped back into the system for additional treatment. Forest trees can be planted to receive final effluents for further purification. Or the sand layer of the sludge drying beds can be increased in depth.

- Proper outfit and protective clothing will be given to the operator of the plant.

- A fence will be installed around the site to keep out animals and for avoidance of vandalism at the site.

- Proper landscaping will be done at the site and trees will be planted around the plant and other locations of the project area.

- Overloading of the plant (both as flow and as concentration of organic matter) will be resolved by replacing the rock media by plastic media that provides a larger surface area and a greater capacity. Siphons are installed at the inlets of the trickling filters in order to avoid shock loads for the microorganisms. So the system is supplied with an intermittent flow. The Municipality will be in charge of financing the change of the media if it occurs.

- Proper handling and drying of sludge will be done in drying beds, during the summer season. Drying can also be made under transparent plastic sheets (Solarization) to ensure better hygienic conditions.

7.2- Effects on Biological, Physical, Social and Economical Environment

7.2.1- Human beings

Impacts

- The residents of the town will experience net positive environmental benefits from the project. The public health of the community will be upgraded due to improved standard of wastewater management. Income opportunities will be created for local people during the construction and operational phases. A cleaner environment will encourage the development of eco-tourism and other projects in the project area.

- However, the workers of the plant might experience negative health impacts by being exposed to disease-carrying vectors.

Mitigation

- Municipal staff responsible for the treatment plant will be trained for applying safety measures. In addition, adequate protective clothing will be provided to the attendants or operator of the plant.

7.2.2- Nuisance (Odor, Noise, Vermin and Fire)

Impacts

- There will be odor, and vermin problems at the plant that can affect the people who do not picnic near the site.

- The plant may attract flies at the inlet of the plant and become the breeding site for mosquitoes in the last open pond of the system.

Mitigation

- Some odors will be generated at the perimeter of the plants, and will not be felt beyond a distance of 50m around the site. But since the closest house is located at a distance of 3km, there will be no probability of the odor reaching the town. For further prevention, trees will be planted in the vicinity of the plant

- Flies will only be attracted to the inlet of the primary separation tank where wastewater is still untreated. Proliferation of flies will be encountered by the installation of screens at the inlet and over other surfaces that may attract flies.

- The effluents can be discharged deeper in the valley by connecting the outlet of the plant to a pipe that transports the effluent to a farther point in the valley.

7.2.3- Water

Impacts

- In general, the existence of the WWTP will have a positive impact on the surface and ground water quality of the area, because, it will treat the raw sewage overflowing from septic tanks, as well, eliminate the existing open bottom septic tanks in Rashaya, which cause contamination of water resources and create health problems. During the dry season, the discharged water can be used for irrigation of planted trees, or even be used by farmers for irrigating their plantations.

Mitigation

- With continuous sampling and laboratory tests, the performance of the WWTP will be optimized.

- The effluents can be discharged deeper in the valley by connecting the outlet of the plant to a pipe that discharges the effluent to a farther point in the valley.

- The effluents will be discharged in a tree plantation for further purification of the water.

- Awareness campaign will be launched for the residents in order to reduce the discharge of solid wastes and organic material in their sinks and toilets.

7.2.4- Air

Impacts

- Air pollution will result during the excavation and construction phase. Dusty conditions will occur. In addition, vehicular emissions will take place. Gaseous and particulate emissions will have their impacts on the natural vegetation. However, this will occur during the construction phase. During the operational phase of the WWTP, no such conditions will result.

- Biogas will be generated from the anaerobic digestion in the primary separation tank, which will be released into the atmosphere. This will contribute to the climate change phenomena, due to the presence of methane gas in the biogas mixture.

Mitigation

- During the construction phase, water will be sprayed in order to minimize dust emission at the site and along the road if not asphalted.
- Unnecessary vehicular trips will be controlled.
- Biogas generation, a mixture of methane (70%), carbon dioxide and other gases, will occur. But this would be minimal since anaerobic digestion is not the principal biological method of digestion. The amounts generated are not considered as a big environmental threat.

7.2.5- Climate

Impacts

The existence of the WWTP will not have any negative effect on the microclimate of the area. On the contrary, when treated, wastewater is available for irrigation of forest trees; this will boost tree growth and contribute positively.

7.2.6- Soil

Impacts

Limited quantities of soil will be excavated during the construction phase of the treatment plant. If it coincides with the rainy season, this will cause soil erosion at the site. Leveling at the plant site can create soil disturbances, erosion problems and dusty conditions.

The reuse of treated wastewater for irrigation will improve the fertility of lands of the area. Nevertheless, when unsatisfactorily treated effluents are released, these might contaminate the soils.

If the sludge is not properly handled and stored and dried, it can contaminate the nearby soils and create unsightly conditions.

Mitigation

- The staff of the plant will be trained for proper management of the sludge, to avoid soil contamination.

- Effluent will be used for irrigation in tree plantations. This will assist in further purification of the effluents and avoid soil contamination.

- Excavated soil will be utilized for landscaping and then tree planting will take place on them.

7.2.7- Landscape

Impact

The construction of the plant will affect the view of the area. However, the visual impact on the area would not be significant, because trees will be planted around the WWTP.

Mitigation

- The external walls of the structure will be painted in a color that matches with the landscape.
- The effluent wastewater of the WWTP will be utilized for irrigation of the trees around the plant.
- Trees will be planted in the vicinity to isolate and suppress the diffusion of odors and also hide the treatment plant.

7.2.8- Flora

Impact

Although the biodiversity of the project site is not quite rich, during the construction phase of the treatment plant, some wild grasses will be removed.

Mitigation

To avoid loss of biodiversity, proper management of WWTP outputs will be done, as stated in various sections here above.

7.2.9- Fauna

Impacts

The fauna in the project area consists of birds, some rodents, snakes, lizards, chacals and foxes. During the construction phase of the WWTP, these animals will be disturbed and their habitat affected.

Effluent of the WWTP will have a minor impact on the soil microorganisms, particularly beyond the immediate vicinity of the plant. In dry season, the effluents can become a water source for the wild animals and birds.

Mitigation

Various mitigation measures such as proper drainage of runoff, reduction of the number of trips and working time of vehicles on site and other measures are already mentioned

under different headings. All of these will contribute in the mitigation of the impact on the species that are found at the vicinity of the plant.

Tree planting will enhance biodiversity at the site. Trees will attract many bird species and other animal species.

7.2.10- Sensitive areas

Faqaa forest is located in the vicinity of the project site, about 2km, south-eastern direction.

Incidental release of untreated wastewater from the WWTP might cause pollution of surface water resources down the valley, particularly during the rainy season.

Mitigation

Various mitigation measures that are already mentioned previously, under different headings, will contribute in the mitigation. In addition to that, Faqaa forest is located 2km south and above the level of the proposed site, hence it will not be affected by the effluents of the WWTP.

7.2.11- Cultural Heritage

Rashaya attracts a number of tourists that come to see the historical fortress and the traditional houses and souks. The establishment of the WWTP will have positive impact on the ecotourism industry of the town.

