Terms of Reference

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I. General context

1: The context

Libya is a country located in North Africa on the southern side of the Mediterranean Sea with a shoreline on the Mediterranean of 1’955 km. Libya’s area is 1’759’540 Km^2 and it shares borders with six countries Sudan, Chad, and Niger to the south, Tunisia and Algeria to the west and Egypt to the east.

Benghazi city, the second largest city in Libya after the capital Tripoli, is located 1,043 km east of Tripoli. The city is the cultural and the economic center in the eastern part of Libya (Cyrenaica region) and has an estimated population of 750’000 inhabitants.

The city planning followed a radial concentric pattern with various ring roads and major radials that leads to the central business district in downtown, the planning of the city projected that the population of the city will be at 1 million by 2014.

1.1. Political and economic situation

Libya is currently divided between two governments in conflict with heavy clashes in Tripoli, the Interim government/LNA (Libyan National Army) controlling the East and South of Libya, while the GNA (Government of National Accord) controls the North West and center of Libya. The general situation in Libya is degrading with a security instability, a continuous degradation of services and an economic crisis (the market exchange rate LYD/EUR is approximately 3 times higher than the official exchange rate).

Currently the totality of the Benghazi and its surroundings is under the political control of the interim government and the House of Representative and the military control of the LNA (former Operation Dignity).

Clashes broke out in 2014 between Dignity operation and BSC (Benghazi Shura Council) to take over Benghazi city. The whole city suffered damages of various intensity, the heaviest clashes being recorded in the economic center of the city, composed of two neighbourhoods Al-Sabry and Downtown, which forced the residents to flee their homes until the clashes ended in July 2017 after Dignity took control over the two neighbourhoods.

These two neighbourhoods hosted most of the governmental bodies’ and private companies’ offices, banks, Benghazi sea port, central markets and Central Bank of Libya Benghazi branch. After the end of the clashes, and despite the spread of landmines and booby-traps, the numbers of returnees (people returning to their home) increased gradually.

Al-Sabry and Downtown are the oldest two neighbourhoods in Benghazi city and densely populated areas; most of the resident being middle class or poor families, working as governmental employees, anglers, technicians or workers. Situated in the city’s costal side, covering 20% of the city’s total area, their estimated population before the clashes was 181’397 inhabitants.

Economically Benghazi is an important trade and logistical hub in the country, despite the huge impact of the clashes on the local market and movement of goods due to the damages that occurred to the main facilities at the e port and airport. In terms of income the city’s population heavily depend on the government, as governmental salaries are the main income for more than 80% of the city’s households, accordingly a respective percentage of the city’s population facing finical challenges due to the ongoing lack of cash and late payment of governmental salaries.

1.2. Climate

Libya has three different climate zones, the desert climate, the Steppe climate, and the Mediterranean climate (see Figure 1).

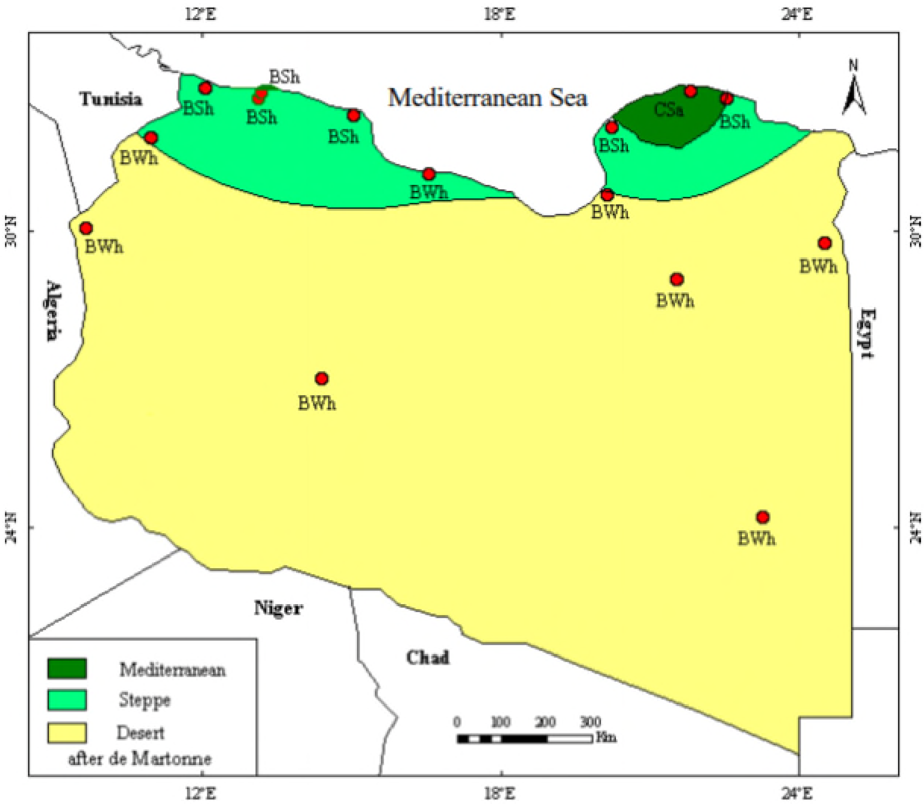


Figure 1: Climate zones in Libya.

The desert Climate zone is the dominant climate in most of the country occupying the southern part of the country and Sirte Gulf region, where the temperature varies dramatically between different seasons, with mean summer temperature of 30 C°, while mean winter temperatures are around 14.5 C° and annual precipitation less than 25mm. The relative humidity is low between 30% in summers and 45 in Winters.

The Steppe climate zone, which mostly found in the northern part of the country, with annual mean temperature of 20.1 C° and annual precipitation ranges of 100 to 350mm, with high relative humidity above 70%.

The Mediterranean climate zone, which found in the Green Mountain area and area around Tripoli city has a mean annual temperature of 16.5 C° and annual precipitation of above 500 mm.

In general, Libya receives less rainfall than other Mediterranean countries, the northern part of the country receives an average between 200 to 500 mm per year while the desert receives less than 25 mm per year. The wettest area in the country is Al-Jabal Al-Khadar; it receives 850 mm precipitation per year. 90% of the rain falls in the cold seasons (winter and fall). The number of rainy days ranges between one month to three months. The maximum daily rainfall in a day is reaching about 150 mm in the area around Tripoli. The humidity ranges from 31% to 96% over the course of the year, the lowest humidity is around the 1st of July, where the humidity drops to 39% three days out of four, and the most humid period is around 12th of January when it is exceeding 94%.

Benghazi city has a steppe climate with mean annual temperature of 25 C° (see table 1), an annual precipitation of around 270 mm (see table 29) and relative humidity varying between 55% to 61%. There are has two seasons: Summer from April to September, hot and dry with the highest temperatures usually registering in August. Winter is from October to March, cold and wet with the lowest temperatures and highest rainfall usually registering in January (Benina weather station report, 1984).

Table 1: Maximum and minimum temperature in °C in Benghazi between 1879 to 1984.[1]

Years		*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Avg.*
1879 - 1962	Max.	13.7	18.2	20.6	27.9	27.3	29.1	29.5	30.1	29.5	27.9	24.3	14.3	24.8
	Min.	8.8	9.2	10.2	13	15.9	18.7	20.6	21	19.3	17.2	14.3	10.7	14.9
1963 - 1984	Max.	16.6	18	20.6	20.3	31.2	32	31.5	32.2	29.4	27.9	23.4	18.4	25.1
	Min.	8.7	9	10.2	13.2	16.5	19.8	20.3	21	19.7	17.1	13.1	10.2	14.9

Table 2: Average of rainfall in mm in Benghazi area between 1879-1984.[2]

Years	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Annual*
1879 - 1962	67	40	19	5	2	-	-	-	3	-	46	66	265
1963 - 1984	63.1	41.4	27.1	12	3.2	0.4	-	0.2	3.5	23.5	35.8	61.1	271
Average	66.2	40.3	20.6	6.4	2.2	0.1	0.0	0.0	3.1	4.7	43.9	65.0	266.2

The climate change impact on the country, in general, is noticeable, with 0.5 C° increase in temperature since the 70s, and with a projected increase of 2°C by 2050, causing more frequent heatwaves and increase of drought days and 7% decrease of annual precipitation by 2050, with an increase in the intensity of rainfall events. (USAID, 2017)

1.3. Topography

There are six mountain ranges: Al-Jabal Al-Khadar (The Green Mountain) in the northern part of the country near east coastline with peak altitude of 882 m above sea level, Jabal Nafusa (Nafusa Mountain) in the western part of the country near Tripoli with peak attitude of 975m above the sea level, Tibesti Massif rises near the Chadian borders amid of the Great Sahara with an attitude of 2’200 meters above sea level, the Massif of Acacus Mountains to the south western border near Algeria, Uweinat Mountain in the south east near the Egyptian and Sudanese borders, and Bikki Bitti mountain south east of Libya near the Chadian border with an attitude of 2’266 meters above the sea level ranked as the highest point in Libya.

Benghazi city is located on the eastern coastal line of Libya 1’043 km east of Tripoli, on 32.7 Latitude and 20.5 Longitude. The city is built on a strip of land in the middle of salt marshes bordered by the Green Mountain to the North and East, eastern cost of Sirte Gulf to the south, the Mediterranean Sea to the north. The topography in the Benghazi area is relatively flat, underlain by limestones covered with clay, sand, and gravel. Karstic galleries present in the area with depths varying between 10 to 100 meters below the sea level. Benghazi plain is dissected by several valleys and streams that come from Al-Rajmah heights (Green Mountain) towards the sea. The highest point in Benghazi is 120 meters and located in 18 km to the East of the city center. The altitude decreases while going toward the sea. The waste water treatment plant (WWTP), located south of Benghazi at an elevation of 22 meters.

1.4. Water resources in Libya

Libya is one of the driest countries in the world where the desert dominates most of its land. The country has no running rivers, lakes, or any other renewable source of freshwater with sufficient quantities to establish settled agriculture; this was the main reason behind the Bedouin lifestyle of most of the Libyan population. Groundwater is the main source of water that covers most of the water demand in the country.

1 Benina weather station & Hadi Bulugma.
2 Benina weather station & Hadi Bulugma.

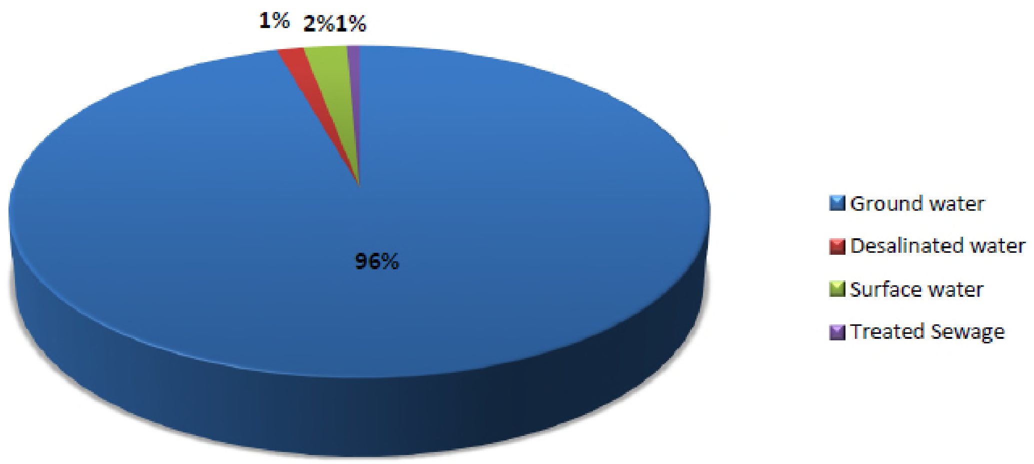


Figure 2: Libya's water sources According to FAO water report 2005

Benghazi has no running rivers, the discharge of water in the valleys lasts for a day or two, the water of valleys empties in the sea. Therefore, the city's water demand is mainly covered by groundwater.

1.5. Surface water

Libya has constructed storage dams to conserve surface water by storing runoff. These dams were mainly constructed in the northern part of the country and there are 16 dams with total storage capacity of 385 million cubic meter, and this water it has been mainly used for agriculture and livestock.

Table 3: Dams / reservoirs in Benghazi Area.

Dam	Reservoir Capacity (m^3)	Average Recorded Storage (m^3)
Wadi Qattara	$135x10^6$	$12x10^6$
Wadi Zaza	$2x10^6$	$0.8x10^6$

The area surrounding Benghazi has several valleys, although two dams have constructed, Qattara dam on Qattara valley (Wadi Qattara) 40km east of Benghazi, and Zaza dam on Zaza Valley (Wadi Zaza) 60km northeast of Benghazi.

Qattara dam is the biggest in Libya with a total designed capacity of 135 million cubic meters, along with secondary dams along Qattara valley, although the use of water retained behind the wall is very limited as a big part of the retained water is infiltrate to the ground and flow to the natural discharge points through the karstic formation that dominates the area.

