**Iraq Salinity Project** **Technical Report 14**

# State of irrigation and drainage infrastructure in Central and Southern Iraq: A review of post war situation

**Reporters:**

Asad Sarwar Qureshi Shawkat Saib Jameel Hassan Abbas

---

*The Iraq Salinity Project is an initiative of Government of Iraq, Ministries of Agriculture, Water Resources, Higher Education, Environment, and Science and Technology, and an international research team led by ICARDA – the International Center for Agricultural Research in the Dry Areas, in partnership with the University of Western Australia, the Commonwealth Scientific and Industrial Research organization (CSIRO) of Australia, the International Water Management Institute (IWMI), Sri Lanka, and the International Center for Biosaline Agriculture (ICBA), Dubai, United Arab Emirates.*

*This research is funded by the Australian Centre for International Agricultural Research (ACIAR), AusAID and the Italian Government.*

This technical report series captures and documents the work in progress of the Iraq Salinity Project, in its seven research themes, working at the regional, farm and irrigation system scales. Technical reports feed into the *Iraq Salinity Assessment*, a synthesis and solutions to solving the problem: Situation Analysis (Report 1); Approaches and Solutions (Report 2) and Investment Options (Report 2).

*Key words: southern Iraq, central Iraq, spatial distribution, remote sensing, irrigation, salinity mapping.*

This report was written and compiled by Asad Sarwar Qureshi Shawkat Saib Jameel Hassan Abbas

With Dr Weicheng Wu (Leader), Dr Feras Ziadat (Co-Leader), Dr Eddy De Pauw-International Centre of Agriculture Research in Dry Areas (ICARDA), Richard Soppe (SCIRO) and Alexander Platonov (IWMI).

*http://icarda.org/iraq-salinity-project/teaser*

*Report*

*On the*

# *State of irrigation and drainage infrastructure in Central and Southern Iraq: A review of post war situation*

Asad Sarwar Qureshi
Shawkat Saib Jameel
Hassan Abbas

**A contribution to the ACIAR funded project on**

**"Soil Salinity Management in Central and Southern Iraq"**

# Table of Contents

# 1 Introduction

Performance assessment of irrigation and drainage infrastructure involves the systematic observation, documentation, and interpretation of the management of an irrigation and drainage system, with the objective of ensuring that the infrastructure provides the basic needs of irrigation (to meet crop water requirements and leaching of salts to maintain appropriate salt balance in the root zone) and drainage (to remove the leaching effluent from the system through a drainage network). This assessment is needed both at the larger scale (district scale) to monitor the overall performance of the system as well as at the local scale (farm scale) to evaluate the efficiency of the system in terms of sustainability of the cropping system.

Regardless of the efficiency of farm-level irrigation practices, adequate collection and disposal/reuse of drainage effluent is crucial to ensuring the sustainability of crop production systems. Considering the fragmented information on irrigation and drainage infrastructure in Iraq, there is a need to assess the current status of the infrastructure to determine key limitations influencing irrigation delivery, irrigation management, and disposal of the drainage effluent.

This study is undertaken with the collaboration of the irrigation, water management and agricultural extension departments in Iraq. The data used in this study consists of irrigation network at project and farm level (irrigation channels/outlets, current irrigation systems such as surface, furrow, drip, and sprinklers and their extent), quality of irrigation water at the farm, irrigation practices, depth of groundwater, quality of groundwater, features of drainage systems (structures, depth of drainage network, efficiency, drainage type, expected life, and drainage maintenance system), collection of drainage effluent, quality of the drainage water, disposal and/or reuse options of the drainage effluent, and cropping system.

The main focus of this study was Babil and Wasit provinces located in the central Iraq. Two major projects of these provinces namely Al-Mussiyan and Al-Dujailah were selected for assessing the existing status and performance of the irrigation and drainage infrastructure. Al-Mussiyab project is fed by the Euphrates River and Al-Dujaila project is fed by the Tigris Rivers. The main objective of this study is to review and document the current state of irrigation and drainage infrastructure in these two projects and assess the factors influencing irrigation delivery, irrigation management, and disposal of the drainage effluent. This report also aimed at highlighting the key deficiencies in the system that contributes to soil salinization and low land and water productivity. This information will finally be used to draw investment plans for the pilot scale development of irrigation and drainage infrastructure.

Figure 1 shows the location of Al-Dujaila and Al-Mussyib projects along with the pilot land-reclamation projects, which were constructed during the second half of the last century. Figure 1 also shows the projects that are non-operational or semi-operational due to deteriorated infrastructure, poor soil and water management and increased soil salinity problems which are directly or indirectly affecting land productivity in these project areas.

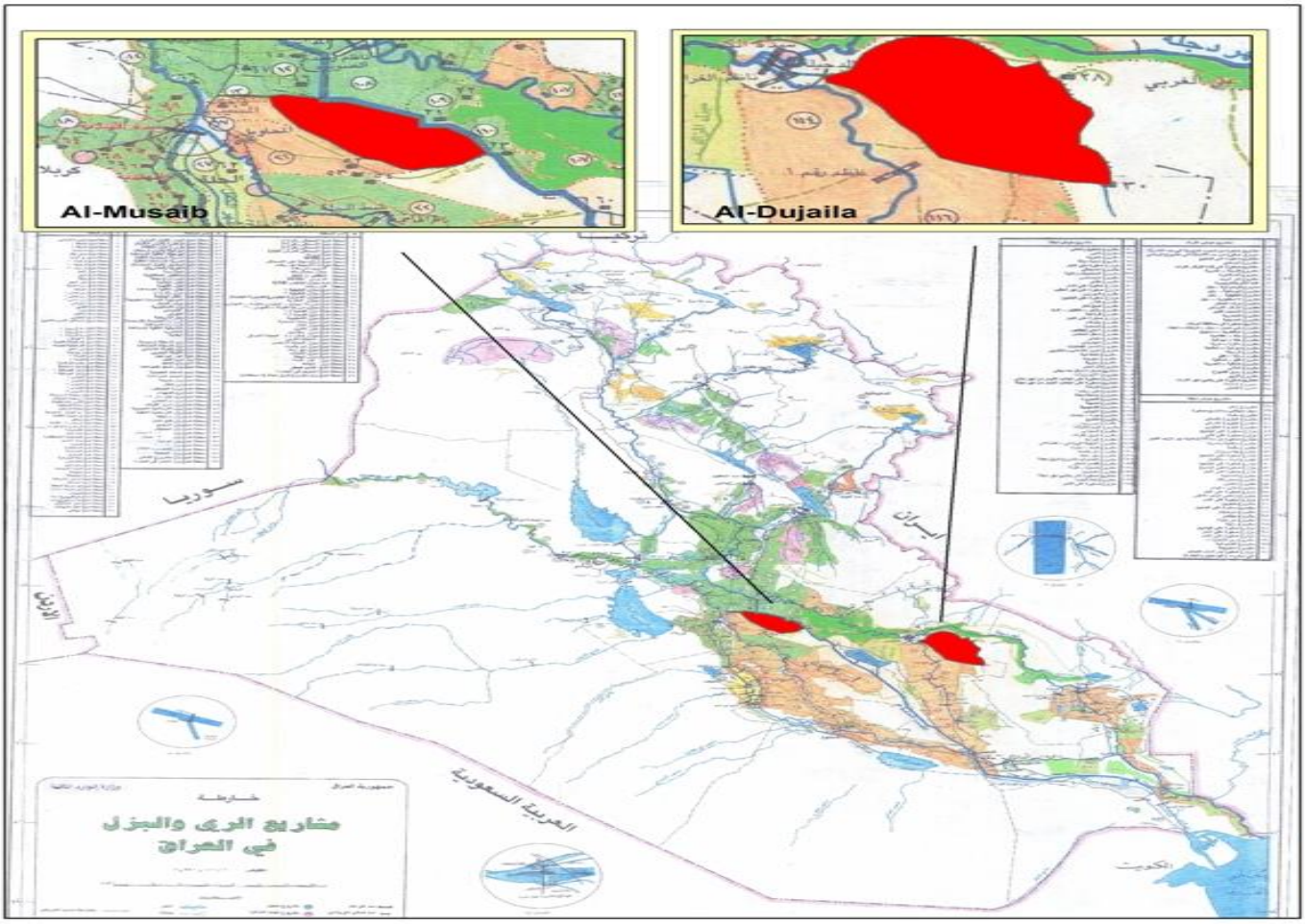



Figure 1: Location of Al-Dujaila and Mussyib project areas

# 2 Description of project areas

## 2.1 Al-Dujaila Irrigation Project

Dujaila project is one of the oldest irrigation projects in Iraq. The project is located in Wasit governorate on the right bank of Tigris River and left bank of Garraf River. It is bordered in the north by the Tigris River and Kut city, in west by East Garraf project, in East by Kut-Bitera project lands located on the right side of the Tigris River. The project lands extend south to border Meisan and Thi-Qar governorates. The project's management office is located 30 km from Kut City and 220 km from Baghdad city. The total area covered by this project is 396,000 donums (97,854 acres) (irrigated and non-irrigated lands), with net irrigated area of 225,000 donums (55,599 acres). About 76,000 donums (18,780 acres) are reclaimed area with full network of branch, collector and field drains. Modern network of main and branch concrete lined canals, field canals consists of sub-surface asbestos pipes feeds the field hydrants.

The construction of main drainage network started in 1954 and work continued in phases. Further development work took place during 1973-1983 in which modern techniques for reclaiming saline lands were introduced in the project area. In 1976 Dujaila agro-industrial compound was constructed. With the execution of this drainage project, soil reclamation started with visible positive impacts on agricultural production. However, maintenance work on this project could not kept pace with the time and the large scale reclamation activity stopped after 1983 due to deterioration of the project infrastructure. The project includes semi-reclaimed areas having unlined irrigation canals and a drainage network until the collector drains but without field drains. The total semi-reclaimed area is 56000 donums (13,838 acres) and the rest of the project lands are non-reclaimed.

The project lands are irrigated by gravity from the right side of Tigris river upstream Al-Kut barrage directly by Al-Dujaila main canal which off takes from Tigris river with a total length of 57 km. The designed discharge of the canal is 42 $m^3/s$. Sixteen branch canals emerge from its either sides in addition to 54 small private intakes belonging to the farmers. Crops cultivated in the project are wheat, barley, corn, clover, sunflower, and winter/summer vegetables. The agriculture density for the reclaimed area is 80% in winter and 20% in the summer. For semi- and non-reclaimed areas it is 50% in winter and less than 10% in summer.