7.3- Summary Table of Effects of Project on Biological, Physical and Socio-Economical Environment

Description						Evaluation	
Impacts on	***Impact number***	***Character***	***Magnitude***	***Duration***	***Consequences***	***Significance***	***Certainty***
Human beings	7.2.1	Positive	All of the people except the staff of the plant	Permanent	Improvement of public health	Significant	High
Nuisance (odor, fire, noise & vermin)	7.2.2	No effect on the population but minor inconvenience at the working environment	At the plant	Permanent	Health threat to workers	Significant	Very low
Water	7.2.3	Reduction of surface and groundwater pollution in the town	Runoff channel at the vicinity of WWTP	Permanent	Contamination of watercourse with new microorganisms	Slight	Low
Air	7.2.4	Production of methane gas	At the plant	Continuous	Damage to climate	Very Slight	Very Low
Climate	7.2.5	Positive	Not known	Continuous	reforestation	Slight	Low
Soil	7.2.6	Soil erosion and disturbance	Vicinity of the plant	Construction phase and wet season	Loss of soil and visual impact	Slight	Low

Description						Evaluation	
Impacts on	***Impact number***	***Character***	***Magnitude***	***Duration***	***Consequences***	***Significance***	***Certainty***
Landscape	7.2.7	Loss of solitude and visibility of structure	At the plant site	Long term	Contrast with the surrounding landscape	Very slight	Very low
Flora	7.2.8	Positive, due to planting of trees	Around the plant	Permanent	Improvement of degraded lands	Slight	Low
Fauna	7.2.9	Disturbance to species during construction	Around the plant	Short term	Migration of species	Significant	Low
Sensitive areas	7.2.10	Faqaa forest	At 2km south from the site	Permanent	Disturbance of the ecosystem	Very Slight	Very Low
Cultural heritage	7.2.11	Rashaya Castle	At 3km from the site	Permanent	Aesthetic view	Very slight	Very Low

7.4 – Program to Reduce the Significant Negative Effects of the Project

The *Impact rating* is calculated as follows:

Five questions are asked. A YES answer is valued as 1 and a NO answer is valued as 0. Calculation of the value (between 0 and 5) is done, which is the sum of YES answers among the following 5 questions. This is called the ***Impact rating***.

Questions that are asked:

1- Is the aspect associated with any legislation, regulations, authorizations or codes of practice? Or does the identified aspect involve the use of any hazardous, restricted or special substance?

2- Is the aspect of concern to stakeholders? I.e.

- Employees
- Neighbors
- Shareholders
- Local community

3- Is the identified aspect or impact clearly associated with any of the more serious global environmental issues?

4- Is the aspect identified is quantifiable, is the amount of use significant?

5- Is the aspect identified is quantifiable, is the amount or frequency of use significant?

Severity Rating Matrix

Rating	Severity
1	No or minor environmental effect
2	Slight environmental effect
3	Moderate environmental effect
4	Serious environmental effect
5	Disastrous environmental effect

In the **Significance Factor** column of the following tables, multiplying the **impact** and **severity** ratings will indicate the **Significance** of the aspect.
The Significance test will generate a **result between 0 and 25** for each of the identified aspects or impacts tested. Any aspect or impact with a value **greater than or equal to 8 is 'notable'** and any aspect or impact with a value **greater than or equal to 12 is 'significant'**.

Process step	Aspect or impact identified	Impact Description	a	b	c	b*c	Mitigation Measures
			Direct or indirect	Impact rating	Severity rating	Significance factor	
Excavation	Dust	Contribute to air pollution directly and indirectly as synergists or carriers of other pollutants. Can affect Health and local ecosystem.	Direct	1	2	**2**	Spraying water during the excavation phase
Excavation	Vehicle emissions	Emissions of VOCs, NOx, SOx, CO_2 and particulate matter to atmosphere and thus contribute to air pollution, greenhouse gas production and global warming.	Direct	2	2	**4**	Reducing number of trips and frequency of operation of the vehicles
Excavation	Soil disturbance	Heavy machinery used will cause soil compaction.	Direct	1	3	**3**	Limiting the excavation area
Excavation	Disposal of excavated material	The excavated material will be used for landscaping, construction and deep rooted tree planting	Direct	1	2	**2**	Rocks and soil reused for terracing
Excavation	Noise	Excessive or prolonged exposure to noise (typically more than 8 hrs above 85-90 decibels) leads to hearing loss, which is not the case here. This will affect the workers on site.	Direct	1	2	**2**	Reduction of the frequency of noisy operation
Leveling	Dust	Contribute to air pollution directly and indirectly as synergists or carriers of other pollutants. It can affect health and local ecosystem.	Direct	1	2	**2**	Spraying water while working

Process steps	Aspect or impact identified	Impact Description	Direct or indirect	Impact rating	Severity rating	Significance factor	Mitigation Measures
Leveling	Transport emissions	Emissions of VOCs, NOx, SOx, CO_2 and particulate matter to atmosphere and thus contribute to air pollution, greenhouse gas production and global warming.	Direct	2	3	**6**	Reducing number of trips, and frequency of operation of the vehicles
Leveling	Soil disturbance	Heavy machinery used will cause soil compaction.	Direct	1	3	**3**	Limit leveling area.
Building retaining walls	Erosion	Establishment of retaining walls for terraces reduces risk of soil erosion by decreasing the speed of water runoff and maximizing water absorption by soil.	Direct	0	1	**0**	This is a positive impact.
Concrete surfaces	Erosion	Structures and pavements can cause additional discharges of runoff, which promotes soil erosion.	Direct	1	3	**3**	Proper channeling and drainage systems
Building the WWTP	Use of power equipment	Combustion of fuel leads to emission of VOCs, NOx, SOx, CO_2 and thus air pollution, acidification, greenhouse gas production and global warming.	Direct	1	3	**3**	Minimize the frequency of operation of the equipment and vehicles.
Building the WWTP	Noise	Excess noise at the construction site cause disturbance on the wildlife	Direct	3	5	**15**	Minimize the unnecessary use of vehicles and equipment.
Operation of the trickling filters	Health impacts	Risks of fly and mosquito breeding at the inlet and the filters that can cause nuisance.	Direct	3	3	**9**	Monitor the proliferation of mosquito and fly populations and install screens

Process steps	Aspect or impact identified	Impact Description	Direct or indirect	Impact rating	Severity rating	Significance factor	Mitigation Measures
Discharge of the effluents during the operation of the WWTP	Water & land contamination	Sub- standard treatment leads into soil and water resources contamination	Direct	3	4	**12**	– Regular lab test to assure proper performance of the plant – Avoidance of accidental runoff water intrusion from the manholes of network
Final effluent discharge	Water quality	If the final effluent contains certain bacteria like salmonella, it poses a risk to contaminate the receiving stream and the food chain.	Direct	3	4	**12**	- Regular testing of the effluent wastewater to ensure better quality - Discharge in a tree plantation for further purification
Effluent reuse	Health Impacts	Risk of transmission of disease to farmers reusing treated wastewater for irrigation.	Direct	2	3	**6**	Advise the farmers not to plant vegetables that can be consumed in raw state.
Sludge Drying beds	Health Impacts	Risk of parasite eggs spreading in the are that can cause nuisance to the inhabitants.	Direct	2	3	**6**	Disinfect the drying sludge by solarization

8- Analysis of the Alternatives to the Project:

Alternatives to the project are analyzed in terms of factors related to the ***sites*** and ***technologies*** that are available, by taking into account their environmental gains and soundness. Alternatives are described at three levels namely:

- **Alternative locations** for the project site.
- **Level of wastewater treatment required**, based on the requirements of MoE Decision 8/1, 2002.
- **Alternative processes of small-scale wastewater treatment** technologies, compatible with trickling filters wastewater treatment process.