1.6. Groundwater

Groundwater is the main source of water in Libya, which covers 96% of the water supply. It can be divided into two main parts, renewable water resources that are represented in the shallow aquifers, non-renewable water resources that are represented in the deep aquifers (fossil aquifers).

There are six Groundwater basins in Libya; some of them are shared with the neighbouring countries such as Egypt, Sudan, Chad, Niger, Algeria, and Tunisia:

- Kufra
- Sarir
- Al-Hamada Al-Hamra
- Murzuk
- Al-Jabal Al-khadar
- JIfarah

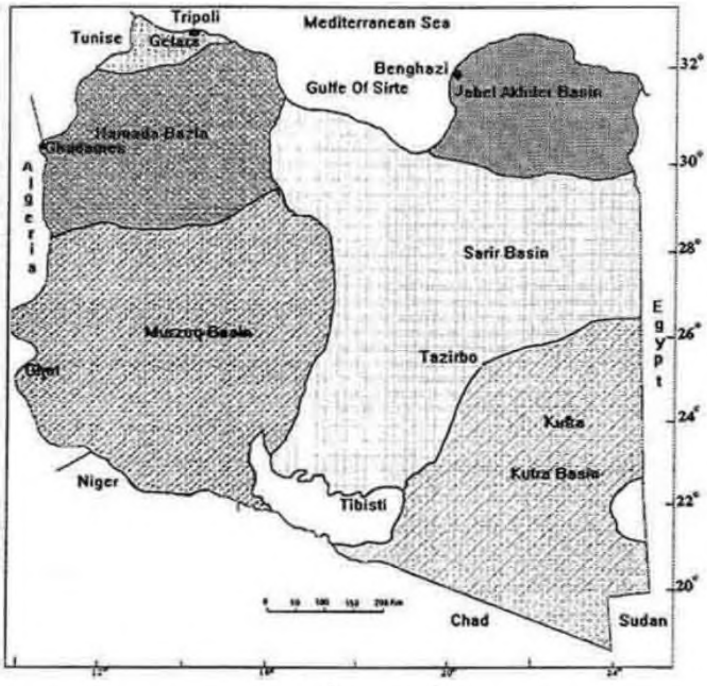


Figure 3: Libya's basins.

The costal basins, Jifarah and Al-Jabal Al-Khadar are relatively shallow and naturally recharged from rainfall, these basins were the main source of water for the major cities in the northern part of the country. In the last decades with the increase of the total population, and the developing economy in those cities, the water demands for agriculture, industry and domestic use increased significantly, and therefore the water level in those basins dropped and seawater intrusion increased.

Kufra and Sarir basins, also known as the Nubian Sandstone Aquifer, is the largest aquifer in the world covering around 2 million km^2 of the north-east Africa and it extends across eastern and south-eastern Libya. Libya shares it with Chad, Egypt and Sudan.

Al-Hamada basin is located at the northern part of Fezzan region up to the Mediterranean coast, its estimated capacity is 4'000 km^3. Murzuk basin is situated in Fezzan region, south-west of Libya, covering total area of 450'000 km^2 and containing 4'800 km^3.

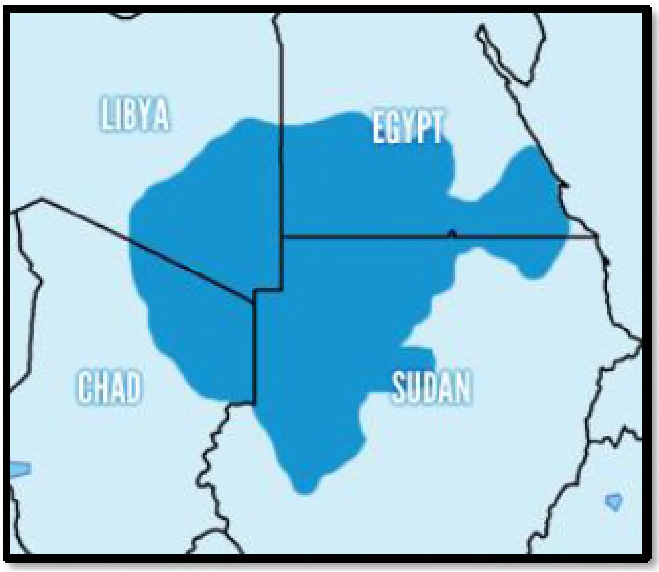


Figure 4: Nubian sandstone aquifer.

There is no surface water in Benghazi area; therefore, groundwater is considered as the main/only local source, although the available groundwater quantities are relatively small. The groundwater is available above a layer of saltwater; the water table descends from Benina area towards the coast to be equal to the sea level. The depth of groundwater in the northern part of Benghazi ranges from 100 meters near the mountainside to only 3-10 meters near the coastal line, while in the southern part ranges between 5-10 meters.

The groundwater reservoirs are recharged by the infiltration of rainfall and valleys' runoff, although the recharging does not take place every year, but only during heavy storms with intense precipitation.

Benghazi area is a plain underlain by limestones covered with clay, sand, and gravel. Karstic galleries present in the area with depth varying from 10 to 100 meters below the sea level. Benghazi plain is dissected by several valleys and streams that come from Al-Rajmah heights (Green Mountain) towards the sea. The water flows through the karstic formations from the high hydrostatic head in Al-Rajmah heights and Benina towards the natural discharge points, as the springs, lagoons, and lakes in the coastal area northeast of Benghazi. There are seven natural discharge points in Benghazi, such as Bu-Dizzera Lakes and Aïn Zayanah lagoon.

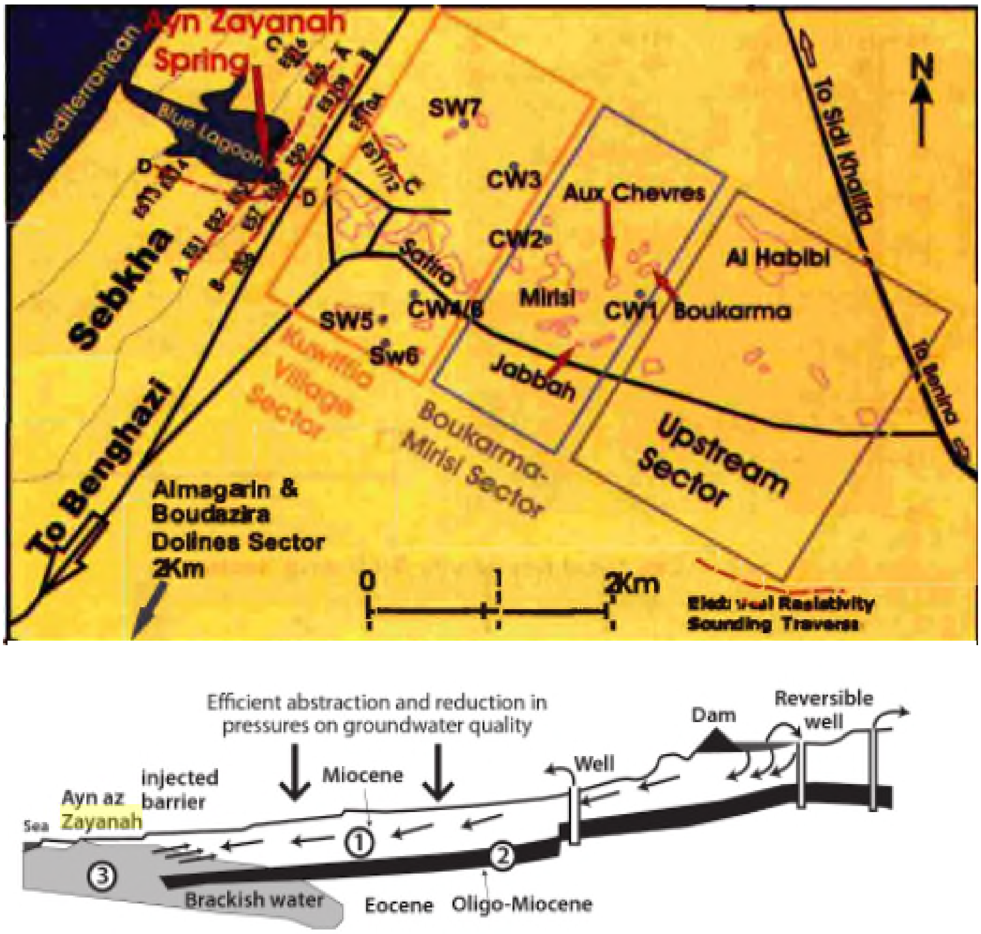


Figure 5: Benghazi Karstic system.

Figure 6: Benghazi lagoons and lakes.

The excessive extraction of groundwater in the coastal aquifer in Benghazi region, in addition to the poor recharge rate due to low annual precipitation and seawater intrusion, led to the deterioration of water quality which is reflected in the increase of T.D.S. Currently T.D.S in Benghazi city varies between 900 to 6,000 PPM depends on the distance from the coastal line and consumption.

In 1984, the ministry of agriculture restricted the digging of new production wells in Benghazi plain. However, after the outbreak of conflict in 2011, the area witnessed a rapid increase in the number of newly drilled private wells, especially in the areas not connected to Man-Made River.

1.7. Demography and population

The total population of Libya is 5’298’000 inhabitants according to the last official census in 2006; the estimated population in 2020 is around 7 million inhabitants, migrants form 12% of the total population (IoM, 2019), 68% of the Libyan population is less than 30 years old. The average size of the Libyan family is six members per family. The country has witnessed several waves of displacement due to the different clashes that took place in various cities across the past nine years, according to UNHCR the numbers of Internally Displaced People (IDPs) is 355’672 IDPs. (UNHCR, 2020)

The country has witnessed an influx of migration caused by the vast increase of human trafficking activities due to the deterioration of the security situation after the clashes in 2011 that translated into a doubling of migrant numbers. There were 655’144 migrants and refugees in October 2019 compared to 359’540 in 2006. Migrants in Libya comes from 39 countries. The majority comes from Libya’s neighbouring countries Niger (20%), Egypt (15%), Chad (15%), Sudan (12%). (IoM, 2019)

The population density in Libya is 3.38 inhabitants per km^2 with the highest concentration in the coastal line than the south. Tripoli is the area with the highest population density in the country, with 1’273 inhabitants per km^2. In contrast, Al-Kufra with 0.11 inhabit per km^2 is the area with the lowest population density in the country. (Authority, 2006)

Benghazi city is the second biggest city in terms of population density in Libya, with a population of 674’951 inhabitants, according to the last official census in 2006. An estimated population of 760’000 inhabitants, with an annual population growth of 1.65%, the average size of the Libyan families in Benghazi is 5.7 (6) members per family. The population density in Benghazi is 59.35 inhabitants per km^2. Although these numbers are rough estimations as the several changes and factors were not taken, as displacement and returning movement were not considered.

In 2014 with the outbreak of the clashes in the city approximately 195’028 of the city population were displaced. Since the end of the clashes in 2018 around 174’000 have returned to the city, with around 22’000 from Benghazi still displaced. On the other hand, the number of IDPs from other regions to Benghazi is gradually increasing especially after the outbreak of clashes in Awbari and Tripoli, although IDPs from Tawergah still form the majority of IDPs in Benghazi. (IoM, 2019)

Benghazi witnessed an influx of migrant population after the end of clashes in 2018, with the latest estimation representing 26’880 from January 2018. The majority of migrants in Benghazi are Egyptians and Sudanese.

1.8. Water and sanitation stakeholders

The organization of water and sanitation sector in Libya has witnessed continuous changes, especially in terms of operation, maintenance, and ownership. As a result, the sector saw the creation of new authorities, merging of others, changing mandates, and responsibilities, which caused instability, conflict of interest, and lack of long-term planning. All that had a significant impact on the quality of services, and led to the present sector’s chronic problems, deterioration of infrastructures, the limited technical capacities, and poor archiving of technical information.

As explained, the organization of Water and Sanitation Stakeholders in Libya is complicated; The stakeholders can be divided into two categories: the owners and the operators.

1.8.1. Owners

Ministry of Housing and Utility (MHU):

The Ministry of housing and utilities is responsible for the general policies for housing and infrastructure, besides supervising the different authorities and companies under its authority. The ministry is the main body responsible for the coordination of carrying out studies and researches for housing and infrastructure development to cope with the population growth. Several entities and authorities are working under MHU as Housing and Infrastructure Board and several Engineering consultation firms.

In the east MHU was replaced with Hosing and Infrastructure Committee.

General Water Authority (GWA):

GWA is the legal owner of all water in the country, GWA is responsible for:

- Setting the policies and legalizations of water and supervises it is implementation;
- Prepares studies and plans considering water resources;
- Supervise the implementation of water extraction projects, approve requests and licenses for drilling wells both for individuals or governmental entities;
- Keep the record of aquifers' data (production, water tables, and water quality);

GWA might be considered as the weakest part of the existing stakeholders as it is the oldest entity in the water sector, also the most affected body with the continues changes, especially that a significant part of its responsibilities and experienced staff were moved to other authorities. The most critical challenge to GWA is human resources, as GWA is no more an attractive employer for fresh graduate engineers and geologists due to low salaries and lack of building capacity programs, which left GWA aging with no fresh blood pumped in its veins.