### 2.1.1 Description of irrigation network

The project lands are irrigated by Al-Dujaila main canal (with a total length of 57 km and a design discharge of 42 $m^3/s$), which off-takes from the right side of the Tigris River upstream of Al-Kut barrage. This main canal has 16 branch canals on both sides. The irrigation infrastructure within the reclaimed area is the most developed having five branch canals with a total length of 40.8 km and total discharge of 22.3 $m^3/s$. There are 23 concrete lined branch canals with a total length of 72.5 km. There are 336.4 km long sub-surface asbestos pipe feeders and 5600 farm intakes (locally called as hydrants). In addition, there is also one main open unlined distributary canal with a total length of 36 km.

Five branch canals are located within the semi reclaimed area with total length of 83 km and total discharge of 12.45 $m^3/s$ while other six canals are feeding the non-reclaimed area with a total length of 72.5 km and total discharge of 11.1 $m^3/s$. On both sides of Dujaila main canal, there are 54 small canals belonging to the private farmers with each having a discharge capacity of less than 400 l/s. On the main canal there are 5 cross regulators located at the distances of 16, 29, 36, 45, and 51 km from the canal head to control water levels and discharges in the branch canals (see Figure 2).

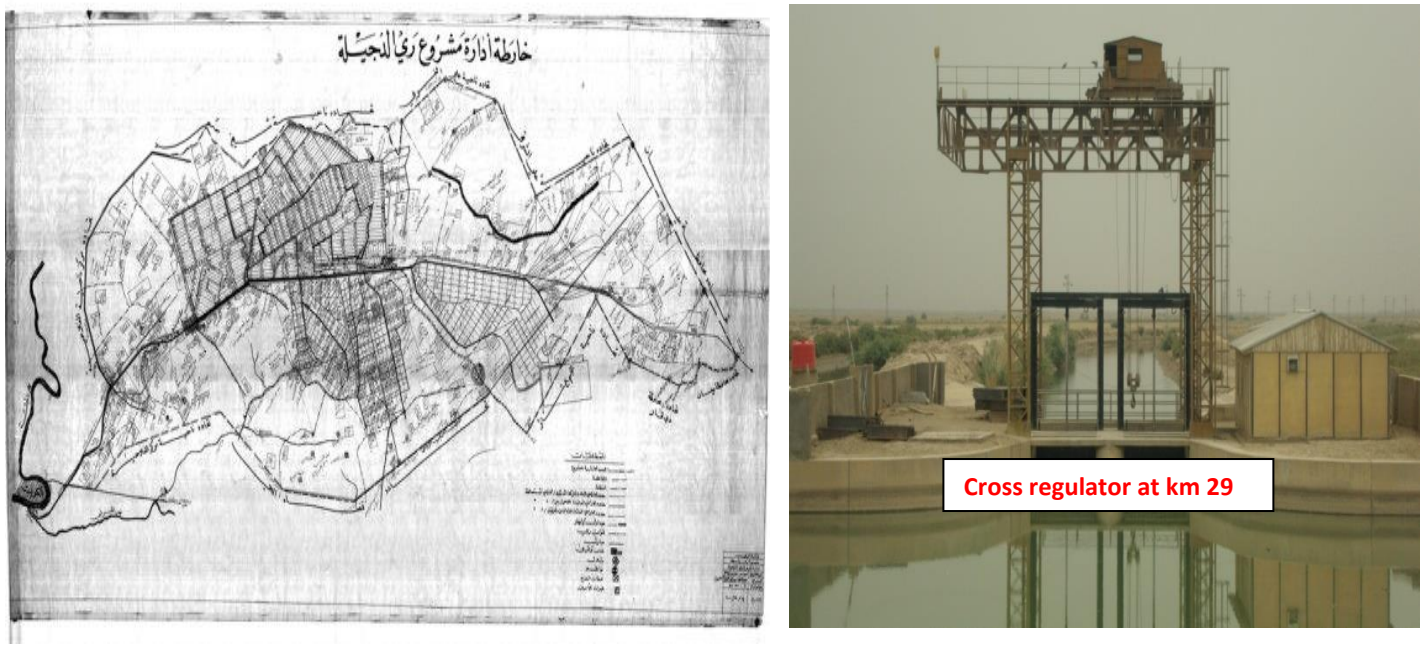



Figure 2: Irrigation network at the Al-Dujaila project area with a cross regulator at 29 km.

Al-Dujaila main canal head regulator and cross regulators (except for regulator 51) and head regulators of the branch canals within the reclaimed area are designed to operate on a computerized system in an electro-mechanical method. In other parts of the project, only head regulators of the branch canals are designed to operate on electro-mechanical method. Table 1 gives details of the canals and regulators located within the reclaimed area, semi-reclaimed area and non-reclaimed area of the Dujaila main canal.

Table 1 Structures and Canals located on Al Dujaila main canal

| no. | | Structure name | Location (km) | Max. Discharge ($m^3/s$) | Canal Name | Canal length km |
|---|---|---|---|---|---|---|
| 1 | Non-reclaimed area | Head regulator | 0+00 | 42 | | |
| 2 | | Cross regulator 1 | 16+540 | 37.168 | | |
| 3 | | Cross regulator 2 | 29+653 | 28.975 | | |
| 4 | | Cross regulator 3 | 36+580 | 17.714 | | |
| 5 | | Cross regulator 4 | 45+572 | 14.934 | | |
| 6 | | Cross regulator Km 51 | 51+022 | 10 | | |
| 7 | | Head regulator B.C 1 | 16+570 | 1 | B.C 1 | 5 |
| 8 | | Head regulator B.C 2 | 16+604 | 2.5 | B.C 2 | 11 |
| 9 | | Head regulator B.C 3 | 16+514 | 3 | B.C 3 | 21 |
| 10 | | Head regulator B.C 5 | 28+576 | 1.5 | B.C 5 | 10.5 |
| 11 | | Head regulator B.C 6 | 28+645 | 1.5 | B.C 6 | 12 |
| 12 | | Head regulator B.C 7 | 28+550 | 1.6 | B.C 7 | 13 |
| 13 | Semi-reclaimed area | Head regulator B.C9 | 42+646 | 2 | B.C 9 | 16 |
| 14 | | Head regulator B.C 10 | 48+968 | 2.27 | B.C10 | 12 |
| 15 | | Head regulator B.C 11 | 51+000 | 1.18 | B.C 11 | 12 |
| 16 | | Head regulator B.C 13 | 57+000 | 3.5 | B.C 13 | 18 |
| 17 | | Head regulator B.C 14 | 57+000 | 3.5 | B.C 14 | 25 |
| 18 | Reclaimed area | Head regulator B.C I-1 | 29+684 | 5.95 | B.C I-1 | 11.58 |
| 19 | | Head regulator B.CI-1-6 | 34+842 | 1.545 | B.C I-1-6 | 4.2 |
| 20 | | Head regulator B.C I-2 | 36+640 | 10.5 | B.C I-2 | 13.66 |
| 21 | | Head regulator B.C I-3-5 | 41+019 | 0.679 | B.C I-3-5 | 2.163 |
| 22 | | Head regulator B.C I-4 | 45+454 | 3.628 | B.C I-4 | 6.397 |

### 2.1.2 Description of drainage network

In terms of drainage, the project area is divided into 2 regions. Fully reclaimed area of 76,000 donums (17,260 acres) consists of a complete network of main, secondary, branch, collector and field drains. The area is irrigated from branch lined canals and unlined distributary canal. Semi-reclaimed area of 56,000 donums (12,717 acres) consists of main, secondary, branch and collector drains but without field drains. Table 2 gives summary of drainage network in reclaimed and semi-reclaimed areas.

Table 2: Summary of numbers and lengths of drains on different levels in reclaimed and semi reclaimed area

| Location | Main drains | | Secondary drains | | Collector drains | | Field drains | |
|---|---|---|---|---|---|---|---|---|
| | No | Length (km) | No. | Length (km) | No. | Length (km) | No. | Length (km) |
| Reclaimed area | 4 | 89.9 | 26 | 64.2 | 231 | 318.4 | 6675 | 2055.2 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Reclaimed area | - | - | 13 | 31.3 | 174 | 137.9 | 2541 | 1820 |
| Semi reclaimed area | 1 | 17 | 65 | 104.5 | 476 | 236 | - | - |
| Semi reclaimed area | 2 | 58 | 38 | 78.9 | 340 | 170 | - | - |
| **TOTAL** | **7** | **164.9** | **142** | **278.9** | **1221** | **862.3** | **9216** | **3875.2** |

### 2.1.3 Drainage pumping stations

The project has 3 pumping stations to pump drainage water from main drains and discharge it to the Malih marsh. Brief description of three umping stations is given below:

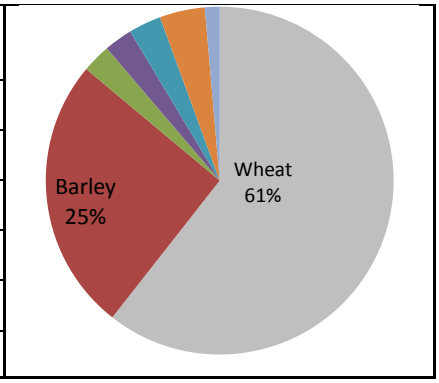
- ***BC 8 pumping station***: This pumping station is located 32 km from the project's management office and comprises of 5 electrical pumps with a design discharge capacity of 1.5 $m^3/s$ for each pump. The total discharge of the pumping station is 7.5 $m^3/s$. This pumping station serves 76000 donums (17,260 acres) of reclaimed area.
- ***BC 10 pumping station***: This pumping station is 38 km from the project's management office and comprises of 3 pumps with a designed discharge of 1.0 $m^3/s$ for each pump. The total discharge capacity of the station is 3 $m^3/s$. This pumping station serves the semi-reclaimed areas for BC 9, 10, and 11.
- ***BC 13 pumping station***: This pumping station is 52 km from the project's management office and comprises of 6 diesel pumps with a total discharge capacity of 12 $m^3/s$. Four of these pumps have been modified and now work on electric power. This pump station serves the semi-reclaimed areas of BC 13 and BC 14. In addition it throws the drainage water of BC 10 pumping station into the Malih Marsh.

### 2.1.4 Cropping pattern (winter and summer)

Wheat and barley are major winter crops whereas vegetables and corn are major summer crops. Table 3 shows the actual cultivated area under each crop within the project area for the period 2006-2010.