8.1- Alternative Locations:

The **proposed WWTP site**, which will occupy an area of 1760m^2 on public land lot # 5575, is located in the South valley of Rashaya town. This is the only convenient location in terms of gravitational flow of the wastewater and for establishing the wastewater treatment plant. The land, on which the plant is to be built, belongs to the Municipality. It is at a distance of more than 3km from the nearest house.

An **alternative site** would be a spot in the same valley for gravitational flow; 500m far from the current proposed location. Although this point has the same environmental and topographic characteristics, it implies the following complications:

It is **public land** owned by the government and it will take a long period of time for the Municipality to purchase it or have access to it.

The **area available** for construction is narrower and not located at the bottom of stiff cliffs. Rock falls might occur and destroy the plant. In addition to that, the **rocky formation** will pose difficulties during excavation. On the other hand, implementation of this alternative will require **additional funds.**

There is **no existing road** connecting the site to the main road, thus requiring further excavation in the valley for road building, which will impart the natural environment.

Therefore, the proposed site is ideally placed for the implementation of the project. Photos of Chapter 6 give a clear idea on the characteristics of the site.

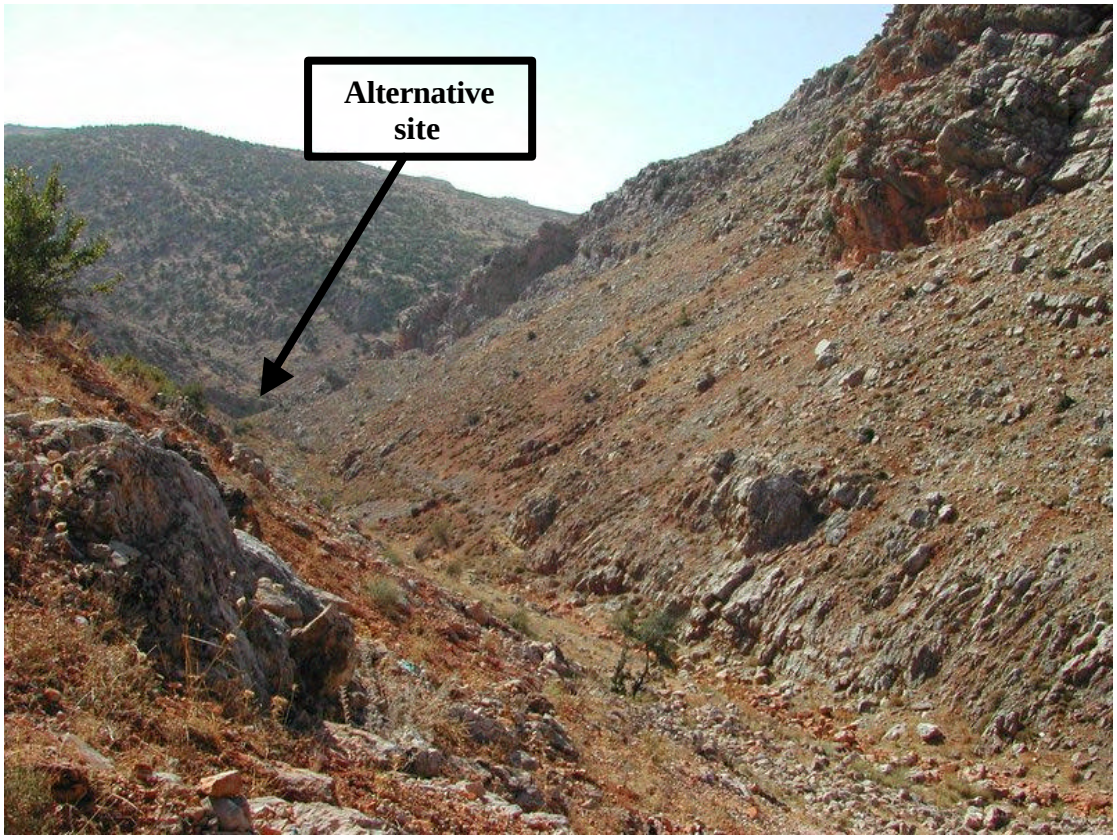


Photo 8-1. Alternative site location.

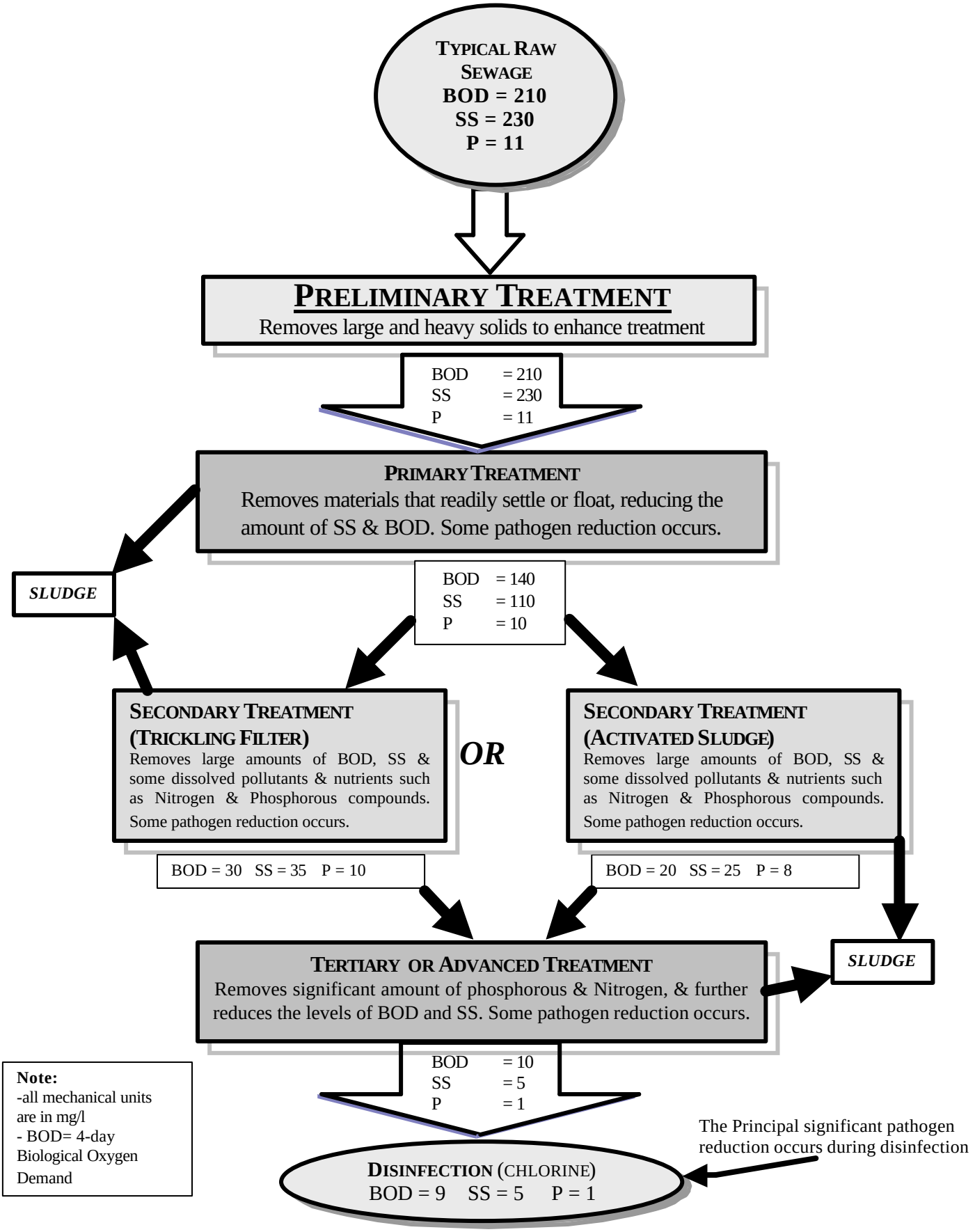
8.2- Technological Alternatives of Wastewater Disposal