However, GWA will remain an important source of old studies and information.

Housing and Infrastructure Board (HIB):

It is a governmental body founded in 2006, with its HQ in TRI and five branches around the country, HIB is responsible for preparing master plans and conduct engineering studies, designs, budget estimations, managing contracts for housing construction projects, infrastructure projects, preparing infrastructure projects general specification and final approval on infrastructure projects. along with contracting and supervising implementation.

Upon its establishment, HIB was directly under the prime minister office; later on, in 2014, it was moved under The Ministry of Housing and Utilities. Financially HIB budget comes directly from the government as it has no revenues. Currently, HIB role is limited to covering the technical aspects in specific cases.

HIB is considered as the main source of technical information related to existing and planned infrastructure. However, HIB does not have complete data as most of the latest studies and master plans were never completed due to the conflict.

Municipalities:

Up until the 80s; municipalities were responsible for operating and rehabilitating the water and sewage networks within their area of responsibility; after that, the file was centralized by the formation of the General Company for Water and Wastewater (GCWW); the municipalities nearly had no visible role in this file.

After the eruption of clashes in 2014, due to the political division and financial difficulties faced by GCWW, municipalities' involvement in the water sector started growing with support from the various governments and business people. Financial support by international organizations, in some cases, despite the municipalities' limited knowledge and technical capacities in this sector created technical problems, sensitivities, and conflicts of interest between municipalities and other stakeholders.

1.8.2. Operators

Man-Made River Authority (MMRA, former GMRA):

MMRA is the responsible authority of operating and maintaining the Man-Made River system, the most significant water supplier in the country; there are two branches of MMRA, one in Tripoli and the HQ in Benghazi.

MMRA is considered as the strongest and most stable entity in the Libyan water sector, with highly skilled and well-trained staff. During Gaddafi's era, MMRA was receiving unlimited funds from the government that gave MMRA staff access for training programs abroad.

General Company for Water and Wastewater (GCWW, former GWSCo):

GCWW is a company owned by the Libyan government, the HQ located in Tripoli, with eight different regional offices, and several service offices and centres operating under them.

GCWW is financially and administratively independent, although it was always working under the supervision of a higher authority. Before 2014, GCWW was under the ministry of local government in the west and National Water Resources Corporation in the east.

GCWW's responsibility is operating and maintaining water and sanitation systems, which include the treatment of water and sewage, also, to conduct the studies and enforce national standards to improve services.

Budget wise GCWW should be independent by law. GCWW is the authorized body for levying the bills for their services, however, the country does not have an existing billing system for water and sanitation services. The project of establishing a billing system by installing water meters started in the 2000s but was not finished due to the outbreak of clashes in 2011. GCWW's current budget is mainly coming from governmental support and revenues of water trucking and sewage discharge trips.

GCWW faces issues in managing the available resources, managing human resources, and building technical capacities, especially for the small offices in the remote areas. These remote areas received less attention from the central level. To tackle the centralization issue, GCWW decided to divide the country into eight regions, each regional office having its operational budget.

GCWW's major problem remains the capacity of its low-level technicians and operators. In the past GCWW had the financial means to either replace broken parts of the system with brand new ones or hire local or foreign companies to do maintenance and installation works. The two options are not available anymore due to the security situation and the inflation of prices in the local market.

General Desalination Company of Libya (GDCOL):

It is a governmental company founded in 2006 for managing and operating the eight desalination plants around the country that were built by foreign companies.

Budget wise GDCOL's primary source of income is the tariff of its service, which should be paid by GCWW, although due to GCWW financial problems, it was not able to pay tariff for GDCOL services, which left GDCOL to depend on the direct governmental support.

The ongoing political division and deterioration of security affected GDCOL's ability to operate and maintain the plants, mainly due to dependence on foreign experts in maintaining the plants, but also due to difficulties in importing spare parts and consumables.

Detailed Description of GCWW Benghazi Region

GCWW Benghazi region depends on GCWW Headquarters in Tripoli regarding salaries and operational budget.

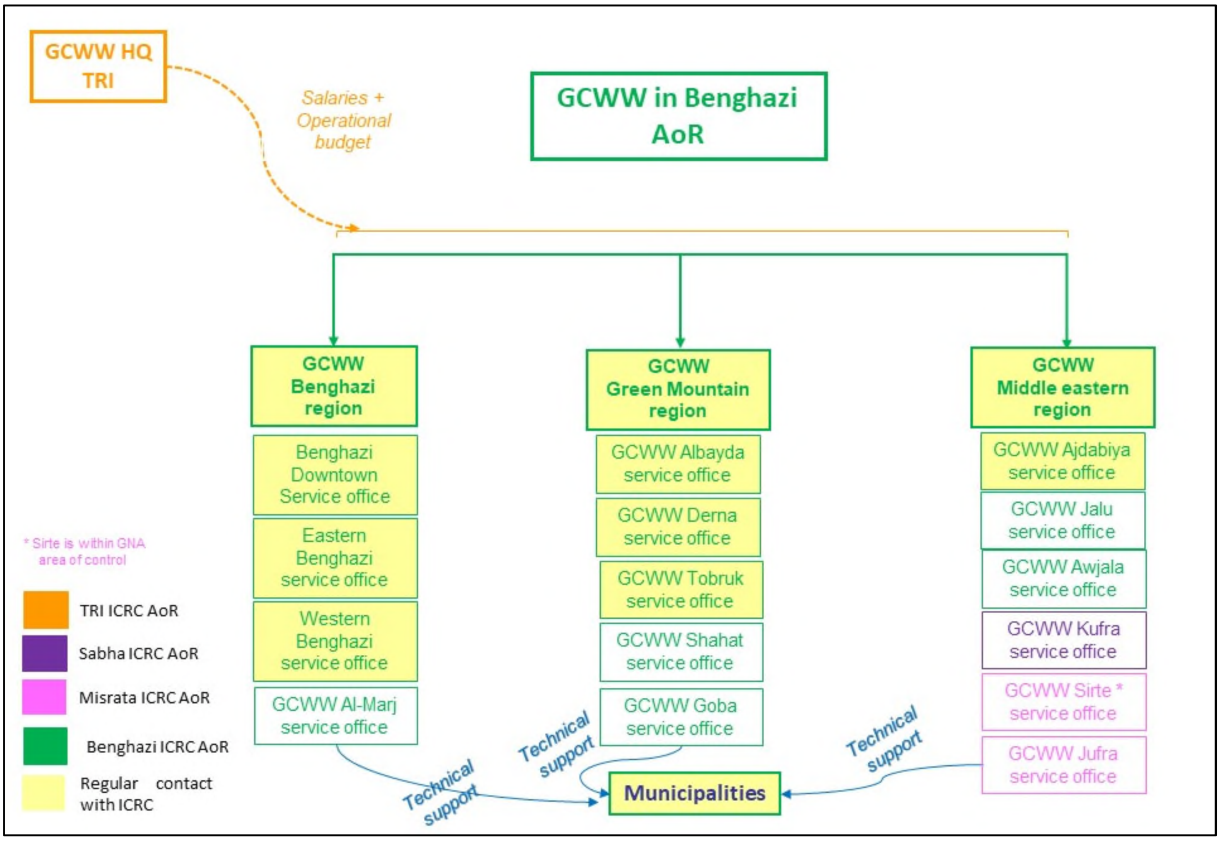


Figure 7: GCWW organigram in Benghazi AoR.

GCWW Benghazi region is one of the biggest GCWW regional offices in terms of the population as its covering nearly above 50% of the population of the eastern part of Libya.

Structure wise GCWW Benghazi region is divided into four service offices (see Figure 7). Technically each service office is managed independently with administrative and technical staff and assets such as water trucks, sewage trucks, and heavy machinery, assigned by the regional office to ensure the continuity of service within the administrative borders of each service office. Three service offices cover Benghazi city and its outskirts, which is the targeted area of the sanitation master plan.

GCWW work force is diverse in terms of technical backgrounds, with employees from different engineering backgrounds, mainly mechanical, civil and electrical engineering, with tens of operators and technicians such as plumbers, welders, mechanics, and electricians. However, due to the low salaries and weak capacity building programs, GCWW does not attract fresh, highly skilled engineers or technicians, which left the company nowadays facing a severe issue of aging, especially for technicians and operators.

Financially GCWW Benghazi region heavily depends on financial support from HQ, mainly for operational budget and salaries, in addition to the limited revenues that coming from services provided to the population (water trucking, sewage discharging and flushing). However, due to the financial crisis which GCWW HQ is facing, they are forced to limit the operational budget transferred to the regional offices and prioritise salaries instead. Including inflation, Benghazi regional office is forced into debt to purchase spare parts and consumables.

GCWW Benghazi region was profoundly affected from the clashes that took place in the city between 2014 to 2018, which caused massive damages to the company's infrastructure, assets, and stocks that stretched the companies already limited resources.

The limitation of information has always been a significant challenge for GCWW in managing the systems, especially wastewater and storm water networks. GCWW put together a team of five staff to work on the mapping and the diagnostic of the wastewater and storm water networks. This team is highly motivated and managed to build a database for a large part of the city's wastewater and storm water networks. However, the team is facing some constraints to enable a proper mapping of the networks due to a lack of GIS skills and required equipment, for which ICRC is currently supporting GCWW by providing GIS training, GIS software license, and mapping equipment.

2: Current situation of sanitation system

2.1. Existing water supply infrastructures

2.1.1. Production

As mentioned above, the main water resources in Libya is groundwater (approximately 96%); other sources such as desalination plant and surface water have a minor contribution to the general water supply.

According to GWA the annual water needs for Benghazi city and its suburbs is 212 million cubic meters, divided to 51 million for domestic use and 161 million for agricultural and industrial activities, around 50% of it is covered by MMRA, while the remaining is covered by local groundwater, GCWW wells (Public wells) and private wells. (GWA, 2006)

MMRA:

MMRA is the main water supplier in Libya; the implementation of the project started in 1984. The GMMR is a network that supplies water to cover the needs of 80% of the Libyan population living in the major cities in the narrow coastal strip in the north. It corresponds to several well fields in the desert, a network of 4'000 km of 4m diameter pre-stressed concrete pipes and various pumping stations and other infrastructure alongside the network. The water used for domestic and irrigation purposes.

The GMMR system is composed of 5 phases.

1. Phase I (Sarir – Sirte/Tazerbou – Benghazi).
2. Phase II (Jabal Al Hassauna – Jifarah)
3. Phase III (Qurthabeia **–** Esdada)
4. Phase IV (Ghadamis – Zwara) *(Not finished)*
5. Phase V (Tobruk) *(Cancelled)*

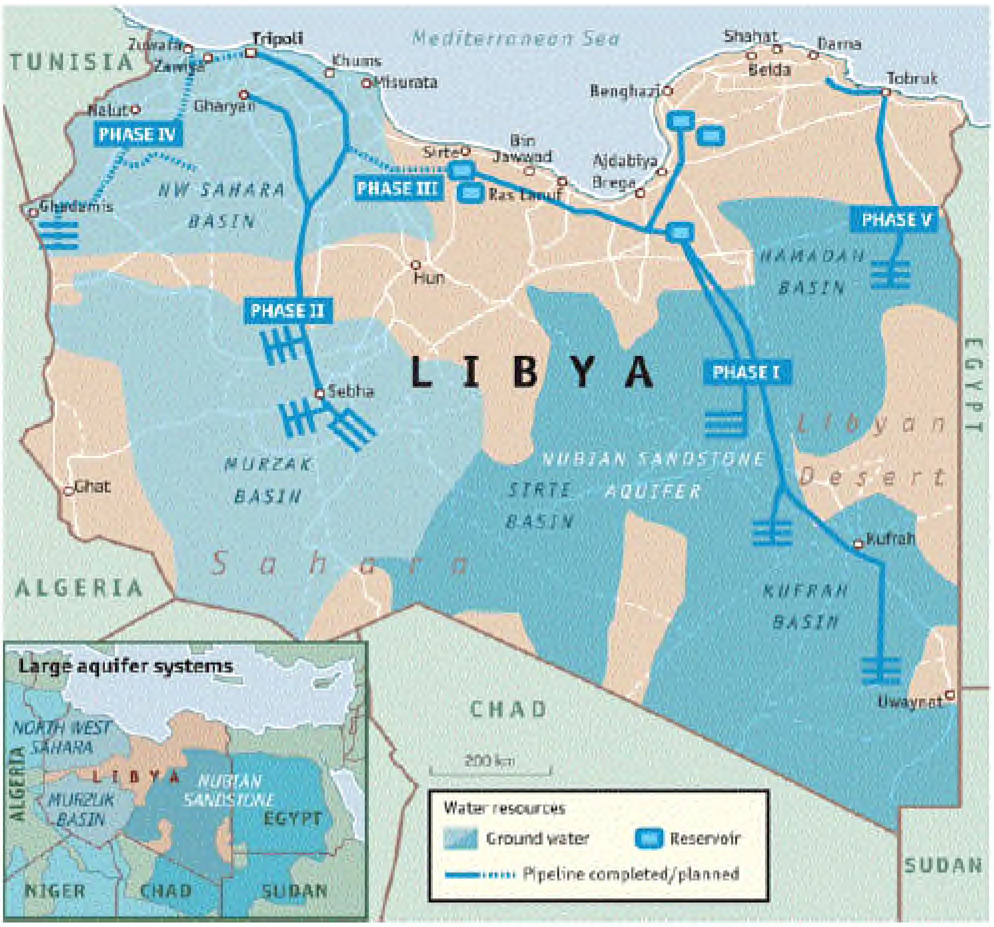


Figure 8: MMRA System (source Wikipedia).