**Table 3:** Cultivated areas (donums) under each crop in Dujaila project during 2006-2010.

| Year | Wheat | Barley | corn | water melon | melon | cucumber | other crops | Total |
|---|---|---|---|---|---|---|---|---|
| **2006** | 51650 | 20000 | 6500 | 2500 | 2500 | 3500 | 1150 | 87800 |
| **2007** | 57200 | 23100 | 3000 | 4000 | 5000 | 4000 | 1245 | 97545 |
| **2008** | 70000 | 21630 | 2000 | 5250 | 6000 | 11500 | 3015 | 119395 |
| **2009** | 57750 | 33650 | 1105 | 0 | 0 | 0 | 700 | 93205 |
| **2010** | 48503 | 21525 | 0 | 635 | 770 | 800 | 332 | 72565 |
| **Average** | **57020.6** | **23981** | **2521** | **2477** | **2854** | **3960** | **1288.4** | **94102** |




### 2.1.5 Management, operation and maintenance

The management, operation and maintenance of all irrigation and drainage projects in Iraq are the collective responsibility of the Ministry of Water Resources (MoWR) and farmers. All the irrigation canals with a design discharge of more than 400 l/s are operated, managed and maintained by the project management unit (PMU) of the MoWR whereas beneficiaries (farmers) are responsible for the management, operation and maintenance of all irrigation canals with a designed discharge of less than 400 l/s.

For the drainage network; all the field and collector drains are the responsibility of the farmers (called as "*private benefit drains"*), while the project management office is responsible of secondary branches, main drains and pumping stations (called as "*public benefit drains*").

The irrigation water is allocated to main branch canals on rotational basis to irrigated different areas. The flow is regulated through cross regulators. Annex 1 shows an example of the monthly rotational system for the winter season of 2011-2012. It appears that two rotations are applied as explained below:

- First rotation extends for 15 days to irrigate reclaimed areas (I-2, I-3, I-4) of the main branch canals. For this purpose, cross regulator located at 45$^{th}$ km is closed to raise the water level at upstream side to irrigate two above mentioned canals. This rotation is further divided into two periods of 7 days and 8 days to maintain rotation between two main canals.
- Second rotation extends for 10 days to irrigate the branch canals within the semi-reclaimed areas (BC 10, 11, 13 and 14) by opening of cross regulator located at 51$^{st}$ km. This rotation is further divided into two periods of 4 days and 6 days to maintain rotation between the two above mentioned canals.
- As for the main branch canals within the non-reclaimed areas (BC 1, 2, 3, 5, 6, 7 and canal BC9) are concerned, a fixed amount of irrigation water is supplied by adjusting the head regulators of these canals based on the irrigation requirements of the area.
- For canal I-1 and its branches within the reclaimed area, the irrigation water is pumped at fixed amounts according to the irrigation requirements of the area during the season.

## 2.2 Great Mussyib Irrigation Project

This project area represents the typical environment and climate of the central region of Iraq. The project construction work started in 1952 and finished in 1956. Soon after its completion, project maintenance problems started emerging which resulted in large scale deterioration. During 1965-1980, project development started again and drainage issues were resolved (golden stage). However, after 1980s, project again went into the negligence phase and drainage problems started surfacing which ended up in low productivity and large scale land degradation.

The project lands are located on the left bank of Euphrates River next to Al-Mussyib City – Babylon governorate. In the North, the project area is bordered by the lands irrigated from Al-Iskandarya and Latifya canals whereas in the South the project is bordered by lands irrigated from Mahawel canal and Babylon canals. In the East, project extends up to the areas irrigated from Tigris River and serves the population of Mahaweel, Al-Imam and Al-Neel districts of the Babylon governorate. The total area of the project is 344780 Donums (85,197 acres) with net irrigated area of 267000 Donums (65,977 acres). Water is supplied to the project from Euphrates River by the unlined main canal (except for the first 500m which is lined). The main canal took off from left side of the Euphrates River - 9.6 km upstream of the north of Al-Hindya barrage. This canal flows to the East until it reaches the lands irrigated from Tigris River within the Wasit governorate. The canal intersects with Baghdad-Hilla main road at the 12$^{th}$ kilometer.

The total length of this main canal is 49.5 km with a design discharge of 40 $m^3/s$. There are 13 branch canals off-taking from both sides of this main canal. The branch canals feed the distributary canals which flow into the farms. All of these canals are unlined. Also, there are farmers' private benefit canals on the main canal. There are three cross regulators on the main canal at the distances of 10, 28, 43 km from the head to control and manage the water levels to ensure the rotation between the branch canals.

The drainage network consists of open field drains which flow into collector drains which in turn flow into branch and secondary drains connected to the main drains of the project (south, north and great drain after its completion). A closed field drain was also built in some parts of the project area but now it is not functional.

Project lands were divided into investment units of 66 donums (15 acre. Farmers and investors were given agricultural lands on rent in small units of 330m x 500m (41 acres) dimensions. Main crops in the project area are: wheat, barley, alfalfa, clover and vegetables in winter whereas corn, alfalfa, clover, cotton, sunflower, sesame and different vegetables in summer. The cropping intensity for the project area is 80% in winter and 20% in summer. The design water duty for the project is 1$m^3$/s/6600 donum (1$m^3$/s/1500 acre).

### 2.2.1 Description of irrigation network

This project is irrigated by unlined main canal (except for the first 500m) which off-takes from the left side of Euphrates River, 9.6 km upstream of Al-Hindiya barrage The design discharge of this main canal is 40 $m^3$/s, with a total length of 49.5 km. The irrigation network of this project consists of the main irrigation canals (branches) and 13 branch canals covering a total length of about 95 km. Seven branch canals are on the right side of the main canal (with a total length of 42.5 km and total design discharge of 36.95 $m^3$/s) and six branch canals are on the left side of the main canal (with a total length of 52.6 km and total design discharge of 37.65 $m^3$/s) (see Table 6 and Figure 3). In addition, there are 9 direct distributary canals from Mussyib main canal (with a total length of 27.25 km and total discharge 6.68 $m^3$/s). These distributary canals are of different lengths and capacities and directly feed the farm units of the farmers. There are two types of distributary canals. First public benefit distributary canals (discharge more than 400 l/s) which are maintained by the Ministry of Water Resources and second private benefit distributary canals (discharge less than 400 l/s) which are maintained and managed by farmers. The total length of private distributary canals are 753km long whereas public distributary canals are only 168km (Annex 7). This shows that farmers have greater responsibility of management and maintenance of irrigation network. All canals of the project are unlined including Mussyib main canal. Table 6 gives the description of different branch canals of the Al-Mussyib project area whereas Table 7 gives details of the types and functions of different structures installed in the Great Mussyib project:

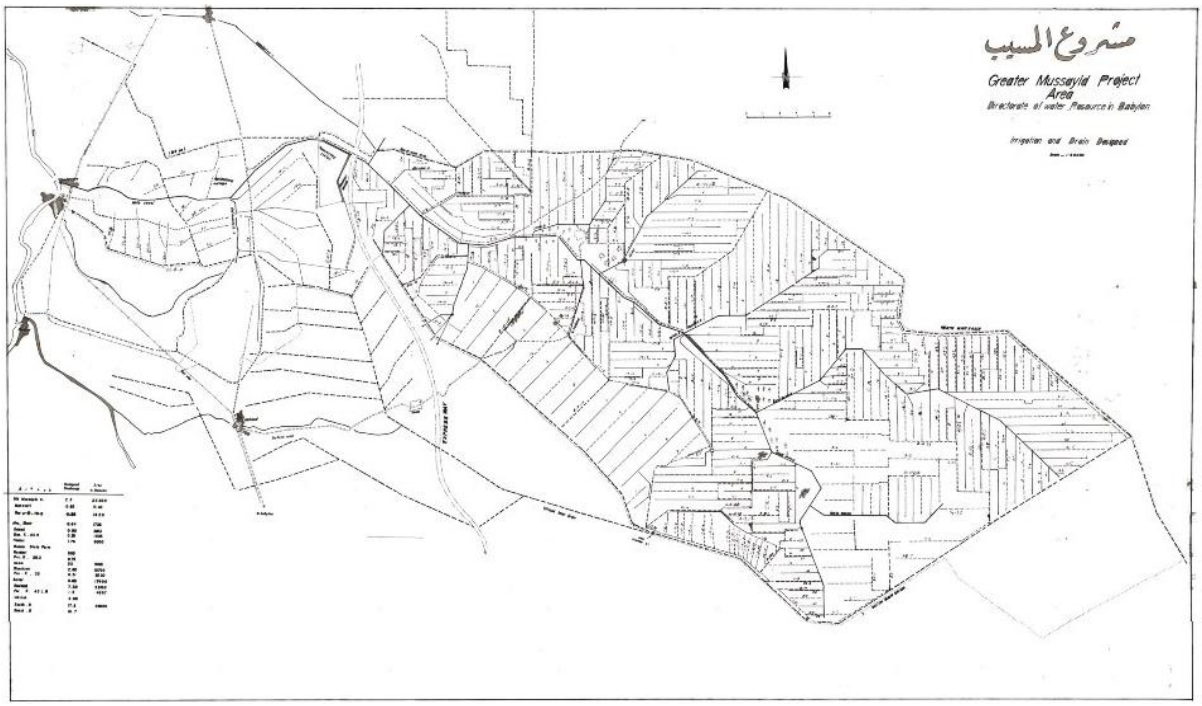



Figure 3: Map of the Al-Mussyib Project area

**Table 4:** Description of Mussyib Branch Canals.

| No. | Branch name | Offtake side | Length (km) | Q ($m^3/s$) | No. of distributaries | Irrigated area (dounm) | Distance from Head (km) |
|---|---|---|---|---|---|---|---|
| 1 | Old mussyib | right | 4.5 | 4 | 3 | 22796 | 10 |
| 2 | Al-Mansouri | right | 4.5 | 0.75 | 3 | 4157 | 19.3 |
| 3 | Abu Shair | left | 1.5 | 0.5 | 4 | 1415 | 22.2 |
| 4 | Dulaimy | right | 3.5 | 1.95 | 7 | 3149 | 23.98 |
| 5 | Hamiyar | left | 2.5 | 1.95 | 4 | 4374 | 24.85 |
| 6 | Al-Haidari | right | 4.5 | 2.2 | 5 | 11906 | 28 |
| 7 | Imam | left | 8 | 3.8 | 12 | 10000 | 31.99 |
| 8 | Kharbana | right | 5.5 | 4.25 | 7 | 10988 | 35.4 |
| 9 | Akaer | left | 8.7 | 7.1 | 11 | 14268 | 37 |
| 10 | Rashaid | left | 9.4 | 7.3 | 27 | 22980 | 43 |
| 11 | Ajrish | right | 5 | 7.8 | 10 | 19048 | 43.5 |
| 12 | Zubaidy | left | 22.5 | 17 | 51 | 39360 | 49.5 |
| 13 | Hilaly | right | 15 | 16 | 38 | 43488 | 49.5 |
| **sub total for right side** | | | 42.5 | 36.95 | 73 | 115532 | |
| **sub total for left side** | | | 52.6 | 37.65 | 109 | 92397 | |
| **TOTAL** | | | 95.1 | | 182 | 207929 | |