The **secondary level** treatment can attain the effluent standards that are set by MoE Decision 8/1, 2002. However, the level of wastewater treatment depends on the financial means of the communities and municipalities and the availability of technical skills. The higher we go in the levels of treatment, i.e., from *Primary* to *Secondary*, to *Tertiary* or *Advanced* levels, costlier would be the operation. For the rural areas of Lebanon, it is always preferable to adopt simple and environmentally sound technologies that require minimum maintenance and minimum running cost. The general procedures for wastewater treatment are described here below:

The General Procedures for Wastewater Treatment

The basic function of wastewater treatment is to speed up the natural processes by which wastewater is purified. In general, there are three basic levels in the treatment of wastewaters, **primary**, **secondary** and **tertiary**, which are outlined here below. In the **primary level**, solids are allowed to settle and floatables rise up to the surface and then both of these removed from the wastewater. The **secondary level** uses biological processes to further purify wastewater. The **tertiary level** uses advanced treatment techniques capable of removing nitrogen and phosphorous. These three levels of treatment are summarized in the following diagram, also present in Annex 3.1.

WASTE WATER TREATMENT



Primary level treatment

As sewage enters a plant for treatment, it flows through a screen, which removes large floating objects such as rags and sticks that might clog pipes or damage equipment. After sewage has been screened, it passes into a grit chamber, where sand and small stones settle to the bottom. A grit chamber is particularly important in communities with combined sewer systems where sand or gravel may wash into sewers along with storm water. This treatment often is referred to as *preliminary* treatment.

After screening is completed and grit has been removed, sewage still contains organic and inorganic matter along with other suspended solids, which need to be removed. These solids are minute particles that can be removed from sewage in a *sedimentation tank.* When the speed of the flow through the sedimentation tank is reduced, the suspended solids will gradually sink to the bottom, where they form a mass of solids called *raw primary biosolids (sludge).* Biosolids are usually removed from tanks by pumping, after which it may be further treated for use as a fertilizer, or disposed of in a landfill. What has been described in this paragraph is referred to as *primary* level treatment.

Primary treatment alone is unable to meet the modern standards for higher effluent quality. To meet these, cities and industries normally treat to a secondary treatment level, and in some cases, also use advanced treatment to remove nutrients and other contaminants.

Secondary level treatment

The *secondary Level* of treatment removes about 85% of the organic matter in sewage by making use of the bacteria in it. There are two basic biologic technologies for the treatment of wastewater. These are *aerobic* and *anaerobic* processes.

The principal aerobic treatment techniques used in secondary treatment are the *activated sludge* and the *tricking filter* processes.

After effluent leaves the sedimentation tank in the *primary* stage it flows or is pumped to another chamber using one or the other of these processes. A **trickling filter** is simply a bed of stones from one to two meters deep through which sewage passes. More recently, interlocking pieces of corrugated plastic or other synthetic media have

also been used in trickling beds. Bacteria gather and multiply on these stones and they can consume most of the organic matter. The cleaner water trickles out through pipes for further treatment. From a trickling filter, the partially treated sewage flows to another sedimentation tank to remove excess bacteria and organic materials.

The trend today is the use of the **activated sludge** process instead of trickling filters. The activated sludge process is an aerobic process, which speeds up the work of the bacteria by bringing air and sludge into close contact with incoming sewage through mechanical means. In this process, after the sewage leaves the settling tank in the primary stage, it is pumped into and *aeration tank* where the activated sludge process takes place by introducing air and sludge loaded with bacteria and allowed to mix for several hours. During this time, the bacteria break down the organic matter into harmless by-products.

The sludge now activated with additional billions of bacteria and other tiny organisms can be used again by returning it to the aeration tank for mixing with air and new sewage. From the aeration tank, the partially treated sewage flows to another sedimentation tank for removal of excess bacteria and organic material.

To complete the secondary treatment, effluent from sedimentation tank is usually *disinfected* with chlorine before being discharged into receiving waters or in nature. Chlorine is fed into the water to kill pathogenic bacteria, and to reduce odor. Done properly, chlorination will kill more than 99% of the harmful bacteria in an effluent.

In the case of *anaerobic treatment*, wastewater is kept in an airtight and waterproof tank for several days where the anaerobic bacteria digest the wastewater found in the sewage and releases biogas, which can be used as a renewable energy source. Anaerobic systems need less space and minimum mechanical equipment, and less maintenance. Usually the effluent from the anaerobic digester is led into an aerobic pond for further biologic treatment.

According to the WHO standards, effluents from secondary level treatment of household wastewater can be safely used for irrigation.

Tertiary level treatment

Water pollution problems have placed additional burdens on wastewater treatment systems. Today's pollutants from industries, such as heavy metals, chemical compounds, and toxic substances are more difficult to remove from wastewater. The

increasing need to reuse water calls for better wastewater treatment. These challenges are being met through better methods of removing pollutants at treatment plants. This level of treatment is referred to as *tertiary* or *advanced treatment.*

To return more usable water to receiving lakes and streams, new methods for removing pollutants are being developed. ***Advanced wastewater treatment techniques*** in use or under-development range from biological treatment, capable of removing nitrogen and phosphorus, to physical-chemical separation techniques such as *filtration, carbon absorption, distillation,* and *reverse osmosis.*

These advanced wastewater treatment processes, alone or in combination, can achieve almost any degree of pollution control desired. Wastewater effluent purified by such *tertiary* treatment can be used for industrial, agricultural, or recreational purposes, or even drinking water supplies. Nevertheless, attaining tertiary level treatment costs a lot of money!