MMRA in Benghazi

MMRA 1st phase consists of well fields in Sarir and Tazirbu, supplying the main collecting (storage) reservoir in Ajdabiya and from there to the other reservoirs in Benghazi and Sirte. There are three main sites for MMRA around Benghazi:

- Al-Talhiya site, supplying water to Benghazi by gravity;
- Grand Omar Mukhtar reservoir used for irrigation;
- Suluq site composed of:
    - o Omar Mukhtar reservoir used mainly for irrigation;
    - o Suluq pumping station pumping water to Al Talhiya reservoir.

Figure 9: Satellite image of MMRA system in Benghazi area

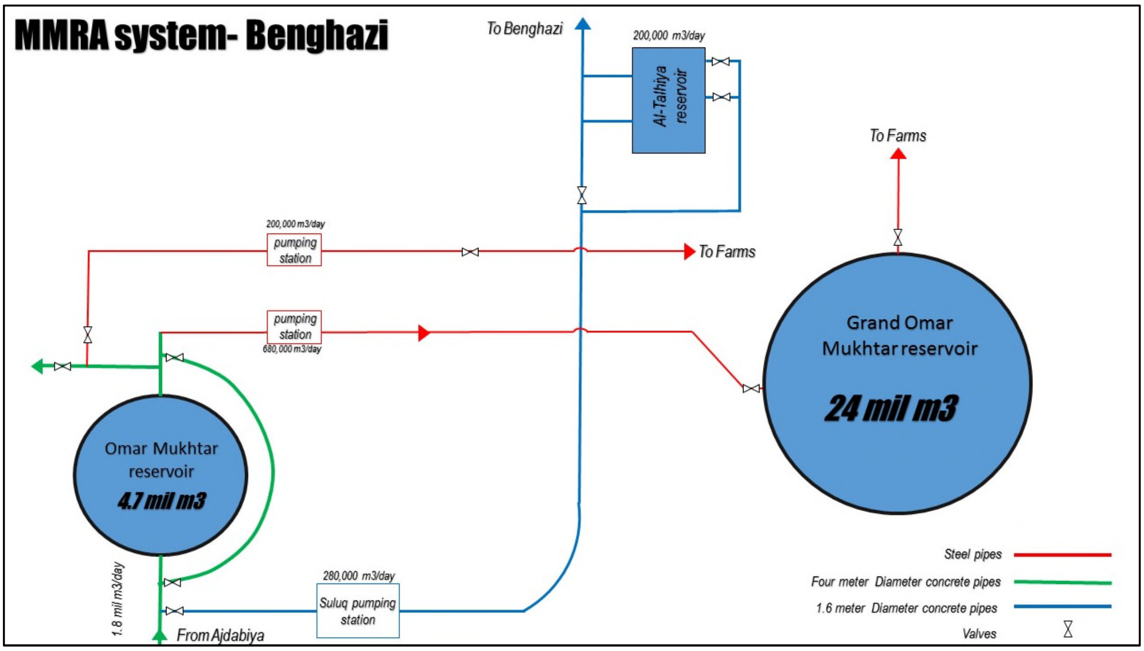


Figure 10: schema of MMRA system in Benghazi area

On average, MMRA is supplying Benghazi city with 288’000 m^3/day (the quantity can reach up to 300’000 m^3/day during summer time) through a network covering approximately 80% of the Benghazi population. According to MMRA, a high percentage of this quantity is being lost due to the many leakages in the city network, however due to the lack of measurement equipment, it is impossible to determine an estimation more precise than an approximate range for the leakage rate.

Benghazi city is very vulnerable to an interruption of service of the MMRA, either for a short or long term. In this regard, the ICRC is implementing the installation of a backup generator, table to power half of the pumping capacity (minimum required by the system to operate), to ensure water supply during power blackouts.

GCWW well fields

GCWW has several well fields around the city (see Table 4). These wells were the main source of water supply to the city before MMRA started pumping its water to Benghazi; currently, these wells supply the city suburbs and neighbourhoods not connected to MMRA, although these wells’ contribution to the water supply of Benghazi city have decreased significantly, due to the deterioration of water quality, lack of regular maintenance and conflict damage.

Table 4: GCWW operated well fields around Benghazi.

Well field	Designed capacity (m^3/day)	Current situation
Benina Well fields	60’000	Partially working (high TDS, sewage contamination, conflict damages, technical issues)
Sidi Mansur 1	30’000	Out of Service (conflict damages and technical issues)
Sidi Mansur 2	30’000	Partially working (conflict damages and technical issues)
Sidi Khalifa	5’000	Partially working (high TDS and technical issues)
Al-Kawayfia	3’528	Partially working (high TDS, Sewage contamination)
Al-Hawari	4’284	Partially working (technical issues)
Serat Najem	5’688	Partially working (technical issues)
Total	138,540	

Technical issues refer to problems related to pumps, control panels, electrical supply, or pipelines. The current production of well fields is not available, due to instability of operational conditions (availability of electricity & human factor), continuity of technical problems, and absence of measuring devices.

Private wells

Due to the deterioration of the security situation and the continuous disruption of MMRA services, GWA was not able to maintain the ban of digging new private wells in the area. Therefore, most of the newly-drilled wells were not registered; thus, there is no data for the private wells in the area.

However, in terms of the geographical distribution of the private wells in Benghazi city, they are concentrated in the city’s suburbs and neighbourhoods in the eastern and northern parts of the city.

2.1.2. Distribution

MMRA is the main water provider for Benghazi city, while GCWW is responsible for distributing, operating, and maintaining the network.

Most of the neighbourhoods are connected to the city water network, which has been built between the 60s and 70s, mainly from ductile iron pipes with diameters varying between 100 mm to 900 mm. Due to the lack of regular maintenance, the absence of capacities for leak detection, in addition to the severe damage to networks in some neighbourhoods caused to the clashes, the network has suffered continuous deterioration. The leakage rate estimated between 40% and 70% based on the two assumptions below (minimum and maximum leakage rate possible):

- MMRA calculation considers that the actual need of water for BEH should not exceed 210'000 m^3/day, which is equivalent to 280 l/person/day. This calculation has been made based on the 2006 census, where BEH population was 750'000 inhabitants. It corresponds to a 42% leakage rate. However, the consumption hypothesis per inhabitant is very high, and there are only little industrial activities still functioning in Benghazi to support this hypothesis.
- If a lower consumption per inhabitants of 150 l/person/day is considered (average consumption in urban areas in Europe), then the leakage rate corresponding would be 69%.

Since November 2017, ICRC has assessed the water and sewage networks and supported GCWW with pipes, fittings, and pumps to rehabilitate part of the water network. GCWW implemented the rehabilitation works, reconnecting part of the city network, which was destroyed during the clashes and increasing the pressure in the main network.

GCWW foresees a reduction of clean water available due to increasing leakage rates and a reduction of the production capacity. Therefore, to ensure access to water for all neighbourhoods in the city, GCWW may have to impose a zoning distribution during certain periods in the future. In this regard, GCWW is aiming to update its water supply network mapping with an objective to eventually create hydraulic modelling of their water supply network to be able to enforce an efficient zoning system.

2.2. Existing sanitation infrastructure

2.2.1. Collection network

The construction of the sanitation system in Benghazi can be divided into three phases; the 1st phase started in 1961 upon the oil discovery. This phase included the building of networks and pumping stations in the city centre, besides building a WWTP in Al-Qawarsha area south of Benghazi. The 2nd phase began in 1973 with preparing a master plan covering the sewerage and sewage treatment to 2014, followed by the construction of networks and pumping stations, in addition to the extension to the existing WWTP and building a new treatment plant north of the city. The 3rd phase started in 2009 with preparing a master plan and preparing designs for renovating, maintaining, and extending the sewage network to include the rest of the city. The maintenance and renovation works have started, although they were never completed due to the outbreak of clashes in 2011.

The city sewage and drainage system were designed in two separate networks, wastewater network (sanitary sewer) and storm water network, connected to several pumping stations, wastewater pumped to WWTPs, storm water pumped to the sea through ten box culverts with a maximum size of 10 square meters with various lengths between 2.5 km to 12.8 km connecting the city to 12 marine outfalls. The city sewage and drainage system are covering approximately 40% of the city. The designed flow capacity of the wastewater network is 280 liters/day per capita.

Wastewater network built with pipes from different materials, asbestos pipes, and GVC pipes for gravity lines, and cement and ductile iron used for pumping lines, the diameters vary between 200 mm and 1,400 mm for main and collection lines, and 150 mm for household connections. The drainage network is built with pipes from different materials with a maximum diameter of 2000 mm.

As mentioned, Benghazi is generally flat, the land descends towards the sea. Sewage can be carried by gravity, except for the central and northern neighbourhoods where pumping is needed to lift wastewater from these low areas to the main lifting stations and WWTP. There are 28 pumping stations within the network, which normally pump wastewater to Al-Qwarsha treatment plant. However, this plant is out of service, and therefore, the waste and storm must be pumped directly to the sea through several sea outfalls.

The separate system delivers the sewage and storm water to two separate chambers of the pumping stations. However, some of the houses have illegally connected their sewage to the storm water network. The current operation of the network can be compared to two combined (sewage and storm water) systems installed in parallel.

The 28 pumping stations are out of service, even though they have been under renovation and redesigning contract with KSB, which started in 2008. KSB was able to complete the civil works and to install control systems for most of the pumping station. Unfortunately, due to the increase of hostilities and the deteriorating security situation after 2011, KSB was not able to install the pumps and restore proper operation in any of the pumping stations. Most of the sewage pumps supplied by KSB and stored in GCWW warehouse were destroyed after a shell landed in GCWW warehouse in 2017. The rehabilitation contract with KSB is currently on hold but not terminated, despite the different governments' efforts to terminate or resume the contract.

The pumping stations are technically still under KSB responsibility. However, the urgent need to discharge wastewater and storm water out of the city forced GCWW to operate the systems despite the uncompleted works, using dewatering pumps and sewage submersible pumps as a temporary solution.

In addition, the sewage system in several neighbourhoods of the city (especially Al-Sabry and Downtown) was severely damaged during the clashes, which caused extensive sewage flooding in the lower part of the city.

2.2.2. Treatment

Al-Qwarsha WWTP is the only wastewater treatment facility for Benghazi city, as the second WWTP that should be built in the north of Benghazi, specifically in Al-Kawafiya area, has never been built.

According to its initial design, the WWTP is designed to use an activated sludge process and is composed of seven sections, with a design treatment capacity of 27’000 m^3/day for each section. In the past, only two sections have been functional.