**Table 5:** Types and functions of Irrigation infrastructure in the Mussyib project area

| No. | Structure type | Function |
|---|---|---|
| 1 | Mussyib main canal head regulator | Control water entrance to the main canal |
| 2 | 3 cross regulators on the Mussyib main canal | Control water levels in the main canal |
| 3 | Branch canals head regulators | Control water entrance to the branch canals |
| 4 | Distributary canals head regulators | Control water entrance to the distributor canals |
| 5 | Branch canals cross regulators | Control water levels in the branch canals |
| 6 | Weirs | Provide irrigation water to the farm intakes in its upstream |
| 7 | Farm intakes | A small structure to provide irrigation water to farm units |
| 8 | Tail escapes | Discharges surplus irrigation water to the drains |
| 9 | People and vehicles bridges | Provide roads to the vehicle and people |

### 2.2.2 Description of drainage network

The drainage network of this project consists of open field drains surrounding the arm units with a spacing of 330m between drains. The total length of field drains in the entire project is 1472 km. In addition there are closed field drains installed in some parts of the project. The total length of closed field drains is 379 km. These drains have a spacing of 70-100 m between field drains and depth between 2-2.4 m. Most of these drains are non-functional now due to lack of maintenance. Field drains are connected to the collector and the main collector is connected to the branch drains. There are 56 branch drains in the project area with a total length of 243 km. These drains are finally discharged into the main drains of the project (north, south and great drain). Details of these drains are given below (see also Annex 8):

- 23 branch drains with total length of 118 km are connected to the main south drain.
- 3 branch drains with total length of 9.75 km are connected to the main north drain.
- 30 branch drains with total length of 115.5 km are connected to the great drain

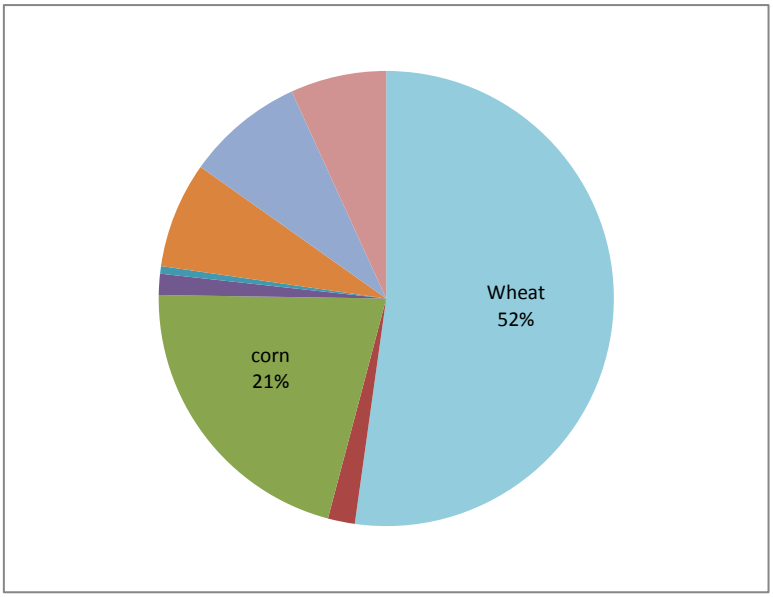
The total length of these main drains (south, north and great drain) is 69 km. On the passage of the drainage network there are many culverts, siphons and bridges. All left side drains discharge their water into the great and north drain while the right side drains are discharged into the south drain. The south drain is then discharged into the great drain through Kesh pumping station which is one of the biggest drainage stations located in Kesh area within the Al-Neil district, 35 km away from Babylon governorate center. The main pumping station site comprises of three stations (old Kesh station, new Kesh station and horizontal station). This pumping station extract drainage water from the right side of the project and discharge it to a canal connected to the main south drain located 33 km from the junction between south drain and the great drain. Operation of the pumping stations depends on the water level in the south drain at the pumping station.

### 2.2.3 Cropping pattern (winter and summer season)

Wheat in winter and corn in summer represent the main cropping pattern in the project area. In addition barley, alfalfa, clover, and different vegetables are grown in winter whereas white maize, cotton, sunflower, sesame, chickpeas, alfalfa, clover and different vegetables are grown in summer. Designed water duty for the project is 1 $m^3/s$/6600 donums (1 $m^3/s$/1630 acres). Table 8 shows the actual cultivated area within the project from 2006 to 2010 based on the data collected from the Ministry of Agriculture.

Table 6: Cultivated areas under different crops in the Al-Musasyib project area during 2006-2010.

| Year | Wheat | Barley | corn | cotton | sunflower | other crops | winter vegetables | summer vegetables | Total |
|---|---|---|---|---|---|---|---|---|---|
| 2006 | 85063 | 3146 | 36964 | 1803 | ------ | 11134 | 9113 | 6242 | 153465 |
| 2007 | 84341 | 3000 | 40950 | 3096 | 2996 | 11993 | 12550 | 12350 | 171276 |
| 2008 | 67078 | 3163 | 29843 | 2864 | 249 | 12298 | 12944 | 15177 | 143616 |
| 2009 | 82564 | 2578 | 29601 | 2227 | 33 | 12080 | 15277 | 10358 | 154718 |
| 2010 | 83419 | 2871 | 25446 | 1544 | 32 | 10559 | 14652 | 8408 | 146931 |
| **Average** | **80493** | **2951.6** | **32560.8** | **2306.8** | **827.5** | **11612.8** | **12907.2** | **10507** | **154001.2** |



### 2.2.4 Management, operation and maintenance

Irrigation system of the project operates on a rotational system. Main branch canals of the project works on two rotations. The discharge between these two main rotations is controlled by adjusting regulators (Figure 4). Table 9 shows a monthly pattern of the rotational system. According to this table, first rotation consists consists of 4 branch canals from the right side of the project and two from the left side with a total design discharge of 36.7 $m^3/s$. The second rotation consists of 4 branches from the left side and three from the right with a total design discharge of 37.9 $m^3/s$. The rotational system is based on opening the canals for 4 continuous days and closing for 6 days except for Hilaly and Zubaidi canals for which opening and closing is for 5 days because they irrigate larger areas as compared to the other canals. The actual discharges of the main canal vary from month to month depending on the season and crops grown. Table 10 shows the average discharge in Mussyib main canal for the year 2011 allocated based on the existing agricultural plan of Babylon Governorate.

Figure 4: View of typical regulators to control flows in the irrigation canals.

Table 7**:** Rotational system for the Mussyib main canal and Branches for the period (22.11.11 to 21.12.11) (*Source: Water resources office of Great Musaib Project*)

| no. | Branch Name | length (Km) | Irrigated area (Donum) | Design Discharge ($m^3/s$) | 22/11 | 23/11 | 24/11 | 25/11 | 26/11 | 27/11 | 28/11 | 29/11 | 30/11 | 1/12 | 2/12 | 3/12 | 4/12 | 5/12 | 6/12 | 7/12 | 8/12 | 9/12 | 10/12 | 11/12 | 12/12 | 13/12 | 14/12 | 15/12 | 16/12 | 17/12 | 18/12 | 19/12 | 20/12 | 21/12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FIRST ROTATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Zubaidy | 22.5 | 39360 | 17 | X | X | X | X | X | O | O | O | O | O | X | X | X | X | X | O | O | O | O | O | X | X | X | X | X | O | O | O | O | O |
| 2 | Rashaid | 9.4 | 22980 | 7.3 | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X |
| 3 | Kharbana | 5.5 | 10988 | 4.25 | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X |
| 4 | Al-Haidari | 4.5 | 11906 | 2.2 | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X |
| 5 | Dulaimy | 3.5 | 3149 | 1.95 | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X |
| 6 | old mussyib | 4.5 | 22796 | 4 | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X |
| | **sub total** | | **111179** | **36.7** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | **SECOND ROTATION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Hilaly | 15 | 43488 | 16 | O | O | O | O | O | X | X | X | X | X | O | O | O | O | O | X | X | X | X | X | O | O | O | O | O | X | X | X | X | X |
| 8 | Ajrish | 5 | 19048 | 7.8 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| 9 | Akaer | 8.7 | 14268 | 7.1 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| 10 | Imam | 8 | 10000 | 3.8 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| 11 | Hamiyar | 2.5 | 4374 | 1.95 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| 12 | Abu Shair | 1.5 | 1415 | 0.5 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| 13 | Mansouri | 4.5 | 4157 | 0.75 | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X | O | O | O | O | X | X | X | X | X | X |
| | **sub total** | | **96750** | **37.9** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

*x = closed, o = open*

(*Note: In emergency cases such as floods, main canal is closed and the rotational system is readjusted based on closed number of days)*

Table 8: Average discharge ($m^3/s$) in Mussyib main canal for the year 2011

| month | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Discharge | 10 | 6 | 21 | 23 | 18 | 20 | 25 | 25 | 20 | 18 | 17 | 16 |

In the project area, canals are operated on the basis of high and low irrigation demand. In the high irrigation demand period, main canal is run on full authorized discharge. In the low irrigation demand period, the discharge is limited to drinking water demands. Table 11 shows the periods of high and low irrigation demand in a year.

Table 9: High and low irrigation demand periods in a year

| Season | Irrigation intensity | Period |
|---|---|---|
| winter | high irrigation(first planting) | 1/11 to 15/12/2010 |
| winter | low irrigation | 16/12 to 31/1/2011 |
| winter | high irrigation (second) | 1/2 to 15/2 /2011 |
| winter | low irrigation | 16/2 to 14/3/2011 |
| winter | high irrigation (last) | 15/3 to 15/4/2011 |
| winter | low irrigation | 16/4 to 30/6/2011 |
| summer | high irrigation | 1/7 to 10/7/2011 |
| summer | low irrigation | 11/7 to 15/7/2011 |
| summer | high irrigation | 16/7 to 25/7/2011 |
| summer | low irrigation | 26/7 to 30/7/2011 |
| summer | high irrigation | 31/7 to 9/8/2011 |
| summer | low irrigation | 10/8 to 14/8/2011 |
| summer | low irrigation | 15/8 to 31/10/2011 |

Table 11 shows that there are three high irrigation periods during winter season and three in the summer. These high irrigation periods are in accordance with the water requirements of the main crops grown during these periods. For selecting high irrigation periods, wheat and corn are considered as the main winter and summer crops, respectively.

# 3 Data Collection

Data collection process faced a lot of difficulties in the beginning of the project because most of the information expected from the Ministry of Water Resources (MoWR) was not available from their responsible directorates. Moreover, the little data that was available was very old and did not represent the current status of Dujaila and Mussyib projects. The project team, therefore, had to explore new sources for information to collect data from two projects sites. The team carried out many site visits, field surveys and interviews with officials from irrigation and agricultural departments to get the needed information. Most of the collected data i.e. maps, tables and reports, were in paper form. Therefore to perform any meaningful analysis, this data and information were converted into electronic form, checked and analyzed.