Therefore, for the Lebanese rural areas, secondary level treatment for household wastewaters can be considered satisfactory, which is suitable for use in irrigation or discharging in nature. This complies with the MOE Decision 8/1, 2002.

8.3- Alternative wastewater processes comparable with TSTF process:

The TSTF process of GROSSIMEX is a favorable wastewater treatment technology for the project area because of its dependability, due to the non-mechanical (i.e. gravitational) flow of wastewater in the system and low maintenance requirements of the WWTP. During the last decade several wastewater treatment projects have failed in rural areas of Lebanon when mechanical systems were installed. This is due to the high operational costs, unavailability of funds for the replacement of equipment parts, frequent electric power cuts, and the need of skilled technicians that are often not available in the rural areas.

On the other hand, GROSSIMEX claims that the TSTF technology has the **capability of complying with the national effluent standards**, which are listed in the Decision 1/8 of MOE. **Nitrogen, carbon** and **infectious bacteria** are consumed in the process. Accumulation of **heavy metals** like lead and others in the wastewater treatment plant is not likely to occur, because there are no industries in the area that discharge heavy metals. All of the generated wastewater is of domestic origin.

It is a well known fact that many types of wastewater treatment technologies are practiced and promoted worldwide and in Lebanon as well. Here below two innovative small-scale wastewater treatment technologies are described that achieve similar effluent characteristics as **trickling filters** do but which are not so flexible for this project site.

8.3.1- Alternative 1: *AIWPS process of IBC Co.*

The alternative wastewater treatment technology that can be used at the WWTP is the anaerobic process known as the Advanced Integrated Wastewater Pond Systems (AIWPS) technology provided by the International Business Consultant's (IBC) Company.

Description of the AWPS Process

Wastewater is conveyed from the sewage network of the town to the Grease and Sand Trap by a gravity sewer line. The trap retains grease and sand; grease rise to the surface and heavy objects such as metal and sand will sink to the bottom sump and the flow will pass through the submerged pipe connected to the Anaerobic Digester. The Anaerobic Bio Digester is the main reactor of the WWTP, which retains the sewage for a specified period (10 days) to allow the growth of anaerobes that multiply in the absence of oxygen. The anaerobe organism digests the organic component of the sewage and produces the biogas, a mixture of Methane Gas (about 70%), carbon dioxide (about 20%), and other gases. The released biogas is flared intermittently with an automatic torch. Wastewater then reaches the Aeration Pond followed by the aeration Channel that provide aerobic treatment. These two open structures expose the anaerobic effluent to light and air. In here, the anaerobic microorganisms die and the aerobic bacteria overtake which further digests and purifies the wastewater. Air, sun and wind are the main factors that help to the aerobic process.

The Operation and Maintenance of the WWTP is very simple. It is based on gravitational flow without any use of electricity and pumps. The system as designed is self-operational. However, it needs continuous testing of wastewater at the Grease and Sand Trap, the effluent from the Digester and the final outflow (effluent) from Aeration channel. These samples must be tested for pH, BOD, coliform bacteria and other parameters as required.

Sludge is cleaned once every 20 years and put in drying beds and then used as a soil conditioner.

For additional information on AIWPS wastewater treatment process and diagram, please refer to Annex-3.

8.3.2- Alternative 2: *POLYTECH Bio-Process for Wastewater Treatment*

The **second alternative** for the proposed WWTP at Rashaya is the **Bio-Process** System developed by POLYTECH Agro-Environment Technologies Company of Lebanon.

Description of the Bio-Process

The **Polytech Bio-process** is composed of four rectangular or circular shaped concrete or steel tanks, coated with epoxy to prevent corrosion and oxidation (rust). It operates through gravitational flow. The bio-products Balsam and Polyzymes are the basic enzymes that enable the process to be simple and effective.

The Process:

1. First, the main sewer system is connected to the controlled bio treatment screen system.

2. The screened water passes to the bio treatment compartment, the bio-reactor.

3. The sewage overflow to the grinder compartment for further mixing and grinding the organic solid waste particles that are below 2.5 cm in size.

4. The sewage continuously flows in through a 10 to 15 cm in diameter heavy duty plastic pipe to the bottom of the bio-reactor.

5. The bio-reactor is equipped with a floating air blower giving very fine bubbles. This enables the aerobic digestion of biowastes that are found in the wastewater.

6. The treated sewage in the Bio-reactor overflow to the first settling tank through a V weir, passing homogeneous water slowly between the tank wall and a plastic lamella, without turbulence and turbidity.

7. From the first settling tank the water continue overflowing to the second, third and fourth tanks (clarifier) through V weir and lamella.

8. The treated water in the clarifier is overflown through a V weir to a gutter surrounding the lower base of the tank.

9. The collected water (final effluent) in the gutter is flown through a pipe by gravity, to be used in irrigation or discharged in nature, free of malodor and feacal coliforms. The bio-product Balsam when added in the process, it kills 98% of all pathogens. These results comply with the Decision 8/1, 2002 of MoE.

The Bio-Process System operates gravitationally. It does not produce and sludge. The Balsam/Polyzyme bio-products are added by the automatic dosing system, which inactivate the anaerobic bacteria and suppress odor generation by 95%. These bio-products also kill the coliform bacteria and sterilize the final effluent. They also dissolve the organic matter in wastewater, including tissue paper, and eliminate the accumulation of sludge. The limited quantity of settled sludge in the three settling tanks are periodically pumped and reinserted in the first tank, in the bioreactor. The system does not need continuous aeration. The automatic air blowers are operated only occasionally.

The Bio-Process System operates with minimum maintenance. A part time attendant can daily check the dosing system and operate the pumps and the blowers for a couple of hours.

For diagrams and additional information please refer to Annex 3.3.

8.3.3- Comparison of Technological Alternatives:

The **summary matrix** for the characteristics and advantages of the three small-scale wastewater treatment processes are presented here below. The favorable conditions are graded on a scale from 1 to 5. Five being the highest favorable condition.

Functions	Wastewater Treatment Technologies/ Processes		
	TSTF	***AIWPS***	***POLYTECH***
Compactness	4	4	5
Reduced odors	4	4	4
Need for electricity supply	5	5	4
Local level maintainability	5	5	4
Low operational cost	5	5	3
Speed of treatment process	5	3	4
Quality of effluent	4	4	4
Convenience and aesthetics	5	5	5
Life time of the system	5	5	4
Environment friendliness of the technology	5	5	5
Performance in cold weather	4	4	3
Total Grades	51	49	44

The total grades indicate that, with 51 points the TSTF process presents an advantage over the other two small-scale wastewater treatment processes. Actually, its low maintenance, speed of treatment process and low operational cost features make it more attractive for this project site.