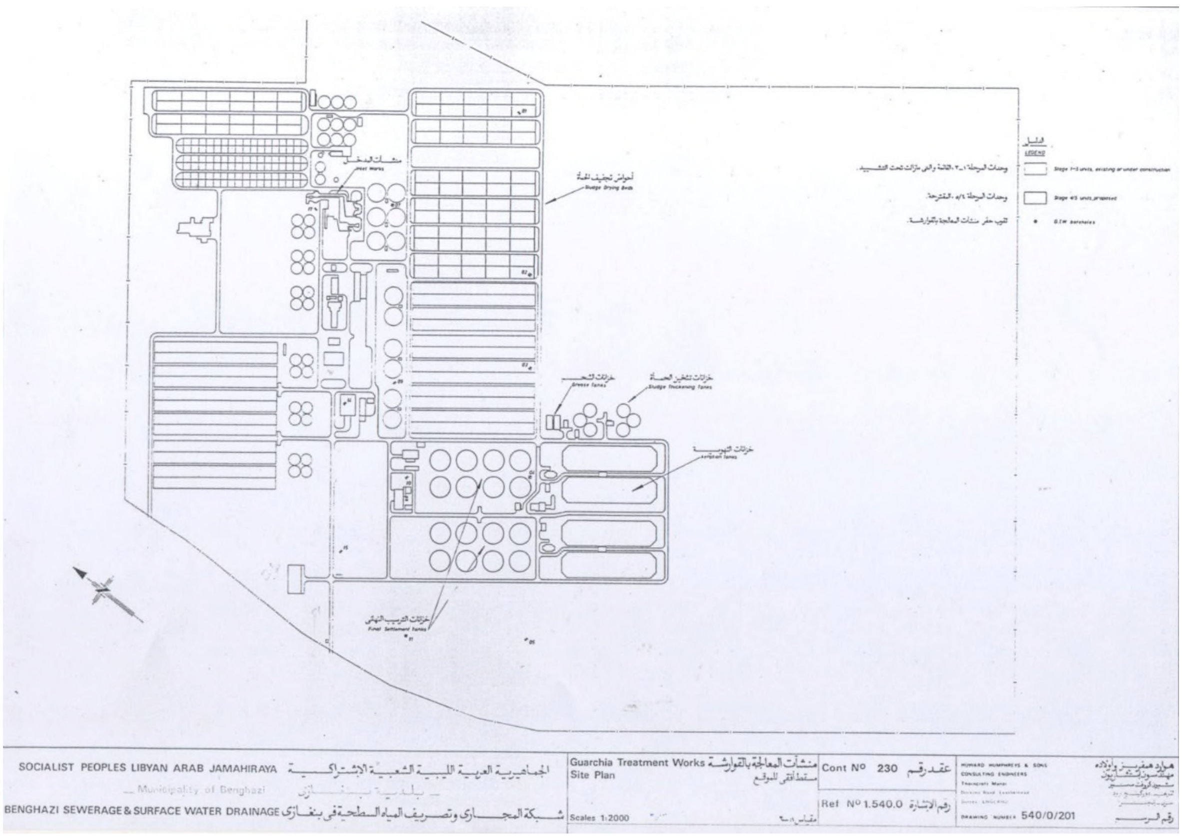


Figure 11: Layout of Al-Qwarsha WWTP

A rehabilitation project of the WWTP started in 2000. The old installed electro-mechanical equipment was dismantled, the rehabilitation civil works were completed but the new electro-mechanical equipment was supplied but never installed and eventually looted after the revolution. Therefore, the WWTP is currently by-passed and there is no treatment of wastewater in Benghazi.

2.3. Electricity in Libya

2.3.1. Power supply and electrical network

The General Electrical Company of Libya (GECOL) is the sole electrical producer and supplier in the country; its current production capacity around 6,766 MW. The cost of electricity in Libya is 31.7 Dirham/Kwh, as the government subsidizes fuel for power plants. GECOL owns 15 power plants in different locations around the country. The average annual consumption per capita is 4,390 Kwh.

The conflict and security instability affected the national electrical system, causing deterioration of services, translated in disruption of electrical supply, blackouts, and increase of cut-off hours. Caused by direct damages and looting to the electrical system component, in addition to the lack of regular maintenance to power plants and all production expansion projects that got suspended after the breaking out of clashes in 2011.

The whole of Benghazi is covered by the electrical grid, which is relatively in good condition; the city and its surroundings are connected to two power plants, Northern Benghazi Power Plant and Zwaytina power plant, both with an estimated production of 1.75 MW. As for the rest of the country, the city witnessed several power blackouts during the past few years, with an average of 10 days of without power per year and a maximum duration of 24 hours per blackout. In addition to voltage instability in the cities suburbs and surrounded villages.

II. Scope of the Intervention

The aim of the Benghazi Sanitation Master Plan is to have a long-term planning tool for investments in sanitation in Benghazi leading to efficient wastewater and rainwater drainage networks capable of evacuating waste and storm water, and thus reducing nuisance and water-borne disease vectors in Benghazi. It is expected that this document will assist authorities to seek and acquire the financing necessary to carry out the investments in order of priority.

Due to current security situation, movements in Libya are restricted and the ICRC doesn't expect the Consultant to be present on site. Therefore, the ICRC supported by the local authorities will take over the role of local partner to the Consultant and provide all required data and information to the best of its abilities.

1: Generalities

In the framework of this project, ICRC aims to support GCWW to improve its waste and storm water service provision by developing a master plan.

As mentioned above, parts of the sewage system were severely damaged during the clashes. In addition to the non-functioning waste and storm water pumping stations, extensive sewage flooding occurred regularly in the lower part of the city. As temporary solution, GCWW uses portable solids-handling dewatering pumps, made by Italian manufacturer VARISCO, to keep the system running. The pumps ports diameters vary between 4" to 12", with average of 2 dewatering pumps in each pumping stations, one as a main pump and the other as a back-up to be used during peak hours.

GCWW was not able to evacuate the sewage safely using their available dewatering pumps, due to the shortage of functional pumps in stock. ICRC supported GCWW in March 2020 with the supply of additional dewatering pumps, spare parts, hoses and fittings to increase the dewatering capacity. In addition, the Municipality of Benghazi also donated 16 sewage submersible pumps (Q=550 to 750m^3/h, H=12-18m) to GCWW in January 2020.

The conditions in the lower parts of the city remain vulnerable due to dysfunctional dewatering pumps, especially taking into consideration the growing number of returnees moving back to the area of Sabry and Downtown. Furthermore, the recent increase of supplied water (due to repair on the water supply network implemented by GCWW) will eventually lead to an increase in the quantities of wastewater flow in both storm and waste water networks.

There is an urgent need to ensure the evacuation of wastewater from these built-up areas to prevent further untreated wastewater from flooding into the streets and nearby homes.

The actions taken so far by the ICRC were aligned with the delegation priorities in terms of: emergency preparedness and response; supporting local partners and strengthening their capacities; and safeguarding public health. However, the general wastewater situation requires further action to reach a sustainable long-term solution, as the ICRC projects currently being implemented only represent short-term emergency solutions, tackling the immediate consequences on public health of the failure of the sewerage and drainage networks, but does not appropriately address the root causes of the issue.

The support from ICRC to GCWW should therefore entail the complete rehabilitation of the pumping stations and network. While the completion of the master plan will enable funding for the project's implementation to horizon 2040 to be sought, the process of data collection will enable ICRC to carry out remedial works where necessary.

The diagram below explains the three steps which should be undertaken:

Over the past years, GCWW collected and cross-checked information on the wastewater and drainage system with site investigations. Using these data, they updated their existing network drawings (DWG format) and created a sanitation network database alongside, containing all the technical information related to their network (manhole and collectors data). A display of the sewage network and storm water network in GIS-format is available.

2: General Objectives

The general objectives of this study are:

- The diagnostic of the existing networks and equipment for the drainage of wastewater and storm water including the identification of dysfunctions in terms of wastewater (dimensioning, unsanitary discharge, insufficient treatment, etc.) and rainwater (dimensioning, urbanization, flood zones, storm basins, discharges, etc.) but also problems of mixing of the two types of water and, if appropriate, the establishment of solutions that can be provided for the separation of these waters.
- Renewed study of sanitation needs in Benghazi and the surrounding areas with a planning horizon of 2040 as well as an intermediate horizon of 2030 proposing solutions for wastewater and storm water systems;
- The definition of technical, operational and financial provisions to propose the best possible solution and at low cost to the problems posed by the collection, transport, treatment, discharge, reuse and storage of wastewater for the whole study area.
- The development of an investment program proposed for possible financing by institutional partners for the intermediate horizon to 2030 as well as for the final horizon for 2040;

The purpose of the project is to provide the city of Benghazi with an effective planning tool for wastewater and rainwater management, and to define the appropriate technological options according to the different districts of the city of Benghazi with the aim of optimizing investments.

3: Geographical area to cover

The project area covered by this Sanitation Master Plan is the one of the city of Benghazi with an area of 66.5 km^2, the exact delamination is subject to change (see Figure 12).

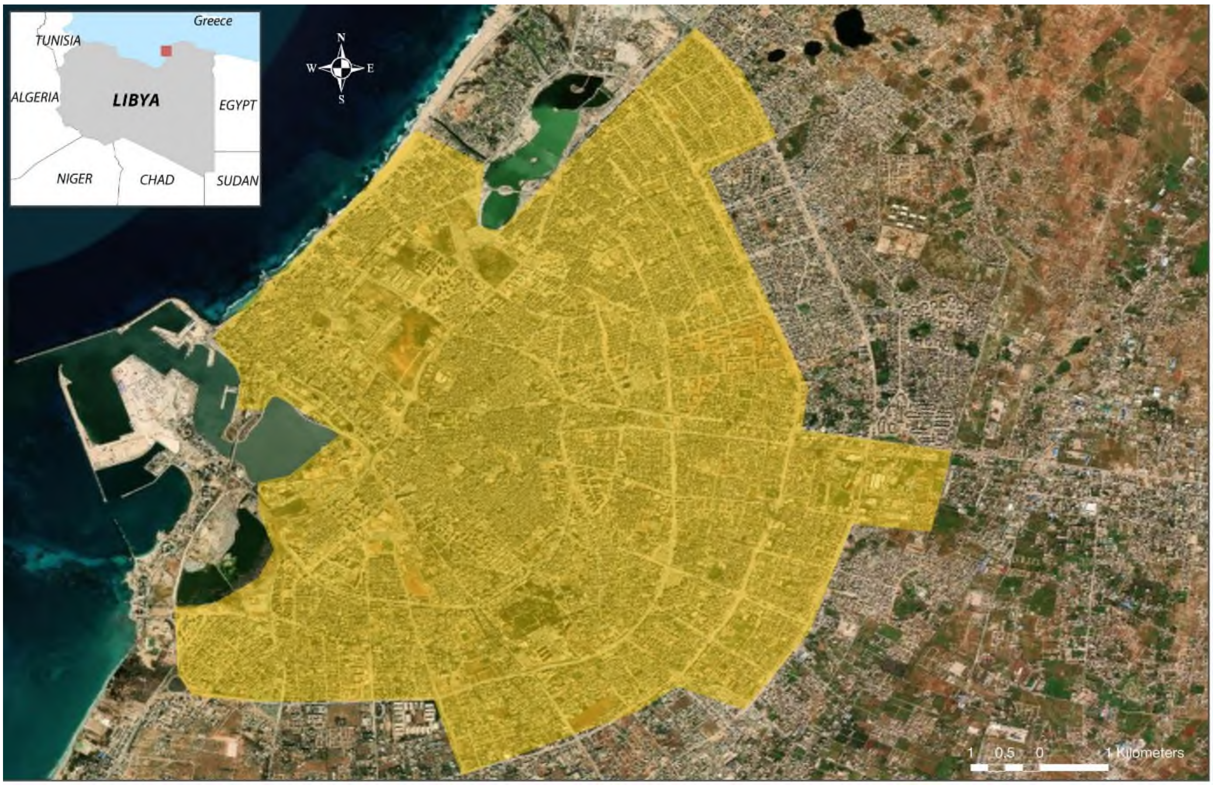


Figure 12: Study area (subject to change).

For the optimization of the overall scheme of wastewater treatment as well as the management of sludge and the discharge and reuse of purified water, the Consultant is invited to consider the bordering neighbourhoods if technically desirable.

4: Planning horizons

The study will have as final planning horizon the year 2040.

The technical and financial forecasts will be defined for the horizons:

- Short term (intermediate) 2030.
- Long term 2040.

Each horizon and interval between them will be the subject of a priority analysis of the projects and works to be carried out for the achievement of the objectives fixed at the final horizon according to the criteria of urbanization, existing infrastructure, and environmental and socio-economic impacts.

III. Description of Missions

A kick off meeting in Tunis organized (venue, lunch coffee breaks etc.) by the Client shall be held to agree on general approaches and methodologies to be utilized in the development of the study. The Client will take the responsibility for the transport and for the accommodation of the Libyan participants. The Consultant will take responsibility about theirs.

Given the current context, the study is divided into four missions, which should be carried out successively. The different missions subject of this study contract are as follows:

- Mission A - Data review and consolidation,
- Mission B - Elaboration of design criteria, hydraulic modelling of existing infrastructure and growth scenarios for different horizons
- Mission C - Development of possible variants for the sanitation of Benghazi.
- Mission D - Benghazi Sanitation Master Plan

The Client and local partners will perform the requisite field work for the completion of the missions as directed by the consultant.

MISSION A: Data review and consolidation

The objective of mission A is to gather all relevant baseline data for the completion of the Sanitation Master Plan and create a GIS database containing all information collected for the study.

A.1. Stage 1 – Existing data analysis

Tentatively, the following data and documents will be provided to the Consultant for review and critical analysis:

- Network plans, plans of existing and planned works and installations (current and / or planned projects), existing sanitation systems (number of private, public, industrial connections, etc.);
- Cartographic data: Up to date satellite image (DTM of Benghazi city with 1 m precision, December 2019);
- Pollution and water quality data;
- Climate and hydrological data of the region, (pluviometry data, Intensity-Duration-Frequency (IDF) curves, etc.)
- Urbanization and urban development;
- Demographic data of the region (census 2006);
- Geology and hydrogeology of the study area, catchment areas and protection perimeters;
- Agricultural activities in the region and studies concerning agriculture, geology and soil (pedology, permeability, infiltration capacities, etc.);
- Industrial activities, their effluents and studies concerning their discharges;
- Water use (consumption, production, etc.);
- Basic institutions within regions such as hospitals, schools, dispensaries, administrations;

The Consultant will compile a bibliographic collection of all documents made available to them. This list will include, as a minimum, the title of the document, its year of publication (if applicable, last revision index) as well as the author. The documents will be classified in the list according to their object (master plans, development and town planning diagrams, wastewater networks, storm water network, meteorological and pluviometry data, etc.).