## 3.1 Sources of data collection

- Various directorates of MoWR (Baghdad and local sites).
- Previous studies and research done related to soil salinity in Iraq, especially for the two selected projects.
- Field trips and field surveys to the Dujaila and Great Mussyib projects.
- Meetings with officials from the irrigation and agriculture offices in the projects sites.
- Water sampling for the irrigation and drainage water quality.
- Meetings and interviews with the farmers.
- Information from internet.

### 3.2 Description of collected data

The data collected from different sources includes:

- Irrigation and drainage network design in the targeted project areas (historical and current status).
- Information on operation and maintenance of irrigation and drainage networks that includes water allocation for projects, drainage water effluent as well as the responsibilities of operation and maintenance.
- Water allocation for farmers and lands (water ration).
- Cropping pattern (winter and summer).
- Irrigation and drainage water quality.
- Irrigation and drainage network maps. Physical verification of irrigation and drainage infrastructure.
- Historical data regarding irrigation, salinity build up, cropping patterns, irrigation practices.

## 4 Evaluation of the current status of irrigation and drainage infrastructure

### 4.1 Dujaila Project

To assess the current state of irrigation and drainage infrastructure, assessment was performed at two levels. Level 1 investigation include evaluation of cross regulators on the Dujaila main canal, performance efficiency and working of head regulators at the main branch canals, working of drainage system including main, branch and secondary drains and pumping stations. At the second level, evaluation of feeding canals and farm intakes and field and collector drains was performed. The work also included irrigation and drainage water sampling at different locations of the project. For this purpose, areas within the reclaimed lands of the concrete lined canals I-2, I-3, and I-4, semi-reclaimed areas within BC 9 and non-reclaimed areas within BC 6 were selected (Figure 5).

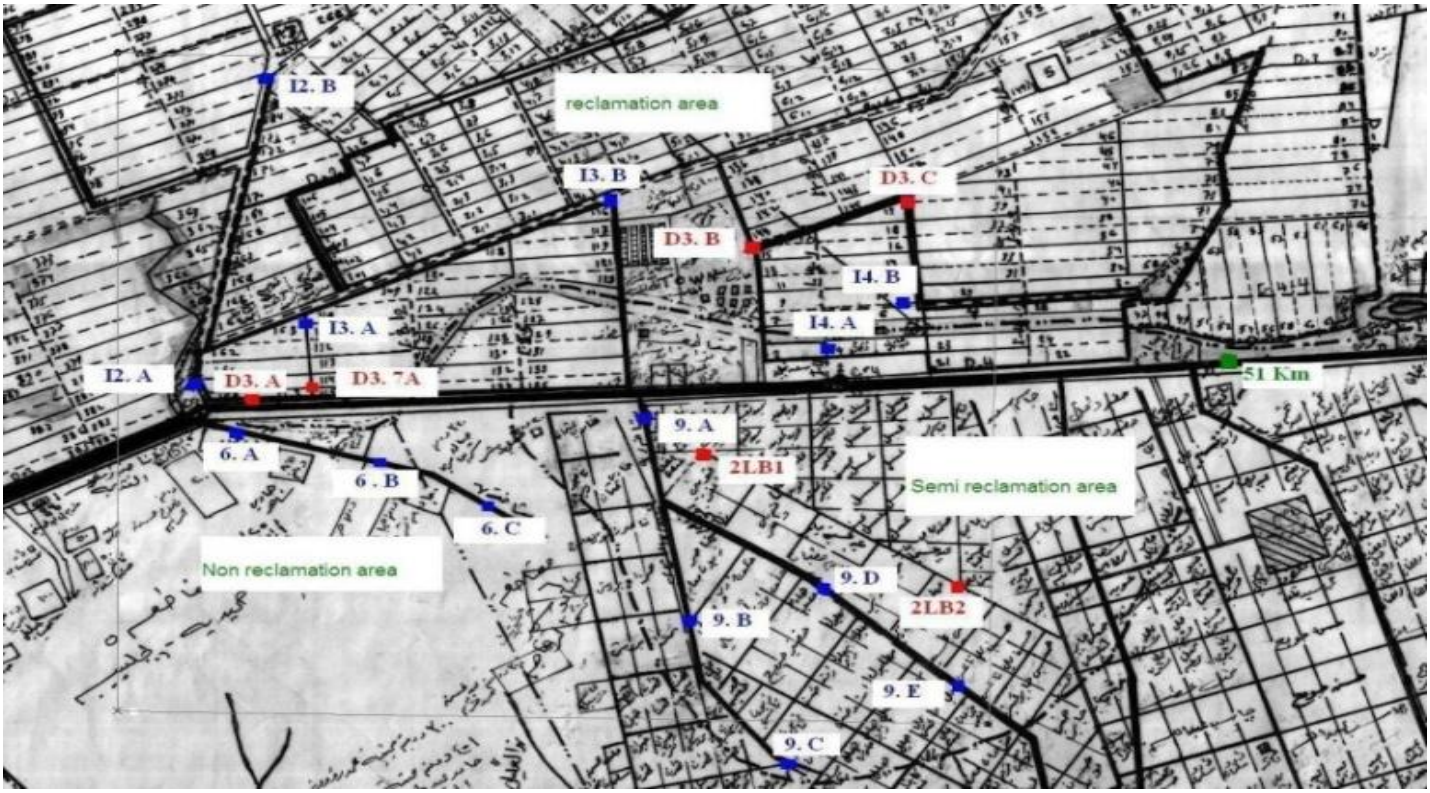



Figure 5: Areas selected for the monitoring of current status of irrigation and drainage infrastructure

Summary of results regarding the evaluation of irrigation canals and regulators is given in Table 12. Inspections during the field visit to irrigation canals have shown that in reclaimed area, most of irrigation and drainage infrastructure is in poor state and urgent maintenance and rehabilitation work is needed. The average efficiency of canal system and regulators is only 50-60 percent in reclaimed, semi-reclaimed and non-reclaimed areas of the Dujaila project. The computerized system of the cross regulators on the Dujaila main canal is totally damaged (Figure 6). The computers, along with many other components of the electrical control system have disappeared. Because regulators are controlled electro-mechanically with a simple electric system therefore the control set needs urgent and full rehabilitation. Concrete lining of canals have been damaged or collapsed, which is causing seepage and water losses problems. Main branch canal head regulators are operated manually/mechanically instead of electric control therefore needs continuous maintenance. The feeders and hydrants have also deteriorated at different levels.

Table 12: (a) Cross and head regulators evaluation -large scale

| Regulator type | Location | No. | Efficiency range | Average efficiency | Remarks |
|---|---|---|---|---|---|
| Main head | Tigris river | 1 | 70% | 70% | Maintenance required |
| Cross | Dujaila main canal | 5 | 50-60 % | 54% | Maintenance and rehabilitation required |
| Head | Non-reclaimed areas | 6 | 60-80 % | 67% | Maintenance and rehabilitation required |
| Head | Semi-reclaimed areas | 5 | 30-70 % | 54% | Maintenance and rehabilitation required |
| Head | Reclaimed areas | 5 | 50-70 % | 60% | Maintenance and rehabilitation required |

Table 12: (b) Dujaila main canal Branches evaluation – large scale

| No. of canals | Location | Canal type | Length (km) | Conveyance efficiency | Average conveyance efficiency | Status | Remarks |
|---|---|---|---|---|---|---|---|
| 6 | Non reclaimed | unlined | 72.5 | 60-80 % | 65 % | Medium | Many contradictions in design |
| 5 | Semi-reclaimed | unlined | 83 | 50-70 % | 58 % | Average | Many contradictions in design |
| 5 | Reclaimed | lined | 40.8 | 80 % | 80 % | Medium-Good | Many contradictions in design |
| 54 small | All of the project on both sides | unlined | | 50-70 % | 60 % | Average | Less than 400 l/s discharge , without head regulators |

Table 12: (c) Feeders and farm intakes evaluation (Reclaimed areas)

| Feeders evaluated | Evaluation locations | Average gates efficiency | Remarks about gates | Length of evaluated feeders (km) | Average feeders status | No. of farm intakes | | | | Remarks about feeders and outlets |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | total | working | Not working | Not working (%) | |
| 51 | Canals I-2, I-3, I-4 | 59% | Disabled or lost gate | 70.75 | medium | 962 | 241 | 721 | 25% | Maintenance required |

Table 12: (c) Feeders and farm intakes evaluation (Semi-reclaimed areas)

| Feeders evaluated | Average head regulators/ gates efficiency | Remarks about gates | Length of evaluated feeders (km) | Average feeders state | Average convey efficiency | Remarks about feeders |
|---|---|---|---|---|---|---|
| 34 | 40 % | Broken or lost gates | 56.90 | Average | 51% | Unlined canals and levels below design |

Table 12: (c) Feeders and farm intakes evaluation (Non-reclaimed areas)

| Feeders evaluated | Average head regulators/ gates efficiency | Remarks about gates | Total length of evaluated feeders km | Average feeders status | Average convey efficiency | Remarks about feeders |
|---|---|---|---|---|---|---|
| 16 | 40 % | Lost gates | 34.2 | Average | 51 % | Unlined canals and levels below design |

Figure 6: View of collector drain, damaged bridge and electromechanical regulators.

In the semi-reclaimed and non-reclaimed areas, cross regulators on main canal are old and have deteriorated over time and needs extensive repair. The irrigation canals in these areas (public or private benefit) are unlined and have lost their carrying capacity due to continuous negligence. Flows in these canals are badly restricted because of weeds, plants growth, and deposition of sediments. Over the past many years, these canals were continuously cleaned using hydraulic excavators and other heavy machinery. As a result, these canals have lost their design cross sectional dimensions and these channels have become many times larger than their designed dimensions. This has resulted in huge water losses through seepage leading to increased groundwater levels.

The irrigation water quality across the project during summer of 2011 ranged between 1.1-1.3 dS/m with an average 1.2 dS/m. The evaluation of drains and drainage structures in the Dujaila project on the large spatial scale is described in annexes 5 and 6. The assessment results of drain's efficiency in the project at all levels is shown in Table 13.

Table 13: Assessment of drain's efficiency in the Dujaila project at all levels

| Location | Main drains | | Branch drains | | Collector drains | | Field drains | |
|---|---|---|---|---|---|---|---|---|
| | Avg. effic. | Remarks | Avg. effic. | Remarks | Avg. effic. | Remarks | Avg. effic. | Remarks |
| Reclaimed areas (I-1, I-2, I-3, I-4) | 70% | Cleaning work being done. | 70% | Cleaning work being done. | 50% | Few maintenance works (private benefit) | 20% | most of them are non-functional due to lack of maintenance. |
| Reclaimed areas BC8 | 70% | Cleaning work being done. | 70% | Cleaning work being done. | 50% | Few maintenance works (private benefit) | 20% | most of them are non-functional due to lack of maintenance. |
| Semi reclaimed areas BC9,10,11 | 60 % | Cleaning work being done. | 60% | Cleaning work being done. | 50% | Few maintenance works (private benefit) | none | none |
| Semi reclaimed areas BC 13,14 | 50% | Requires additional cleaning work using special excavators because of its wide cross section | 60% | Cleaning work being done. | 50% | Few maintenance works (private benefit) | none | none |

The range of drainage water quality across the main drains during summer of 2011 is between 9.2-10.7 dS/m with an average of 9.8 dS/m.