8.3.4- The Most Preferred Alternative to the Project:

Taking the three levels of alternatives (site, suitability of technologies and wastewater treatment processes) that were discussed here above, it is obvious that the TSTF wastewater treatment process presents an advantage over the other two processes, for this particular project and site. This advantage is in terms of capital and operational cost, siting and appropriateness of the technology. For other geographic locations and scale of operation, the other two processes might present additional advantages.

8.4- The overall two stage trickling filter wastewater treatment operation in brief:

The wastewater treatment procedure at Rashaya town will include the following steps:

1- Wastewater Collection

60% of Rashaya's houses will be connected to the sewage network after its construction and will be connected to the WWTP. The flow diagram is presented in Annex 2.1.

2- Wastewater Treatment

Step 1: Wastewater flows through screens installed at the inlet of the plant to retain large pieces and particles and floating objects.

Step 2: Wastewater is then introduced in a primary separation tank for sedimentation. The tank is roofed and separated in 2 chambers in which sedimentation of sludge is accomplished. In the first and second chambers anaerobic digestion of the settled material takes place. Gases produced by the digestion are escaped through a 3m long vent.

Step 3: Next the effluents of the primary separation tank reach gravitationally the trickling filters (a set of two) that are the main reactors of the WWTP. Trickling filter (TF) is an aerobic treatment system (needs oxygen) that removes organic matter from wastewater. TFs contain rock or plastic media, to which microorganisms are attached. Liquid wastewater is distributed gravitationally over the top of the medium, and as it percolates gravitationally through the media, the organic content is digested by the microorganisms. While the microbial layer thickens through microbial growth, some of the microorganisms detach from the media and are collected in an underdrain system.

Step 4: After wastewater passes through two similar trickling filters, effluents reach the secondary clarifier for further separation. The clarifier is a tank in which effluents are detained for 6 hours to separate flocculated materials from the liquid component of wastewater. The sludge settles at the bottom of the tank, (sloped 45 degrees) and is collected for periodic disposal.

3- Final disposal of treated byproducts

Step 5: Sludge is then transferred gravitationally to drying beds for dewatering. It dewaters by drainage through the underlaid sand and by evaporation from the surface exposed to air. A lateral drainage system is installed to collect percolating water from the sludge. Sludge is completely dried during the summer season, which can be used in agriculture as soil conditioner. At this point also solarization can be applied for sterilization of the sludge cake.

Step 6: The **final effluent** wastewater from the clarifier is discharged in the narrow valley next to the plant. At this stage, it would have undergone secondary level treatment, which complies with the standards set by MOE. However, for further purification and benefit, the effluents are used for irrigating forest trees.

The local community will not experience any odor problem or any other sort of nuisance, when the WWTP of Rashaya will be operated. This is because of the distance of the WWTP from the human settlements. Even neighboring towns, which are more than 10km far, will not be affected by the odor. It is anticipated that no smell from the WWTP will go further than 50 m from the site.

9 – Environmental Management Plan (EMP)

The proper implementation of a comprehensive environmental management plan (EMP) will ensure that the proposed WWTP meet regulatory and operational performance. GROSSIMEX will be responsible for the construction of the proposed WWTP and training of employees and will be responsible for implementing the mitigation measures set, and performing the monitoring procedures required in the EMP.

Objectives of the Environmental Management Plan

Environmental management/monitoring is essential for ensuring that identified impacts are maintained within the allowable levels, unanticipated impacts are mitigated at an early stage (before they become a problem), and the expected project benefits are realized. Thus, the aim of an EMP is to assist in the systematic and prompt recognition of problems and the effective actions to correct them, and ultimately good environmental performance is achieved. A good understanding of environmental priorities and policies, proper management of the facility (at the municipality level), knowledge of regulatory requirements and keeping up-to-date operational information are basic to good environmental performance.

9.1- Monitoring Schemes

Two monitoring activities have to be initiated for the proposed WWTP to ensure the environmental soundness of the project. The first is *compliance monitoring*, and the second is *process control monitoring*. Compliance monitoring provides for the control of final effluent quality, while process monitoring relates to detecting the impact of the operational activities. Together, the objective is to improve the quality and availability of data on the effectiveness of operation, equipment, and design measures and eventually on the protection of the environment.

9.1 – Program to Reduce the Significant Negative Effects of the Project

Impact	Mitigation Measures	Phase of the Project	Party Responsible for Implementation	Environmental Effects of Mitigation Measure	Additional Costs Involved
1.Water pollution problems	- Properly treated effluent wastewater will be discharged in the shallow runoff valley next to the WWTP or used for irrigating nearby forests.	- Operational	- Municipality of Rashaya	- Positive	- Included in operational cost.
	- Forest trees will be planted around the plant in order to ensure further purification of the wastewater discharged.	- Operational	- Municipality of Rashaya	-Positive	- Included in operational cost
	- A pipe will be connected to the outlet of the plant to discharge effluents in a farther location in the valley.	- Construction	Contractors	- Positive	- Included in Project cost
2. Soil erosion and pollution	- Earth moving operations will be carried out during the rainless season, to avoid soil erosion.	- Construction	- Contractors	- Positive	- Included in project cost
	- Excavated soils and rocks will be used for landscaping and establishing terraces at the project site.	- Construction	- Contractors	- Positive	- Included in project cost
	- Rain runoff from the plants' open surfaces will be channeled properly into the nearby runoff watercourse in order to avoid soil erosion.	- Construction and operational	- Contractor	- Positive	- Included in projects cost and running cost
3. Nuisance ▪ Odors ▪ Litter ▪ Noise ▪ Vermin	- Plant attendant will be trained for proper maintenance and operation of the plant, including elimination of odors, vermin and mosquito.	- Operational	- Contractor	- Positive	- Included in project cost
	- Fencing around the site.	- Construction operational	- Contractor & Municipality	- Positive	- Included in running cost
	- A pipe will be connected to the outlet of the plant to discharge effluents in a farther location in the valley.	- Construction	Contractors	- Positive	- Included in Project cost

Impact	Mitigation Measures	Phase of the Project	Party Responsible for Implementation	Environmental Effects of Mitigation Measure	Additional Costs Involved
4. Fires	- Arrangements will be made to use the plant effluents for controlling fires at the site and in the area.	- Construction	- Contractor	- Positive	- Included in project budget
	- Fire extinguishers will be made available at various corners of the plant.	- Construction and operational	- Contractor	- Positive	- Included in project budget
5. Health of staff	- Provision of training and safety clothing.	- Operational	- Contractor	- Positive	- Included in project running cost
6. Air Pollution	- During construction phase dusty conditions will be minimized by spraying water on the earthen surfaces and by paving the vacant areas at the site.	- Construction	- Contractor	- Positive	- Included in project budget
6. Landscape disturbance	- The concrete structures of the plant will be painted with colors matching the landscape. Water based paints will be utilized rather than solvent based.	- Construction	- Contractors	- Positive	- Included in project budget
	- Establishment of a tree nursery at the project site for demonstrating the beneficial use of effluent wastewater.	- Operational	- Contractors	- Positive	- Included in running costs
	- Proper landscaping will be done at the site. The excavated soil will be used for landscaping. Also trees will be planted at the project site.	- Construction	- Contractors	- Positive	- Included in project budget

The monitoring means of specific activities, their parameters, frequencies and recording system is summarized in the following **monitoring scheme** for the project:

9.1.1- Compliance Monitoring

In this context, compliance to the regulations set by the Ministry of Environment to limit air, water, and soil pollution shall be observed. Compliance monitoring shall be the responsibility of the WWTP administration (Municipality).