Furthermore, the Consultant will review and analyse the documents provided, to assess whether the information is sufficiently complete and consistent for the study. Shortfalls in the studies, inconsistencies and other uncertainties will be highlighted.

In anticipation of the analysis to be carried out in this study, the Consultant will devise a list of remaining information to be acquired as well as data collection methodologies for each.

The above information will be compiled into an inception report with a complete bibliographic review to be presented two weeks later at a first feedback meeting for the mission in Tunis, organised by the Consultant.

A.2. Stage 2 – Support for additional data collection

Following the presentation of the available and missing data at the first feedback meeting for Mission A, further field investigations will be carried out to complete the required data for the study.
At this stage, it is expected that these investigations would last around 6 months and include:

- Information gathering from partners,
- Visual inspections of the network,
- Visual inspection of the inspection chamber,
- Cleaning and endoscopy of the network,
- Flowrate measurements,
- Topographic surveys,
- Assessment of GCWW facilities (pumping stations, treatment plants, etc.)
- Wastewater sampling and analysis.

In order to ensure the usefulness of these investigations, the Consultant will:

- Clearly define the required information,
- Propose data collection methodologies,

- When needed, support with the development of terms of reference for local contractors or consultants.

Equipment currently available for investigations includes:

- Flushing truck with hoses and jetting
- Digital Terrain Model DTM (1 m precision).

ICRC is procuring the following items, which should also be available at the time of the investigations:

- 5 Ultrasonic flow meters.
- 1 Automatic waste water sampler.
- Sewer portable video inspection system.
- Stecto Catch Basin Cleaner or similar.

Should any essential data collection require additional equipment, the Consultant will be responsible for the definition of their specifications.

The Consultant will regularly monitor the progress of the data collection investigations, assess the quality and reliability of the results and, when required, propose improvements and adjustments.

A.3. Stage 3 – Data compilation and context presentation

Upon completion of the field investigations, the following information will be presented at a second feedback meeting for the mission in Tunis, organised by the Consultant:

A.3.1. Institutional and regulatory framework

The study will identify any institutions and stakeholders that are relevant to sanitation services in Benghazi, presenting organigrams, responsibilities, etc. that explain the organisation of the sector.

As Libya is currently governed by 2 entities (LNA vs GNA), the Consultant should expect to be confronted with several entities with competing mandates. While it is not foreseen that this will create major differences between regulations, it is likely to have created a complex and partially dysfunctional institutional framework.

National and/or local legislation and regulations that apply will be identified and the relevant contents (discharge quality, quotas, etc.) will be highlighted. If such regulations are missing, the Consultant will rely on international regulations and common practice.

A.3.2. Environmental and hydrological data

The study will identify all receiving environments (natural marine environment, lagoons, etc.), their use (swimming, fishing etc.).

The study will detail the main effluent discharge points (raw, treated waste water, storm water weirs, etc.) and draw up a vision of the pollution discharged into natural environments. Finally, the study will establish the current water quality of the receiving environments and its evolution over time.

The Consultant will also present of the climate in the Eastern region (temperature, rainfall, sunshine, wind force and direction, air humidity, etc.) from the national meteorological services (rainfall, curves IDF, return periods, etc.) and deduce the expected storm water that will need to be handled.

A.3.3. Urbanization

Based on the documents provided the Consultant will establish the spatial distribution of the current population based on official neighbourhood delimitation following the type and mode of urbanisation and the percentage of land use, locate these neighbourhoods within the drainage basin of the system and specify the factors likely to influence the design, implementation and maintenance of sanitation infrastructure.

A.3.4. Demographic data

It will be a critical and comparative analysis of existing information on the demography of the Municipality of Benghazi and its spatial distribution. This critical analysis will be based at least on the last existing censuses as well as on information concerning the rate of demographic growth as wells as considering socio-economic factors such as educational attainment, occupation, income, wealth etc.

A.3.5. Water consumption and wastewater production

Based on the results of the urbanization analysis, the Consultant will propose estimates of drinking water consumption (average and peak) that are as realistic as possible by type of urbanization and determine subsequent the population equivalent (PE) of wastewater discharge by type of user (domestic, industrial, agricultural, administrative, etc).

The analysis should consider both average and peak production from all water sources for which data is available (MMRA, private wells, etc.)

The analysis will also estimate pollutant loads (BOD5, COD, TSS, NTK, N-NH4, TP etc.) transiting in the system.

A.3.6. Polluting industries

The Consultant will review the list of the main polluting industries and, for the most polluting establishments, identify the nature of the effluents and their toxicity, estimate the average pollutant load and determine pre-treatment requirements before discharge into the sewer and measures to be taken to achieve these.

A.3.7. Presentation of all sanitation infrastructure and equipment

The Consultant will make a comprehensive presentation of all collection, conveyance, treatment and discharge infrastructure for the collective sanitation of Benghazi, which will be presented both as analytical reports and in a GIS database.

A.3.7.1. Wastewater Treatment Plant

The Consultant will also a produce descriptive sheet for the currently non-functional Al-Qwarsha Wastewater Treatment Plant based on the documents available (execution studies, reports, etc.) the study will present:

- The main elements of the plant such as the civil engineering and the equipment composing the plant (screening, grit chamber, oil separators, primary treatment, secondary treatment, sludge treatment, pumping station, etc.);
- The expected treatment capacity of the plant
- A summary analysis of the plant's operation as per initial design;

A.3.7.2. Pumping stations

The Consultant will establish descriptive sheets of the main characteristics of each of the estimated 28 pumping station as well as their operation in directing the Client to collect and/or provide specific additional information or data. This sheet must include the following information:

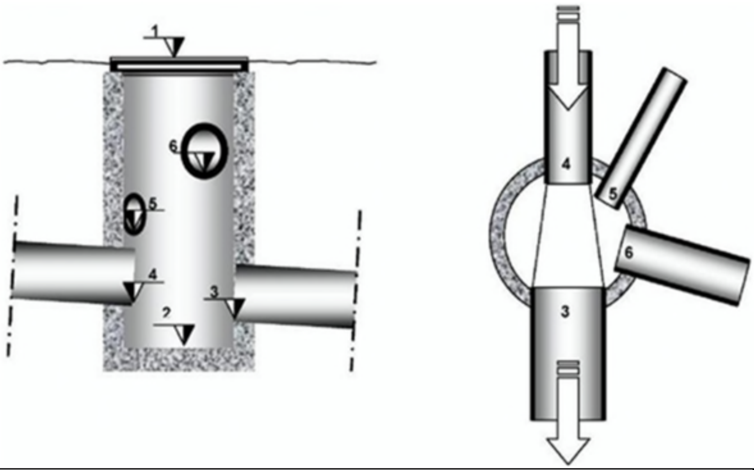
- Type of station (submerged or permanent dry well, discharging into a long force main or lifting to wastewater into a gravity sewer, etc.);
- Main technical parameters characterizing the civil engineering and the equipment of the different elements of the station (tank, screen, valves chamber, grit chamber, control room, etc.).;
- Analysis of the operation and efficiency of each piece of equipment in the station;
- Brief description of the state of the civil engineering and functionality of the equipment of the station, inventory of the difficulties and operating problems encountered, analysis of the origin of these problems (design, maintenance, operation etc.), in particular related to the siltation of the station;
- Impact of the station on the surrounding environment (odours, discharge of raw wastewater by the overflow, noise, waste disposal, flooding, nuisance due to operating operations such as cleaning, etc.).
- The impact that a restoration of the treatment plant would have on the surrounding environment such as odours, the discharge of raw wastewater by the overflow, noise, waste collection, sludge disposal, etc.

A.3.7.3. Network

The network map will be updated from existing documents to be confirmed and completed by field investigations in relevant inspection chambers, as directed by the Consultant to ensure sufficient precision for modelling purposes. For each inspection chamber visited, the following at least the information should be obtained:

- The level of the natural terrain;
- The invert level in drains at the inlet(s) and outlet(s) and their diameters;
- The internal dimensions of the inspection chamber;
- A brief description of its operation (siltation, approximate flow speed, filling level at the time of survey, etc.).

These chambers have an individual descriptive sheet containing all the information collected.



Benghazi Municipality								
(Map/sub-section) name				Inspection chamber name				
Date of survey								
Marker	X	Y	Z	Ø mm	Material	Note		
1								
2								
3								
4								
5								
6								
Particular Remarks								
Inspection chamber cover				Section				
Internal dimension	H mm		Ø mm		L mm		W mm	
Materials								

Figure 13: Example of network survey sheet.

Finally, neighbourhoods not served by the sewerage networks will be identified and the main modes of sanitation will be characterized (septic tanks, direct discharge on the roadway, direct discharge into the lagoon, connections to storm water drainage, etc.).

A.3.7.4. Sea outfall

The Consultant will produce descriptive sheets for the marine outfalls, providing relevant details of the various civil and hydraulic elements of each such as.

- Specify their target design levels;
- Damages, erosion and sediment accumulation etc,
- Feeder pipeline diameter, material, length, upstream invert elevation, downstream invert elevation diffuser ports/sections (if any).

A.3.8. Destination of treatment sludge

The Consultant will describe the management method and the current destination of the treatment sludge from septic tanks and supposed fate of treatment sludge from pre-treatment and treatment plants (landfills, spreading, etc.).

Depending on the wastewater characteristics, it will identify health and environmental problems related to sludge disposal.

A.3.9. GIS database

The design of the GIS database will be proposed by the Consultant but must be discussed and approved by the Client and GCWW prior to implementation to ensure it is fit for purpose. The database should include a feature-rich ESRI environment, containing the raster and DTM (1m precision) provided by the Client and all information collected from the study. The database should be divided into layers by type of infrastructure (primary network, secondary network, manholes, etc.) allowing a choice of displays, editions and prints for mapping purposes.

As a minimum the database should allow visualization and manipulation of:

- General information:
    - Structure of the sanitation system;
    - Type of sanitation system adopted;
    - Receiving environments;
    - Drainage basins and general topography.
    - Three-dimensional location of each structure at ground level (manholes, pipes, pumping stations, dams, etc.) with a hypertext link to any descriptive sheets produced.
- Pipelines:
    - Material, length, diameter and other characteristics of the pipelines;
    - The ground level dimensions and the invert level dimensions;
    - Slope and location of inlet and outlet invert level.
- Discharge points:
    - Location;
    - Population served
    - Average and peak flow rates
- Accessories:
    - Type of accessory (valves, etc.),
    - Dimensions and characteristics of each accessory

A.3.9.1. Training of GCWW

New constructions of sewerage and drainage networks are frequently carried out by the real estate companies and building companies. As-built drawings are not communicated to the GCWW for operation and maintenance.

It is expected that the GIS database will serve as a tool for GCWW to record such modifications and empower them to better monitor and manage their sanitation infrastructure over time. The Consultant will therefore provide a training in the use of the database, which must include at least:

- Basic training in the use of the GIS for Sanitation Projects;
- Presentation the different layers integrated into the GIS database, and training on their use, modification, etc.
- General database management

The Consultant will have these sessions carried out by qualified personnel who have participated in the development of the Benghazi GIS and preferably with GIS training experience.

A.3.10. Identification and description of other projects

The Consultant will list all current and future projects (infrastructure projects, town planning projects, etc.) to take into account their impacts on any proposed sanitation works. This will include the following minimum information for each:

- Project title;
- Project status (studies, works, completed);
- Source of funding, donor;
- Brief description of the project;
- Districts and areas concerned.

- Brief description of the expected impact on sanitation

These projects will be included in the GIS database.

A.3.11. Establishment of an economic and financial database

On the same principle of classifying main works constituting the sanitation infrastructure as proposed in A.3.7, the Consultant will establish a detailed database of economic and financial data to be used subsequently.

The Consultant will estimate investment and operating costs for each type of structure in the form of unit costs (examples: pipes: cost per km depending on diameter; pumping stations: cost per m^3 lifted, treatment: cost per thousand PE; sludge recovery cost: as per level of mineralization, etc.).

The investment costs will represent:

- Costs of the planned works;
- Costs of studies and supervision of the works;
- Provision for contingencies;
- Calculation of asset depreciation.

Operating costs will represent:

- Staff costs;
- Maintenance costs;
- Energy;
- Other consumables.

To carry out this task, the Consultant will study the existing documentation of the administrations, public companies or any other public or private institutions which may be of interest to the study.