### 4.1.1 Status of drainage pumping stations

The current status of drainage pumping stations is given in Table 14.

Table 14**:** Project drainage pumping stations evaluation results

| Pump station name | No. of pumps | Total discharge $m^3/s$ | Efficiency (%) | Remarks |
|---|---|---|---|---|
| BC 8 pump station | 5 | 7.5 | 60 | Two pumps are broken and requires maintenance, building requires rehabilitation |
| BC 10 pump station | 3 | 3 | 50 | Requires replacement of all pumps, building requires rehabilitation |
| BC 13 pump station | 6 | 12 | 50 | Two pumps are broken and requires maintenance, building requires rehabilitation |

### 4.1.2 Summary of Dujaila project area problems

The project's drainage system suffers from many problems. A summary of these problems related to the drainage network as well as pumping stations is as follows:

- Field drainage system is completely deteriorated as most of the field drains are out of order due to lack of cleaning works for a long time.
- Efficiency of the collector drains has declined in all of the reclaimed areas due to lack or absence of required maintenance work. Cleaning of collector drains is the farmers' responsibility and they have not given any importance to this task.
- Sediments, weeds growth, and clogs in some of the main and branch drainage system has choked the system.
- There is deficiency of pumping stations for drainage. Most of the existing pumping stations are out of order and needs immediate maintenance and rehabilitation work for the pumps and reconstruction of buildings.

### 4.1.3 Irrigation efficiency of the Dujaila project

The results of the field experiments to evaluate the irrigation efficiency conducted by Ministry of Agriculture in another project with same conditions some years ago were considered as a reference to estimate the irrigation efficiency in Dujaila project (irrigation efficiency = conveyance efficiency X application efficiency). The estimated irrigation efficiency of the different project areas is given in Table 15.

Table 15: Irrigation efficiency of reclaimed, semi-reclaimed and non-reclaimed areas of the project.

| Location | Conveyance efficiency (%) | Application efficiency (%) | Total Irrigation efficiency (%) | Design efficiency according to irrigation type and field application method |
|---|---|---|---|---|
| Reclaimed area | 80 | 48 | 38 | 63% (lined canals 90%, surface irrigation 70%) |
| Semi reclaimed area | 58 | 48 | 28 | 49% (unlined canals 70%, surface irrigation 70%) |
| Non reclaimed area | 65 | 48 | 31 | 49% (unlined canals 70%, surface irrigation 70%) |

The comparison of existing irrigation efficiency with the designed efficiency indicates a high percentage of water losses in the entire project area despite the scarcity of irrigation water and that a large area of the project is covered by concrete lined irrigation network.

The cropping intensity in the project area during 2006-2012 remained about 42 percent. The lower cropping intensity in the project area was mainly due to shortage of water from the Tigris River. Equally important problems are the lack of irrigation and drainage infrastructure leading to land deterioration problems specially the salinity problem and its negative effects on the agriculture productivity.

## 4.2 Great Al-Mussyib Project

### 4.2.1 Assessment of the current status of the project

In order to assess the current status of the project's infrastructure, the investigations were done on two main levels. The first level consists of assessing the main canal and the branch drains including branch canal's cross and head regulators. It also includes evaluation of the main branches and secondary drains and drain pumping stations.

The second level of assessment includes a spatial scale evaluation of water allocations between farmers and distributary canals and farm intake structures. In addition, on-farm irrigation methods and their efficiency, field drains and collector drains were also evaluated.

In order to carry out a detailed assessment on the second level, one of the branch canals (Akaer canal) of the main canal was selected. The distributary canals and drainage network associated with this canal was also selected to represent the entire project's lands (Figure 7). Akaer canal is one of the branches of the Mussyib main canal. It off-takes at the 37$^{th}$ km left side of the main canal. The total length of canal is 8.7 km with a design discharge of 7.1 m$^3$/s. The total command area of this canal is 14268 donums (3526 acres) out of which 17000 donums (4200 acres) are irrigated. In total 11 distributary canals off-takes from Akaer canal. Out of this, 10 are private benefit and one public benefit canal. In addition, there are other 7 secondary distributary canals.

The drainage network consists of 241 open field drains connected to 21 collector drains which are connected to two branch drains surrounding the Akaer area and discharging the drainage water into the great drain. Detailed description of irrigation and drainage network for Akaer area is shown in annex 9.

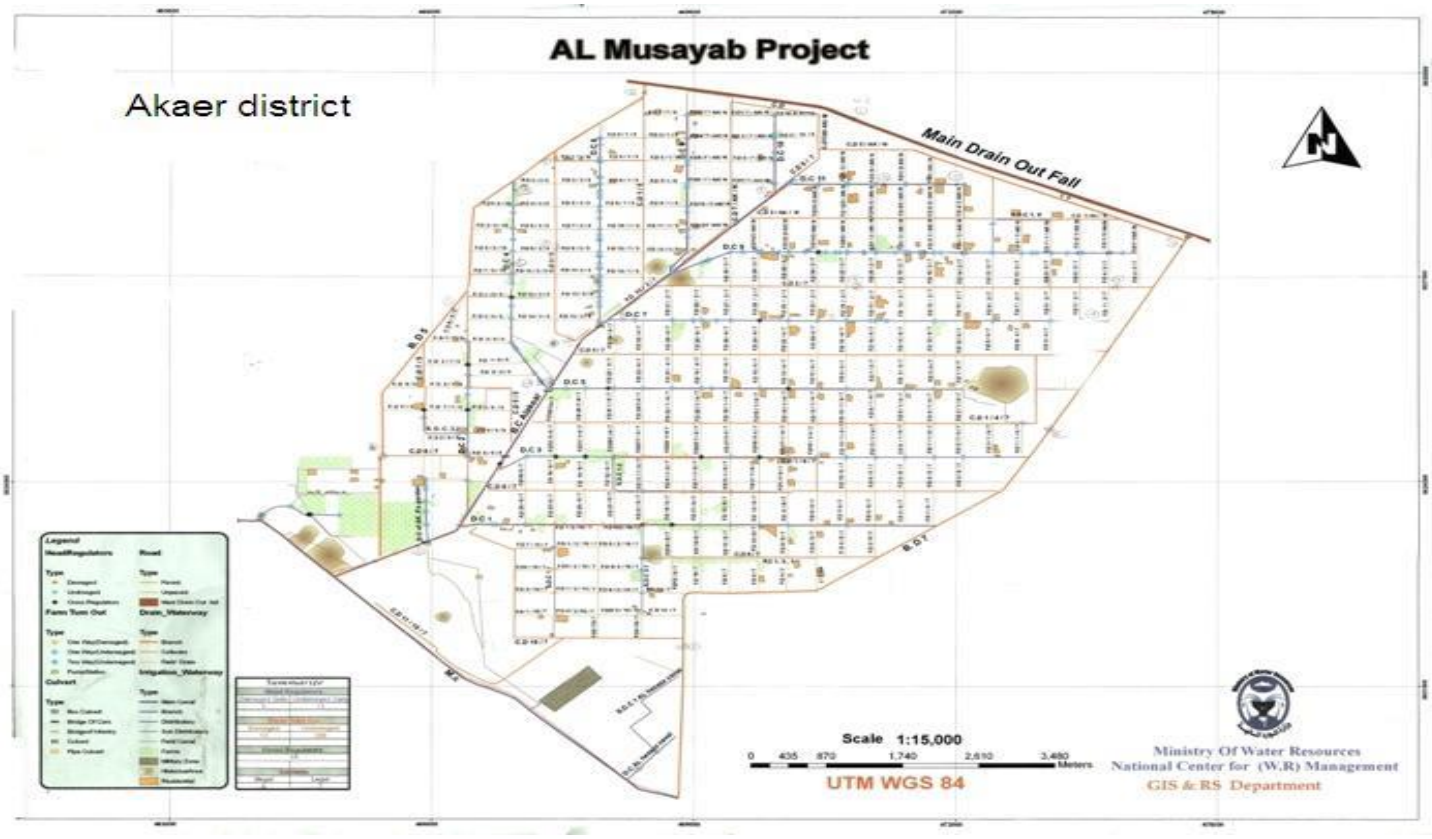



Figure 7: Map of the Al-Kaer district

### 4.2.1 Status of irrigation canals and structures

The irrigation network of the project is composed of unlined canals. These canals have lost their design cross sections and carrying capacity due to continuous negligence of maintenance. This has increased the irrigation water losses through seepage, causing high ground water levels. Moreover, these new cross sectional dimensions have caused decrease in irrigation water levels at the farm intakes and weirs. This has prompted farmers to lower their farm intakes and weir levels and install water pumps directly on the canals. The beneficiaries from these distributaries changed these structure levels in order to pass the water to their canals because the structure level is higher than the irrigation water levels upstream.

Despite some maintenance on the irrigation structures (public benefit structures) every year, all of these structures and the private benefit structures are in bad shape due to age and poor maintenance. Many of them have completed their lifespan and needs intensive rehabilitation which requires additional financial allocations to execute required rehabilitation work. Table 16 shows a summary of the current status and efficiency of the existing irrigation infrastructure.

Table 16**:** Summary assessment for the project structures

| | Structure type | Function | Efficiency | Remarks |
|---|---|---|---|---|
| 1 | Mussyib canal head regulator | Control water flow to main canal | 70% | *Under annual maintenance- works good* |
| 2 | 3 cross regulators on the main canal | Control water levels within the main canal | 65% | *Under annual maintenance- works good* |
| 3 | Branch canals head regulators | Control water flow to the branch canals | 65% | *Under annual maintenance- works good* |
| 4 | Distributor canals head regulators | Control water flow to the distributaries | 40% | *Private benefit, poor maintenance*<br>*Most of its levels were lowered* |
| 5 | Branch canals cross regulators | Control water levels in the branch canals | 50% | *Modified because of the low water levels in its upstream* |
| 6 | weirs | Provide irrigation water to the farm intakes in its upstream | 0% | *Useless because of the low water levels resulting from bad maintenance works*<br>*The levels of these structures are lowered in order to provide water to the tail parts of the canal* |
| 7 | Farm intakes | Small structure to pass water to the farm units | 0% | *It's been demolished by farmers because of the low water levels in its upstream and replaced by lower level pipes* |
| 8 | Tail escapes | Overflow irrigation water to the drains | 0% | *Completely demolished because of the deepening of canal and the low water levels* |
| 9 | Bridges for vehicles and people | Provide roads to the vehicles and people | 50% | *Needs maintenance works* |

### 4.2.2 Status of drainage network

Most of the open field drains and collector drains are not cleaned and maintained because they are private property and the responsibility lies on the beneficiary farmers. Consequently these drains have low efficiency causing groundwater table to rise which contribute to the salinity problem. The distance between field drains is 330 m which is not effective in draining the water on time. Therefore it is suggested that the network of field drains should be redesigned keeping in view soil characteristics, cropping pattern and existing irrigation water quality. The main and secondary drains are also poorly maintained by the irrigation department.