For effective compliance monitoring, the following shall be assured:

- Trained staff and defined responsibilities,
- Authorized Standard Operating Protocols (SOPs) for representative sampling, laboratory analysis, and data analysis,
- Provision of safe storage and retention of records.

In the case of the proposed WWTP, the attendant of the WWTP should be able to take wastewater samples for laboratory testing. Both contractors and consultants would be involved in knowledge transfer to the attendant and the Municipality representative.

It is noteworthy to mention that the Municipality of Rashaya should cooperate with the GROSSIMEX for a better approach in process control. A sound understanding of the treatment process and the technology will lead to better effluent quality.

Given that the plant capacity is not big, it is recommended that compliance monitoring occurs once every 3 months. However, in the case of WWTP expansion, the frequency of monitoring should be increased accordingly.

It is noteworthy to mention that initial accurate characterization of the influent wastewater to be treated is necessary for proper facility design, operation, and future monitoring. The frequency of monitoring should not be reduced. However, in case of any sudden change in the trend of influent, it is imperative to locate and correct the cause of change, and to adopt a more frequent monitoring scheme until a regular trend is re-established.

Within the framework of the quality monitoring procedure, sample-taking and analyses must be carried out by external monitoring laboratories. The analysis should cover all of the parameters set by the MoE for wastewater effluent that is treated at secondary level. All test result should be recorded.

9.1.2- Process Control Monitoring

This course of action is needed since a precise and adapted process control strategy translates into a better process performance, and thus effluent quality compliance.

Occupational health and safety is crucial for the proper performance of the WWTP. Therefore, the Municipality must continuously observe the occupational safety standards of the part time attendant of the WWTP.

The main access roads connecting to the facility must remain in good condition to avoid vehicles accidents and erosion problems.

The WWTP attendant must also regularly check for outdoor cleanliness. This is performed weekly by a field visit to the area surrounding the facility.

Table 9-1. Process Performance Monitoring Parameters

Domain	*Parameter*	*Frequency*
Health and Safety	Around the WWTP	Quarterly
	Occupational safety	Ongoing
Odor	Off site odor levels	Weekly
Pests	Drying beds and effluent discharge canal	Weekly

9.1.3- Record Keeping and Reporting

The monitoring activities at the WWTP will concentrate on: good housekeeping, awareness raising, limiting exposure of operating personnel to wastewater, effluent testing, maintenance of drainage canals, noise and odors that are generated at the plant site, sludge disposal and extent of soil erosion problems and biodiversity loss (or gain) around the project site.

However, monitoring efforts would be in vain in the absence of an organized record keeping practice. It is the responsibility of the WWTP administration, the Municipality, to ensure the development of a database that includes a systematic tabulation of process indicators, maintenance schedules, logbook, and compliance and process performance monitoring outcomes. Such a historical database benefits both the facility operator and design engineers. Such record keeping shall be assured by the Municipality.

9.2- Institutional Arrangements

No matter how meticulously an environmental management scheme has been prepared, it will fail in the absence of predefined responsibilities and strong technical bodies. Compliance monitoring shall be the responsibility of the treatment facility administration; in this case Rashaya Municipality, or a contracted operator, and thus its activities shall be budgeted for accordingly. However, it is recommended that a private sector be contracted for the operation of the WWTP.

In accordance with the requirements of the regulatory authority (MoE), the treatment facility should submit a periodic Compliance Monitoring Report to the enforcement authority (Municipality/ Ministry of Interior and Municipalities/ Ministry of Agriculture). The assigned authority will be responsible for drawing conclusions based on the monitoring data, and deciding on specific actions to alleviate pollution impacts. The coordination with the MoE and MoA is also important since they are responsible for effluent compliance standards and reuse of treated wastewater in irrigation practices. Figure 9.1 is a typical set up of an institutional arrangement.

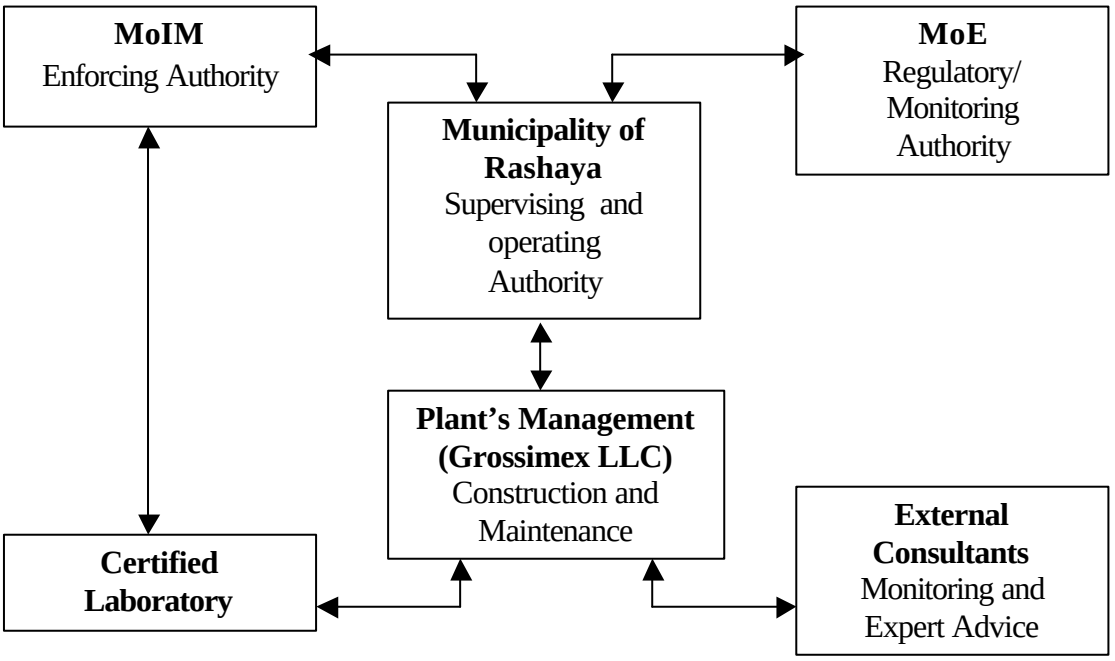


Figure 9.1- Proposed Institutional Setting for the Management of WWTP Operation

9.2.1- Institutional Roles During the Administration of WWTP:

Adequate management of the WWTP and the sewage network entails the cooperation of various parties. The parties who are going to be involved and play roles during the project implementation and operation include the following:

- Municipal Council of the Rashaya town
- YMCA Lebanon
- Local population of the town
- GROSSIMEX LLC Company
- Ministry of Environment (MoE)
- Ministry of Interior and Municipalities (MoIM)

The role of parties pertains to their substantial contributions for effective management of wastewater in the project area, including effective operation of the WWTP. In this regard, the parties will shoulder the following tasks:

- **Municipality of Rashaya**: It will be in charge of excavation and concrete-based activities, which will cover 50% of the total project cost. The construction of the sewer network has been contracted to AL MADAR Company. The Municipality will also launch an awareness campaign for reducing waste generation at domestic level. It will be responsible for the daily affairs of the plant. It will keep the records of the lab tests of the effluents generated at the plant. It will pay the salary of the attendant of the plant.