A.4. Deliverables

At the end of the mission, the consultant is expected to provide the following:

- An inception report presenting all the documents collected and indexed throughout the mission. It should represent a comprehensive literature review
- A mission report, presenting all the collected and processed information, comprehensively describing the sanitation situation in Benghazi and illustrated with drawings, plans and maps.
- A comprehensive Geographic Information System (GIS) database

The Consultant will organize a second feedback meeting in Tunis that will include:

- Presentation and discussions with ICRC and its Partners on the mission report
- Training for GCWW staff on the GIS database

MISSION B: Hydraulic modelling & diagnostic

Mission B concentrates on establishing a hydraulic model of the existing sanitation and storm water networks of Benghazi. The model will be used to confirm findings of Mission A and to develop a comprehensive diagnostic of the current system's shortfalls.

B.1. Stage 1 – Design criteria

The Consultant will establish the basis for the design of the current and future sanitation infrastructure:

- Rainfall regimes and calculations of rainfall flows to be evacuated for new constructions;
- Sanitation technologies: separate or combined; individual household sanitation;
- Wastewater networks;
- Storm water network;
- Pumping and lift stations;
- Treatment plants: treatment levels according to legal quality requirements for receiving environments; design / sizing of structures;
- Additional treatments for specific uses of treated wastewater;
- Pipes for the transfer of treated wastewater to recovery sites;
- Recycling of sludge from wastewater treatment plants (on-site and off-site);
- Marine outfalls;
- Etc.

For each design criterion, the Consultant will include:

- A description,
- A justification of the relevance,
- An analysis on the relative importance and,
- The impact of uncertainties on the results of the studies.

B.2. Stage 2 – Hydraulic modelling of the existing system

B.2.1. GIS data-based model

The Consultant will develop a hydraulic model allowing the representation of the complete sanitation system of Benghazi including wastewater, storm water and combined sewers.

The model should integrate collected information for the primary and secondary and, if needed, tertiary networks.

The model will then be calibrated according to the data collected in the previous mission to ensure it realistically depicts the operation of the system. Calibration should be first based on dry weather conditions.

The Consultant will use modelling software which will be feature-rich Esri GIS environment. The software will have the following features:

- Separate and combined sewer collection systems, storm water drainage networks;
- Modelling of overland flow and pipe flow;
- Advanced control strategies;
- Long term statistics.

In its offer, the Consultant should clearly indicate and present the software that will be employed in the modelling works. The project does not envisage to purchase modelling software for the Client or its Partners, who will not carry out further modelling works, but the data should be presented in report format justifying the Consultant's conclusions.

B.2.2. Simulations for rainwater impact

After the hydraulic model calibration, simulations on the network will be carried out by varying the flow rate values, thus making it possible to assess the impact on operation and identify the limits of existing infrastructure.

The impact of increased flow values must take into account factors such as the infiltration of rainwater, discharge of wastewater into the storm water sewerage and vice versa, etc.

These various simulations should provide clarifications on the deficiencies and dysfunctions within the system and pave the way for solutions to be developed within the framework of this sanitation master plan. Rainfall return periods will be extrapolated from these deficiencies in order to assess their likelihood of occurrence, quantify the risk and prioritize interventions.

B.3. Stage 3 – Diagnostic of the system

Based on the simulations carried out on the hydraulic model, as well as, the information collected during mission A (such as condition of the facilities, etc), the Consultant will undertake a comprehensive diagnostic of the system.

It will review the various components of the system to analyse their shortcomings individually, but also assessing their collective impact on the overall system.

Furthermore, the Consultant will first present a summary of both hydraulic and pollutant loads generated and transiting in the system. The current confirmed or likely impact of the shortcomings of the treatment will be described.

This assessment of the current situation, will lead to descriptions of:

- The system as it functions today with the identification of the non- or under-performing elements (breakdowns of the pumping stations, damaged pipelines, performance of the WWTP, etc.)
- The system as it would function today under design conditions.

From this the Consultant will identify the deficiencies affecting the network, highlighting whether they are due to poor functionality or outdated design. The Consultant will subsequently propose a prioritised lit of immediate measures to be implemented to prevent the deleterious consequences of the system's dysfunctionalities, such as wastewater flooding.

The diagnostic should also include a broad review of the operation and maintenance of the wastewater system by GCWW and, when relevant, suggest institutional, management or organisational improvements.

B.4. Deliverables

At the end of the mission, the Consultant is expected to provide a comprehensive report containing:

- The design criteria
- The hydraulic model
- The results of the various simulations
- The full diagnostic of the current system

The Consultant will organize a feedback meeting in Tunis to present and discuss the mission report.

MISSION C: Development of variants for the different horizons

Mission C focuses on the evolution of the state of urbanisation and wastewater production in the city of Benghazi and will propose various sanitation solutions.

C.1. Stage 1 – Evolution of the context

Based on the results of the previous mission, this activity aims to project the evolution of the context until 2030 (intermediate horizon) and 2040 (final horizon). The Consultant will clearly indicate and justify the hypotheses that underpin each of the below scenarios and, where relevant, provide projections describing the lowest, most likely, and highest estimates.

C.1.1. Urbanization scenario

From the information obtained in Mission A on the current situation of urban zoning and proposed urbanisation plans, the Consultant will project the evolution within these zones, such as changes in neighbourhood typology, densification, etc.

The Consultant will also consider the expansion of these zones and will therefore study the housing sector, focussing both on official urban planning programs as well as general urban sprawl from development projects of private or institutional promoters.

The evolution of the different urban zones will be mapped to provide an image of the projected state of urbanisation in Benghazi in 2030 and 2040.

C.1.2. Demographic scenario

Based on the information obtained in Mission A, the Consultant will project population growth to describe the densification of population in residential areas. The scenario should include the demographic dynamics, such as population size and growth, fertility and mortality trends, population distribution and migration (returnees). The Consultant will also consider the increase of relevant wastewater producing industries.

The evolution of the population will be mapped to provide an image of the projected demography in Benghazi in 2030 and 2040.

C.1.3. Water consumption and wastewater production scenario

The Consultant will then use the results of the defined water consumption and wastewater production in mission A, the urbanization scenario, and the demographic scenario, to propose water consumption by type of consumer and project estimates of wastewater discharge by type of user as well as estimates of pollution release for the different horizons. These projections should consider:

- Daily (and if relevant seasonal) average and hourly peak productions.
- Quantities consumed from MMRA and estimated from wells located in the study area.
- Technical performance of drinking water networks.
- Foreseeable evolution of consumption habits
- Discharge quantities according to the types of water usage and location.

The wastewater production evolution will be used to estimate the pollutant loads to be treated by the system.

C.2. Stage 2 – Preparation of variants

C.2.1. Definition of comparison criteria

The Consultant will draw up a list of criteria for the future comparison of the variants that will be proposed for the development of sanitation solutions for Benghazi city. Each criterion should be accompanied by a description, a justification of its relevance, an explanation of its relative importance compared to other criteria and the associated weighting. These criteria could include for example:

- Capital expenditure
- Operational expenditure,
- Compliance with regulatory targets,

- Resilience
- O&M considerations,
- Complexity of the works
- Sustainability of the system
- Nuisance factors (noise, odors, etc.)
- Any other criteria necessary for the comparison of variants.

C.2.2. Technical consultation meeting

The likely evolution of the context and the proposed evaluation criteria will be compiled into an interim mission report to be presented during a technical consultation meeting in Tunis, organised by the Consultant.

The contents of the report and the various options serving as a base for the variants will be discussed with the Client and Partners during the meeting to orient the Consultant in the preparation of variants.

Within 2 weeks following the meeting, the Consultant will submit a revised interim mission report summarising the discussions of the technical consultation, representing all views expressed and clearly presenting the main decisions directing the variant design process.

C.3. Stage 3 – Development of variants

Following on from the decisions made in the technical consultation meeting, the Consultant will propose several technical variants of sanitation solutions for Benghazi city over project horizons 2030 and 2040.

Should any additional information be required for the description of the variants, the Consultant will define the specific information needed and direct the process.

C.3.1. Development of variants

The Consultant will carry out broad designs for complete sanitation proposals within the project boundary. These will comprise waste and storm water collection and conveyance methods, treatment systems and discharge methods and will respect all criteria previously decided.

The Consultant will present each variant individually, demonstrating:

- The proposed works to be carried out, including all main infrastructure
- The hydraulic model of the system
- The complexity of the proposed works
- The estimated timeline for completion of the works
- The estimated investment costs in 5-year periods
- The estimated operation and maintenance costs
- The expected tariff
- The environmental impact (discharge quality, risk to marine and groundwater resources)
- The reliability of assumptions and calculations
- The extent of inclusion of the existing system
- Depreciation and debt servicing
- Resilience of the system to failures of individual elements of the system
- Flexibility and adaptability to unforeseen variations in urban development prospects
- Any other relevant factor

The proposed infrastructure for each variant will be incorporated into the GIS database.

C.3.2. Comparison of the variants

The Consultant will provide a critical comparison of the variants and score each one using the variant criteria defined in Stage 2 to justify the most appropriate solution for the Master Plan.

While the Consultant should prepare the analysis, the evaluation of the variants will be conducted during a workshop in Tunis, organised by the consultant, with the Client and its partners and where:

- The variants will be presented in detail,
- Participants will propose scoring for the criteria and pre-determine the optimal solution

- Results of the comparative selection will be discussed with an analysis on criteria sensitivity (highlighting how the preferred solutions react to changes of scoring or weighting)
- Decide on the most appropriate solution for the masterplan

Within 2 weeks following the workshop the Consultant will prepare a mission report integrating the whole process.

C.4. Deliverables

Following the technical consultation meeting the Consultant will submit an interim mission report.

At the end of the mission, the consultant is expected to provide a mission report presenting:

- The evolution scenario for Benghazi at both horizons
- The comparison criteria for the selection of variants, including their weighting
- The proposed variants for sanitation systems,
- The results of the workshop
- Updated Geographic Information System (GIS) database including all proposed variants.

MISSION D: Finalisation of the Master Plan – Preliminary Design

The objective of this mission is to complete the study with the preliminary design of the selected variant. The subsequent report will contain the sizing of the main infrastructures and their descriptions, layouts, diagrams and for planning purposes will include an investment plan and a proposed works programme.

This report will provide sound foundation for fundraising and planning of works and will pave the way for detailed technical studies to be carried out prior to implementation.

D.1. Preliminary study of the selected variant to 2030 and 2040 horizons

The Consultant will first develop a technical brief describing the variant selected for the master plan that will contain, at least:

- A description of the project context as well as the relevant baseline data,
- A justification of the selected variant,
- A global overview of the required works, and their phasing,
- A description sheets for each of the main infrastructural components of the system:
    - The relevant design characteristics of each element,
    - Preliminary design diagrams and,
    - Layouts,
- All required plans such as a catchment basin map which overlays the selected sanitation network and relevant infrastructure,
- An estimated timeline for the complete construction of the works. This timeline will include:
    - Emergency works to be implemented within 5 years as identified in Mission B
    - Medium term works (horizon 2030)
    - Long term works (horizon 2040)
- A financial forecast for the implementation of the master plan, which will include:
    - Total costs of the works for the duration of the master plan,
    - Costing of each element to be constructed,
    - A phased program of investments,
    - Itemised running costs, including operation, maintenance, staffing, debt servicing and depreciation.

The GIS database will be updated to contain all the relevant information.

The Sanitation Master Plan will be submitted to the Client and presented 2 weeks later at a feedback meeting in Tunis, organised by the Consultant for approval by the Client and Partners.

D.2. Handover of Sanitation Master Plan

A handover ceremony will be organized in Benghazi by the Client.

The handover will be organized for a wide audience by the Client to officially present and handover the final master plan to the authorities.

The Consultant will contribute to the organisation of the meeting by preparing relevant supporting document such as briefing notes and presentations.

Should the Consultant (subject to interest and security) wish to participate in the ceremony, the associated costs must be covered by the Consultant.

D.3. Deliverables

Prior to handover, the Consultant will submit:

- A Sanitation Master Plan with appendices integrating all reports, plans and maps generated as a result of the above studies
- A comprehensive Geographic Information System (GIS) database containing all information from the above studies.
- Supporting documents for the Hand-over ceremony

IV. Operational management of the study

The complex situation in Libya implies that special management modalities are required for the contract which are laid out below.

1: Field visits

Due to current security situation, movements in Libya are restricted and the ICRC does not expect the Consultant to be present in the country. Therefore, in addition of being the Client, ICRC will also take on the role of local relay to the Consultant and provide required data and information to the best of its abilities. In this role ICRC will be present in the field but may refer certain activities to GCWW or private contractors.

In Tunisia

Throughout the course of the contract several meetings will be held (see section 4: Meetings). Due to the security constraints in Libya, these will be held in Tunis where ICRC has its Libya delegation. For all visits in Tunisia except for the kick-off meeting the Consultant will be responsible for the organisation of the workshop/meetings.