Therefore, despite this maintenance, all drainage structures (public benefit) are working with efficiency between 50-60%, while the pumping stations are rehabilitated recently and are working with good efficiency (Table 17).

Table 107: Status of pump stations

| No. | Pump station name | No. of pumps | Pump type | Operation | Discharge | Date of construction | Efficiency | Remarks |
|---|---|---|---|---|---|---|---|---|
| 1 | New Kesh pump station | 5 | vertical | electric | 3.375 | Seventies | 80% | pumps works good |
| 2 | Old kesh pump station | 5 | vertical | electric | 1.6 | Since project beginning | 70% | pumps works good |
| 3 | support horizontal kesh pump station | 3 | horizontal | diesel | 1 | Since project beginning | 70% | pumps works good |

### 4.2.3 Irrigation efficiency in the project area

Based on the data collected by the Ministry of Agriculture under the project 'national program for efficient use of water resources in Euphrates river basin', average conveyance efficiency of the main, branch and distributary canals is 63% while the average application efficiency is around 48%. This makes the overall average irrigation efficiency equal to 30.24%. These values are substantially lower than the generally considered irrigation efficiencies of unlined canal systems with surface irrigation methods (50%). The lower irrigation efficiency indicates high water losses in the project area. These high field losses together with non-operational field drainage system are the major reason for rising groundwater levels and increase in the soil salinity problems in the project area. The cropping intensity in the project area is about 58%. Shortage of good quality irrigation water, increasing soil salinization problems and poor maintenance of irrigation infrastructure by farmers are major reasons for low cropping intensities.

### 4.2.4 Technical and administrative problems

In addition to the infrastructure problems in Dujaila and Great Mussyib projects, there are other technical and administrative problems which contribute to the deterioration of these projects. These include:

- Illegal interventions by farmers in the water allocation process results in water shortages in many parts of the project especially in the areas located away from the main project head.
- In the areas downstream of the branch canals, farmers do not follow the rotational system and draw larger amounts of water than their actual share. In addition, they also install illegal irrigation intakes and water pumps on irrigation canals (Figure 8). Intentional and unintentional damage to the distributary canal head regulators (private use) has also become common. The illegally extracted water is usually used to irrigate unauthorized agricultural land and for fish ponds.
- Shortage of transport to follow the operation and maintenance works and remove the farmer interventions.
- Shortage of machinery, technical staff and finances to carry out cleaning work on canals and drains. Most of the cleaning work is done by the operation and maintenance directorates of MoWR.
- Lack in technical and financial abilities of farmers to carry out needed maintenance work for field and collector drains and the rehabilitation of head regulators for the private use irrigation canals.
- Lack of farmers' awareness in the importance of the efficient use of irrigation water to avoid problems of waterlogging and soil salinization.

- Absence of water users associations. Presence of water users associations can help in organizing to carry out needed operation and maintenance work, ensure equitable water allocation and improve management of irrigation water at the farm scale.


Figure 8: Illegal pump installed on irrigation canals and view of a choked drain.

## 5 Conclusions

During the process of this assessment, it was strongly realized that existing status of irrigation and drainage infrastructure is directly responsible for the increasing soil salinization and reduction in land and water productivity in the project areas. Based on the comprehensive assessment, we can draw the following conclusions.

- Irrigation networks are old and deteriorated to a large extent due to lack of maintenance. In addition, there are large scale farmer interventions which are further complicating the water scarcity and management problems. These include: noncompliance of the rotational system, illegal water extraction from irrigation canals, irrigating unauthorized agricultural lands and establishment of illegal fish ponds. All these factors led to serious water allocation problems causing water scarcity in many regions of the projects. On the other hand, irrigation efficiencies in the project area are very low which is causing huge field water losses. These water losses not only create water shortage for other parts of the project but also create waterlogging and soil salinity problems
- Low drainage system efficiency on the field and collector drains as a result of lack of cleaning and maintenance work contributes in drainage system disorder and rise in groundwater levels.
- Limited financial allocations to the maintenance and rehabilitation work are the major problems in maintaining the irrigation and drainage infrastructure. This is particularly true for the maintenance of lined irrigation canals and rehabilitation of control systems i.e. gates, regulators, drains and pumping stations.
- Lack of interest of farmers in the management of irrigation and drainage infrastructure and improvements in the on-farm water use efficiency is is the major reason so far as soil salinity development is concerned.

# 6 Annexes

Annexes attached

# 7 Literature consulted


- Water resources directorate in Wassit / MOWR.
- Water resources directorate in Babylon / MOWR.
- Water resources section in Dujaila/ MOWR.
- Water resources section in Mussyib / MOWR.
- Agriculture directorate in Wassit / MOA.
- Agriculture directorate in Babylon / MOA.
- National program for efficient use of water resources in Euphrates river/MOA.
- Irrigation encyclopedia in Iraq / MOWR.
- Mussyib project - general view/ Study by Eng. Haider A. Mutasher and Fadhel A. kassim / MOWR
- Interviews with irrigation officials in Dujaila and Mussyib projects
- Field visits documentation.

## Annex 1. Rotational table for Dujaila main and branch canals for winter season 2011-2012

| No. | locationL ration | interval ration | | taken measurements | notes |
|---|---|---|---|---|---|
| | | from | to | | |
| one | Before regulator no. 45 which includes: | 3/11/2011 | 18/11/2011 | Adjusting regulator no. 45 to elevate water for I-2,I-3,I-4,I-3-5 and their branches the canals | 1. any changes in table should be after the agricultural committee approval. 2. gates openings are guarded by a police force called by Wasit district director to ensure rule of law for the following locations: - canal I-2 Head - canal I-1-6 Head<br>- gate no 24 on canal I-2<br>-gate no 4 on canal I-4<br>- regulator km 51 on Dujailamain canal<br>- head regulator BC 13,14<br>- BC 9 head<br>-patrol force to insure pumps operation and closing gates and keep the canals adjusments 3. adjusting BC 1,2,3,5,6,7,9 and all other branches on Dujaila main canal from main Dujaila head regulator until km 45 and for both sides.<br>Canal I-2 and branches operates on 1 m pump all season long also canal I-1-6 operates on 0.5 m pump for all season long. |
| | 1. Canal I-2 Branches until gate no. 24 and canal I-4 until gate no.3 | 3/11/2011 | 10/11/2011 | closing gate no.24 on canal I-2 and gate no.4 provide the water for all the on canal I-4 and intakes upstream these two gates in addition canal I-3 , I-3-5 and BC 8 to | |
| | 2. canal I-2 branches downstream gate no.24 and canal I-4 downstream gate no 4 | 10/11/2011 | 18/11/2011 | closing the gates and branches upstream gate provide the water to the gates no 24 and 4 to after and keep the pump for canal I-3-1-a during this interval to rotate between farmers | |
| two | After regulator no.45 which includes: | 18/11/2011 | 28/11/2011 | open all of the regulator no 45 | |
| | 1. before regulator no.51 for BC 10 and 11 and other branches | 18/11/2011 | 22/11/2011 | close or adjust regulator no 51 to provide the branches upstream operational water to the regulator | |
| | 2. after regulator no.51 for branches on the Dujaila main canal until km 57 and BC 13,14 and their branches | 22/11/2011 | 28/11/2011 | Entire opening for regulator no 51 to provide the branches on Dujaila main full discharge to and BC 13,14 and their , canal until km57 branches | |

**Annex 2**

**Structures and Canals located on Al Dujaila main canal**

| No. | | Structure name | Location (km) | Coordinates N | Coordinates E | Max. Discharge ($m^3/s$) | Structure Diameter (m) | Structure Dimensions (m) | Structure efficiency | Notes | Canal Name | Canal length km | Conveyance efficiency | Canal State | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | non reclaimed area | Head regulator | 0+00 | 32 29 50 | 45 48 55 | 42 | | 2(5*6) | 70% | Required maintenance work | | | | | |
| 2 | | Cross regulator 1 | 16+540 | | | 37.168 | | 3(5.22*3) | 50% | Ditto above | | | | | |
| 3 | | Cross regulator 2 | 29+653 | 32 27 15 | 46 5 10 | 28.975 | | 3(5*3) | 50% | Ditto above | | | | | |
| 4 | | Cross regulator 3 | 36+580 | 32 25 45 | 46 9 14 | 17.714 | | 3(4.87*3) | 60% | Ditto above | | | | | |
| 5 | | Cross regulator 4 | 45+572 | 32 22 15 | 46 13 33 | 14.934 | | 2(4*1.5) | 60% | Ditto above | | | | | |
| 6 | | Cross regulator Km 51 | 51+022 | 32 20 11 | 46 16 01 | 10 | | 1(2.1*2) 1(2.5*2) 1(2.2*2) | 50% | Ditto above | | | | | |
| 7 | | Head regulator B.C 1 | 16+570 | 32 29 27 | 45 57 53 | 1 | | 0.8*1 | 80% | Ditto above | B.C 1 | 5 | 80% | good | |
| 8 | | Head regulator B.C 2 | 16+604 | 32 29 27 | 45 57 56 | 2.5 | | 1*1.55 | 70% | Ditto above | B.C 2 | 11 | 70% | Medium | Lower elevation Design for water and C.R. |