- **YMCA**: During the planning and construction phase of WWTP, YMCA will cover 50% of the equipment, material cost, sewer network pipes and manholes establishing, and provide technical assistance. This will include the expert fees, coordination with official bodies and experts, and negotiations with suppliers and contractors. YMCA will also cooperate with the Municipality in launching awareness campaigns in the area.

- **Local community:** will cooperate in promoting environmental awareness and adopt good housekeeping measures. The Municipality will coordinate these activities.

- **Ministry of Environment (MOE):** will monitor the overall performance of the WWTP and ensure that environmental standards are kept at acceptable level. MOE will also assist in launching the awareness campaign.

- **Ministry of Interior and Municipalities (MoIM):** will enforce the decisions of MoE.

- **Staff:** The part time attendant of the plant will be trained on taking samples from the plant effluents for laboratory testing and for the frequent cleaning of the screens (every 2-3 days). GROSSIMEX will do the training. These trainings will be carried out during the first month of operation of the plant.

The Municipality will select the attendant. He will be able to do the following tasks:

- Take proper samples from the effluent of WWTP and deliver it to the laboratory.
- Cleaning of the screens every 2 to 3 days
- Regular visual checkup on the good functioning of the filters

- Record keeping on the amounts of sludge removed and reporting to the Municipality on accidents and malfunctioning of the plant.
- Plant trees at the plant site and irrigate it with effluent wastewater.
- Good housekeeping at the plant site.

- **GROSSIMEX LLC.:** It will make sure that the plant is designed and constructed properly. It will also make sure that the plant operates normally. It would also be in charge of elimination of odor and control of vermin and mosquito proliferation at the plant.

9.2.2- Division of Responsibilities during the Operational Phase

Activity	Party Responsible	Executing Party	Duration
Supervision of plant operation	- Municipality	Designated representative of the Municipality	Throughout operation
Data keeping: - Lab. test results of WWTP	- Municipality	Designated representative of the Municipality	Throughout operation
Awareness campaigns	- Municipality and YMCA	YMCA staff and Municipality	First year of operation
Tree planting campaigns	Municipality	Local community	3 years
Good housekeeping at the plant: - Reparations - Gardening	Municipality	- Attendant	Throughout operation
Planning for improvement and emergency response plan	- Municipality - GROSSIMEX LLC Co. and - YMCA	Municipality and GROSSIMEX LLC technicians	One year

9.3- Contingency Plan

Contingency and emergency plans were tackled in the design consideration of the WWTP, which will be always updated by GROSSIMEX, the WWTP attendant and the Municipality. GROSSIMEX LLC will train the attendant for emergency actions and the attendant and the Municipality will take care of the plant.

However, GROSSIMEX assumes all of the responsibility for complying with the national effluent standards, provided that the influent wastewater complies with the limits set by MOE. In this case, the BOD level of influent wastewater is estimated to be 240 mgl. The basic measures for **management of emergency situations** will be as follows:

- In the first place, the annual emergency response plans will be revised by GROSSIMEX and proper instructions will be given regularly to the Municipality and plant attendant.

- In case of fires in the forests around the plant, the effluent wastewater will be utilized, which will be available all the time. Also fire extinguishers will be available.

- Proper drainage channels will drain the uncontaminated rain runoff from the surfaces of the WWTP to the valley.

- In case of huge quantities of surface rain runoff entering the plant through the manholes on street level, the Municipality is supposed to take immediate action to stop the flooding by applying corrective measures.

- The vent for generated gases form the anaerobic digestion in the primary tank will be checked periodically to assure the release via the 3m long pipe.

- In case of structural failures caused by an earthquake to the sewerage network and to the WWTP, the spilled wastewater will be channeled properly to the runoff watercourse and the concrete structures will be repaired within a short time. Canalization at the site will take care of this incident automatically.

Additional environmental practices at the WWTP and the project area will include the following:

- Awareness campaigns will be carried out by the Municipality in order to raise the awareness of the households **in reducing the discharge of waste matter** in the wastewater stream. This will particularly emphasize the reduction of organic wastes intrusion through the kitchen sinks. It will also include campaigns on using proper screens to trap the particulate matter, in order not to overburden the BOD load of the WWTP.

10. Benefits that Justify the Implementation of the WWTP

The establishment of the WWTP in Rashaya will bring net ecological, economic, social and health benefits for the town and its inhabitants. It will achieve a secondary level treatment for the wastewater generated at household level.

The overall benefits of the project would be the following:

1- Ecological benefits will be obtained by:

- Turning the dangerous wastewater, that is currently being disposed into leaking septic tanks to a safe effluent that complies with the standards of MOE for safe discharge in nature or use for irrigation.
- Preventing the occurrence of water resources contamination and nuisance, which is caused by the current septic tanks overflow in the town of Rashaya.
- Increasing water availability by using the effluents for agricultural irrigation.

2- Economic development will be attained by:

- Realizing an appropriate, dependable and affordable wastewater treatment technology, which can be replicated by other municipalities in the region.
- Encouraging ecotourism in the project area.
- Saving the costs spent on emptying septic tanks .
- Saving the cost of excavating and building septic tanks under new buildings.

- Saving the cost spent on reinforcing building structures when soil becomes unstable due to septic tanks overflow.

3- Social and health benefits will be materialized by:

- Improving the health and living standards of the inhabitants, and
- Preventing the spread of diseases and mosquitoes.

4-Touristic benefits will be attained by:

- Protecting touristic areas from the overflow of wastewater odors and flies.
- Improving the aesthetic status of the town.

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12 -ANNEXES

Annex- 1: Public Hearing in Rashaya

Annex- 2: Related Documents

Annex-2.1: Documents Related to the Design of the WWTP

Annex-2.2: Legal Papers on the Status of Proposed Site

Annex-2.3: Maps of the Project Area

Annex- 3: Information Related to Small Scale Wastewater Treatment Technologies and Reuse of Wastewater

Annex-3.1: Wastewater Treatment and Reuse

Annex-3.2: Two Stage Trickling Filters of Grossimex

Annex-3.3: Advanced Integrated Wastewater Pond System (AIWPS) of IBC Co.

Annex-3.4: Bio-Process of Polytech Co.

Annex- 4: List of Individuals and Institutions Involved in the Preparation of the EIA Report