In Libya

Should the presence of the consultant in Benghazi be deemed desirable by all parties involved, the Consultant commits to abide by the ICRC security rules and Code of Conduct. The Consultant will be responsible for their accommodation in Benghazi and their travel arrangement to Libya. ICRC will support where necessary in getting the necessary approvals from the authorities.

2: Communication

The project to develop the Master Plan is carried out by ICRC in partnership with a number of local authorities (Prime Minister's Office, HIB, MHU, Municipality, GCWW, etc.). Given the web of potential interlocutors and the need to balance manage relationships and ensure a consistent level of knowledge throughout, ICRC will remain the Consultant's Client and privileged interlocutor.

As such, ICRC will be the primary conduit for communication with its Libyan partners and will transmit questions and answers from the Consultant to the relevant stakeholders and vice-versa. ICRC will also convene the Partners for any meetings, as well as representing them collectively to the Consultant as the needs arises.

Direct contacts between the Consultant and the Partners shall be approved as necessary.

The Consultant may contact GCWW or private contractors employed for field investigations directly, whilst keeping ICRC informed.

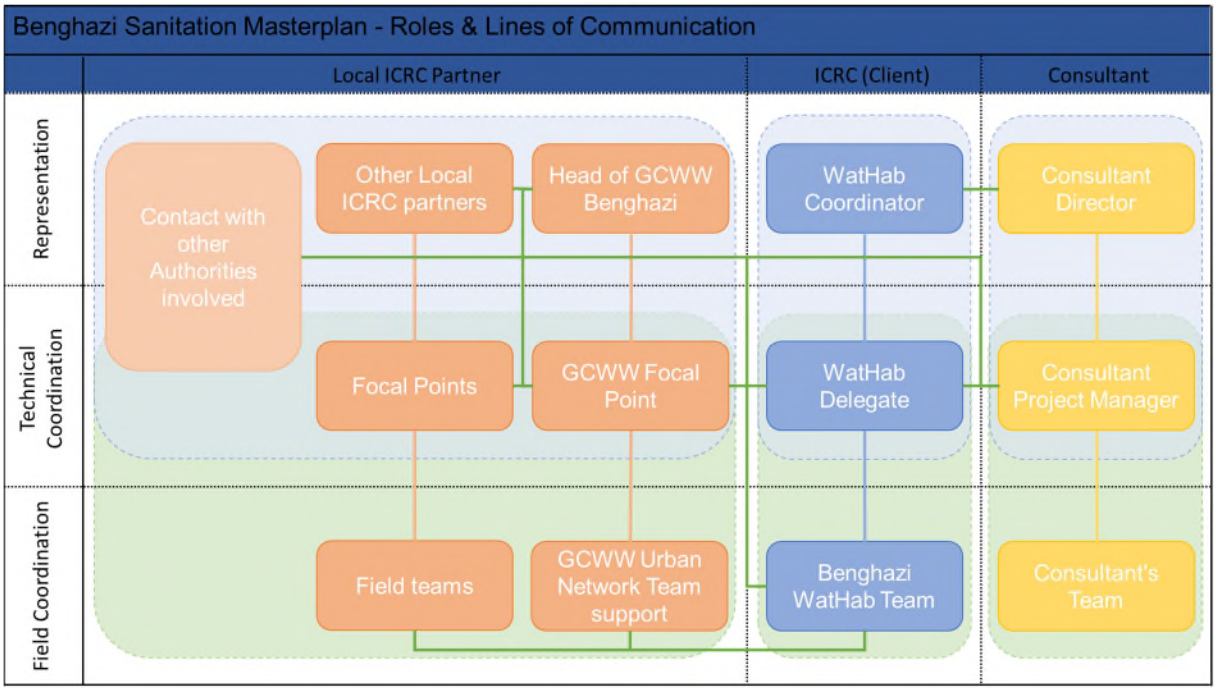


Figure 13: Study organization organigram

3: Deliverables

Monthly activity reports (3 pages maximum) will be sent to the Client illustrating progress made by the Consultant. These will be transferred by email during the first week of the following month.

In addition to the monthly activity reports, the consultant will submit outputs as explained in the mission descriptions. The table below summarises the various deliverables to be submitted.

Mission	Deliverables
A	Inception report presenting a compiled bibliography with critical review and listing the remaining data to be collected and methodologies for the purpose
	Mission report presenting all the collected and processed information, comprehensively describing the sanitation situation in Benghazi and illustrated with drawings, plans and maps. GIS database containing all georeferenced information
B	Mission report presenting: • Design criteria • The hydraulic model • The results of the various simulations • The full diagnostic of the current system
C	Interim mission report summarising the technical consultation meeting
	Mission report presenting: • The evolution scenario for Benghazi at both horizons • The comparison criteria for the selection of variants, including their weighting • The proposed variants for sanitation systems, • The results of the workshop Updated GIS database including all proposed variants.
D	A Sanitation Master Plan with appendices integrating all reports, plans and maps generated as a result of the above studies

	A comprehensive GIS database containing all information from the above studies.

All documents such as reports, plans and maps will be provided to the Client in digital format and in 8 colour hard copies. GIS data will be transferred in digital format.

Deliverables will be submitted 2 weeks in advance of its associated meeting, and any comments, modifications or corrections will be integrated, and the deliverables re-submitted within 2 weeks following the meeting for approval by the Client accompanied by an updated work plan for the study.

Approval of the finalised deliverables for each mission is a prerequisite for the commencement of the next mission.

4: Meetings

Various events will be held in Tunis and Benghazi throughout the duration of the contract. The table below illustrates the objective and duration of each and the party responsible for its organisation. The durations are estimated, and the Consultant should propose durations of each according to their experience. Depending on the meeting the number of participants will vary but will not exceed 25 participants.

Meeting	Responsible	Estimated Duration	Objectives
Kick off Meeting	Client	1 day	Introduction of the partners Agreeing on general approaches and methodologies
Mission A First Feedback Meeting	Consultant	2 days	Presentation of the compiled data Listing the additional data required and methodologies for obtaining them
Mission A Second Feedback Meeting	Consultant	4 days	Presentation of the complete compiled baseline data Training of GCWW GIS staff on the use of the GIS database
Mission B Feedback Meeting	Consultant	2 days	Presentation and approval of the hydraulic model, development scenarios and design criteria
Technical Consultation Meeting	Consultant	3 days	Presentation, discussion and approval of the evolution of the context and variant criteria
Mission C Workshop	Consultant	3 days	Presentation of the proposed variants for the master plan, comparison of the relative benefits of the variants and selection of a variant for the Master Plan
Mission D Feedback Meeting	Consultant	2 days	Presentation and approval of the Sanitation Master Plan
Official Handover Ceremony	Client	1 day	Handover of the Sanitation Master Plan to Authorities in Benghazi

The responsible party will arrange and pay for all necessary elements of the meetings, such as venue, lunch, coffee breaks, accommodation, equipment, transport, etc. with the following exceptions:

- The Client will take responsibility for transport and accommodation of all Libyan participants.
- The Client will organize for the Consultant's transport between Tunis airport, their hotel and the venue.
- The following Hotel standard can be used as reference (https://www.hotelacropole.net/).

V. GLOSSARY

Sewerage system, collection system:	A network of pipes, manholes, cleanouts, traps, siphons, lift stations, and other structures used to collect all wastewater and wastewater-carried wastes of an area and transport them to a treatment plant. The collection system includes land, wastewater lines and appurtenances, pumping stations, and general property.
Combined sewer:	A sewer designed and intended to serve as a sanitary sewer and a storm sewer, or as an industrial sewer and a storm sewer.
Sanitary sewer:	Underground pipe or tunnel system for transporting sewage from houses and commercial buildings (but not storm water) to treatment facilities or disposal.
Storm drain, storm sewer, storm water drain:	A sewer designed and intended to carry only storm waters, surface runoff, street wash waters, and drainage.
Outfall:	The point, location, or structure where wastewater or drainage discharges from a sewer, drain, or another conduit.
Outfall sewer:	A sewer that receives wastewater from a collection system or from a wastewater treatment plant and carries it to a point of ultimate or final discharge in the environment.
Interceptor:	Typically, a large-diameter pipe that acts as a main trunk of a sewer system. The interceptor is fed from sewer mains, which are fed by sewer laterals. In small communities, a septic tank or other holding tank that serves as a temporary wastewater storage reservoir for a septic tank effluent pump (STEP) system may be called an interceptor.
Interceptor sewer:	A large sewer that receives flow from a number of sewers and conducts the wastewater to a treatment plant. Also called intercepting sewer.
CSO	Combined Sewer Overflow. Wastewater that flows out of a combined sewer (or lift station) as a result of flows exceeding the hydraulic capacity of the sewer or stoppages in the sewer. CSOs exceeding the hydraulic capacity usually occur during periods of heavy precipitation or high levels of runoff from snow melt or other runoff sources.
Storm water bypass:	A combined sewer discharge pipeline intended to bypass wastewater treatment plants during a peak runoff events.
Detention basin, retarding basin:	Excavated area built to protect against flooding and, in some cases, downstream erosion by storing water for a limited period of time. These basins are also called "dry ponds", "holding ponds" or "dry detention basins" if no permanent pool of water exists.
Drainage basin:	A drainage basin is any area of land where precipitation collects and drains off into a common outlet, such as into a river, bay, or other body of water. The drainage basin includes all the surface water from rain runoff, snowmelt, and nearby streams that run downslope towards the shared outlet, as well as the groundwater underneath the earth's surface.
Population equivalent (PE):	Unit of measurement to assess the capacity of a treatment plant. This unit of measurement is based on the amount of pollution emitted per person per day. 1 PE = 60 g of BOD5 / day at the station entrance, i.e. 21.6 kg of BOD5 / year.

The European directive of May 21, 1991 defines the inhabitant equivalent as the biodegradable organic charge having a biochemical oxygen demand in five days (BOD5) of 60 grams of oxygen per day.

Manhole (utility hole, maintenance hole, inspection chamber, access chamber or sewer hole):	A manhole is an opening to a confined space such as a shaft, utility vault, or large vessel. Manholes are used as an access point for an underground public utility, allowing inspection, maintenance, and system upgrades.
Invert level:	Invert level is the term given to the level of the bottom of the inside of a drainage pipe or inspection chamber.
Main sewer:	A sewer line that receives wastewater from many tributary branches and sewer lines and serves as an outlet for a large territory or is used to feed an intercepting sewer. Also called trunk sewer.
Branch sewer:	A sewer that receives wastewater from a relatively small area and discharges into a main sewer serving more than one branch sewer area.
Lift station:	A wastewater pumping station that lifts the wastewater to a higher elevation when continuing the sewer at reasonable slopes would involve excessive depths of trench. Also, an installation of pumps that raise wastewater from areas too low to drain into available sewers. Lift stations may be equipped with air-operated ejectors or centrifugal pumps. Sometimes called a pump station, but this term is usually reserved for a similar type of facility that is discharging into a long force main, while a lift station has a discharge line or force main only up to the downstream gravity sewer.
Grit chamber:	A detention chamber or an enlargement of a collection line designed to reduce the velocity of flow of the liquid to permit the separation of mineral solids from organic solids by differential sedimentation.
Sedimentation:	The process of settling and depositing of suspended matter carried by water or wastewater. Sedimentation usually occurs by gravity when the velocity of the liquid is reduced below the point at which it can transport the suspended material.
Screen:	A device used to retain or remove suspended or floating objects in wastewater. The screen has openings that are generally uniform in size. It retains or removes objects larger than the openings. A screen may consist of bars, rods, wires, gratings, wire mesh, or perforated plates.
Pollutant:	Any substance that causes an impairment (reduction) of water quality to a degree that has an adverse effect on any beneficial use of the water. Pollutants may include dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste.
Suspended solids:	Solids that either float on the surface or are suspended in water or wastewater. When referred to as a waterborne constituent, total suspended solids (TSS) is the quantity of material removed from water or wastewater in a standard laboratory test.
BOD_5:	BOD_5 refers to the five-day biochemical oxygen demand. The total amount of oxygen used by microorganisms decomposing organic matter increases each day until the ultimate BOD is reached, usually in 50 to 70 days. BOD usually refers to the five-day BOD or BOD.
COD:	A measure of the oxygen-consuming capacity of organic matter present in wastewater. Chemical oxygen demand is expressed as the amount of oxygen consumed from a chemical oxidant in mg/L during a specific test. Results are

not necessarily related to the BOD (biochemical oxygen demand) because the chemical oxidant may react with substances that bacteria do not stabilize.

TKN: Total Kjeldahl nitrogen or TKN is the sum of nitrogen bound in organic substances, nitrogen in ammonia (NH3-N) and in ammonium (NH4+-N) in the chemical analysis of soil, water, or waste water (e.g. sewage treatment plant effluent). Today, TKN is a required parameter for regulatory reporting at many treatment plants, and as a means of monitoring plant operations.

VI. ANNEX

- List of currently available data (documents, information, studies etc.).
- Extract GIS database of section H3.