| No. | | Structure name | Location (km) | Coordinates N | Coordinates E | Max. Discharge ($m^3/s$) | Structure Diameter (m) | Structure Dimensions (m) | Structure efficiency | Notes | Canal Name | Canal length km | Conveyance efficiency | Canal State | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | | Head regulator B.C 3 | 16+514 | 32 29 29 | 45 57 52 | 3 | | 1.5*1.45 | 70% | Ditto above | B.C 3 | 21 | 60% | Under medium | Ditto above |
| 10 | | Head regulator B.C 5 | 28+576 | 32 27 22 | 46 4 49 | 1.5 | | 1*1 | 60% | Ditto above | B.C 5 | 10.5 | 60% | Ditto above | Ditto above |
| 11 | | Head regulator B.C 6 | 28+645 | 32 27 20 | 46 4 52 | 1.5 | | 1*1 | 60% | Ditto above | B.C 6 | 12 | 60% | Ditto above | Ditto above |
| 12 | | Head regulator B.C 7 | 28+550 | 32 27 21 | 46 4 47 | 1.6 | 0.6 | 1.5*70 | 60% | Ditto above(structure and pipe) | B.C 7 | 13 | 60% | Ditto above | Ditto above |
| | | Average Convey efficiency for non-reclaimed area | | | | | | | | | | | 65% | | |
| 13 | semi reclaimed area | Head regulator B.C9 | 42+646 | 32 23 19 | 46 12 16 | 2 | | 1.5*1.4 | 70% | Ditto above | B.C 9 | 16 | 70% | medium | Ditto above |
| 14 | | Head regulator B.C 10 | 48+968 | 32 20 57 | 46 15 5 | 2.27 | | 2*1.30 | 60% | Ditto above | B.C10 | 12 | 60% | Under medium | Ditto above |
| 15 | | Head regulator B.C 11 | 51+000 | 32 20 12 | 46 16 00 | 1.18 | | 2*1 | 60% | Ditto above | B.C 11 | 12 | 60% | Under medium | Ditto above |
| 16 | | Head regulator B.C 13 | 57+000 | 32 17 57 | 46 18 53 | 3.5 | | 2.5*2.25 | 50% | Ditto above | B.C 13 | 18 | 50% | Under medium | Ditto above |
| 17 | | Head regulator B.C 14 | 57+000 | 32 17 58 | 46 18 50 | 3.5 | | 2(2*2) | 30% | Ditto above | B.C 14 | 25 | 50% | Under medium | Ditto above |
| | | Average Convey efficiency for semi reclaimed area | | | | | | | | | | | 58% | | |

| No. | | Structure name | Location (km) | Coordinates N | Coordinates E | Max. Discharge ($m^3/s$) | Structure Diameter (m) | Structure Dimensions (m) | Structure efficiency | Notes | Canal Name | Canal length km | Conveyance efficiency | Canal State | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | reclaimed area | Head regulator B.C I-1 | 29+684 | 32 27 13 | 46 05 27 | 5.95 | | 3*1.75 | 70% | Ditto above | B.C I-1 | 11.58 | 80% | good | Sabotage and lower water elevation |
| 19 | | Head regulator B.CI-1-6 | 34+842 | 32 26 04 | 46 08 34 | 1.545 | | 1.75*1.5 | 50% | Ditto above | B.C I-1-6 | 4.2 | 80% | good | Ditto above |
| 20 | | Head regulator B.C I-2 | 36+640 | 32 25 44 | 46 09 32 | 10.5 | | 3*2.6 | 60% | Ditto above | B.C I-2 | 13.66 | 80% | good | Ditto above |
| 21 | | Head regulator B.C I-3-5 | 41+019 | 32 23 59 | 46 11 34 | 0.679 | | 1.5*0.4 | 50% | Ditto above | B.C I-3-5 | 2.163 | 80% | good | Ditto above |
| 22 | | Head regulator B.C I-4 | 45+454 | 32 22 18 | 46 13 34 | 3.628 | | 2.6*1.40 | 70% | Ditto above | B.C I-4 | 6.397 | 80% | good | Ditto above |
| | | | | | | | | Average Convey efficiency for reclaimed area | | | | | 80% | | |

**B.C branch canal**

**Note:**
**Al Dujaila main canal has 54 branches from both sides which called private use with discharge less than 400 l/s; the regulator doesn't exist and required to redesign again, additionally to reduce the pipe diameter.**

**Annex 3**

**Structures and Distributary canals of Branch canals according to spatial scale for reclaimed area Canal (I-2)**

| No. | Structure name | Location | Max. Discharge (l/s) | Diameter (mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 1- | I-2-0-1 | 0+230 | 168 | 500 | 60% | Breakdown & lost head regulator gate | 1.5 | 15 | 10 | medium | Required maintenance working |
| 2- | I-2-0-2 | 0+674 | 168 | 500 | 60% | Ditto above | 1.65 | 17 | 10 | medium | Ditto above |
| 3- | I-2-0-3 | 1+260 | 112 | 400 | 60% | Ditto above | 1.5 | 17 | 8 | medium | Ditto above |
| 4- | I-2-0-4 | 0+470 | 224 | 600 | 60% | Ditto above | 1.9 | 29 | 3 | good | Ditto above |
| 5- | I-2-0-5 | 1+204 | 168 | 500 | 60% | Ditto above | 1.5 | 23 | 2 | good | Ditto above |
| 6- | I-2-0-6 | 1+204 | 112 | 400 | 60% | Ditto above | 1.05 | 10 | 8 | medium | Ditto above |
| 7- | I-2-0-7 | 3+998 | 168 | 500 | 60% | Ditto above | 1.6 | 20 | 7 | medium | Ditto above |
| 8- | I-2-0-9 | 5+467 | 56 | 300 | 60% | Ditto above | 0.5 | 6 | 3 | medium | Ditto above |

**Structures and Distributary canals of Branch canals according to spatial scale for reclaimed area Canal (I-3).**

| No. | Structure name | Location | Max. Discharge ($L^3/s$) | Diameter(mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 1- | I-3-1-1 | 0+386 | 112 | 400 | 60% | Breakdown & lost head regulator gate | 1 | 15 | 2 | good | Required maintenance working |
| 2- | I-3-1-2 | 0+986 | 112 | 400 | 60% | Ditto above | 1 | 12 | 5 | medium | Ditto above |
| 3- | I-3-1-3 | 1+586 | 112 | 400 | 60% | Ditto above | 1 | 13 | 6 | medium | Ditto above |
| 4- | I-3-2-1 | 0+525 | 112 | 400 | 60% | Ditto above | 1.5 | 20 | 5 | medium | Ditto above |
| 5- | I-3-2-2 | 1+125 | 168 | 500 | 60% | Ditto above | 1.45 | 18 | 6 | medium | Ditto above |
| 6- | I-3-2-3 | 1+725 | 168 | 500 | 60% | Ditto above | 1.45 | 20 | 4 | medium | Ditto above |
| 7- | I-3-2-4 | 0+363 | 112 | 400 | 60% | Ditto above | 1.6 | 20 | 7 | Under medium | Ditto above |
| 8- | I-3-2-0-1 | 3+109 | 168 | 500 | 60% | Ditto above | 1.8 | 19 | 12 | medium | Ditto above |
| 9- | I-3-2-0-2 | 0+825 | 112 | 400 | 60% | Ditto above | 0.75 | 8 | 5 | medium | Ditto above |

**Structures and Distributary canals of Branch canals according to spatial scale for reclaimed area Canal (I-3)**

| No. | Structure name | Location | Max. Discharge ($L^3/s$) | Diameter(mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 10 | 1-3-2-0-3 | 1+425 | 56 | 300 | 60% | Breakdown & lost head regulator gate | 0.3 | 4 | 2 | medium | Required maintenance working |
| 11 | 1-3-5-1 | 5+349 | 112 | 400 | 60% | Ditto above | 1.1 | 14 | 5 | Under medium | Ditto above |
| 12 | 1-3-5-2 | 3+716 | 112 | 400 | 60% | Ditto above | 1.2 | 13 | 8 | Under medium | Ditto above |
| 13 | 1-3-5-3 | 4+712 | 168 | 500 | 60% | Ditto above | 1.7 | 20 | 9 | Under medium | Ditto above |
| 14 | 1-3-5-5 | 2+163 | 168 | 500 | 60% | Ditto above | 1.5 | 18 | 7 | medium | Ditto above |
| 15 | 1-3-5-6 | 1+563 | 56 | 300 | 60% | Ditto above | 0.75 | 10 | 3 | medium | Ditto above |
| 16 | 1-3-5-7 | 1+563 | 168 | 500 | 60% | Ditto above | 1.5 | 19 | 6 | medium | Ditto above |
| 17 | 1-3-5-8 | 0+963 | 112 | 400 | 60% | Ditto above | 1.2 | 15 | 5 | medium | Ditto above |
| 18 | 1-3-5-9 | 0+963 | 168 | 500 | 60% | Ditto above | 1.5 | 20 | 5 | medium | Ditto above |
| 19 | 1-3-5-10 | 0+363 | 112 | 400 | 60% | Ditto above | 1.7 | 22 | 7 | medium | Ditto above |

| No. | Structure name | Location | Max. Discharge ($L^3/s$) | Diameter(mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 20 | 1-3-5-11 | 0+363 | 168 | 500 | 60% | Ditto above | 1.5 | 20 | 5 | medium | Ditto above |
| 21 | 1-3-9-1 | 0+410 | 112 | 400 | 60% | Ditto above | 1.1 | 15 | 4 | medium | Ditto above |
| 22 | 1-3-9-2 | 0+410 | 112 | 400 | 60% | Ditto above | 1 | 13 | 4 | medium | Ditto above |
| 23 | 1-3-9-3 | 1+010 | 112 | 400 | 60% | Ditto above | 1.15 | 15 | 5 | medium | Ditto above |
| 24 | 1-3-9-4 | 1+010 | 112 | 400 | 60% | Ditto above | 1 | 13 | 4 | medium | Ditto above |
| 25 | 1-3-9-5 | 1+576 | 112 | 400 | 60% | Ditto above | 1.15 | 16 | 4 | medium | Ditto above |
| 26 | 1-3-9-6 | 1+576 | 112 | 400 | 60% | Ditto above | 1 | 14 | 3 | medium | Ditto above |

**Structures and Distributary canals of Branch canals according to spatial scale for reclaimed area Canal (I-4)**

| No. | Structure name | Location | Max. Discharge ($L^3/s$) | Diameter(mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 1 | 1-4-0-1 | 0+358 | 58 | 300 | 60% | Breakdown & lost head regulator gate | 0.95 | 13 | 3 | medium | Required maintenance working |
| 2 | 1-4-0-2 | 0+358 | 168 | 500 | 60% | Ditto above | 1.45 | 20 | 5 | medium | Ditto above |
| 3 | 1-4-0-4 | 0+936 | 56 | 300 | 60% | Ditto above | 0.95 | 12 | 4 | medium | Ditto above |
| 4 | 1-4-0-5 | 1+241 | 84 | 350 | 60% | Ditto above | 0.95 | 11 | 5 | medium | Ditto above |
| 5 | 1-4-0-6 | 1+882 | 56 | 300 | 60% | Ditto above | 1.45 | 19 | 6 | medium | Ditto above |
| 6 | 1-4-1-1 | 0+028 | 28 | 250 | 60% | Ditto above | 1.5 | 21 | 4 | medium | Ditto above |
| 7 | 1-4-1-2 | 0+616 | 56 | 300 | 60% | Ditto above | 0.95 | 12 | 4 | medium | Ditto above |
| 8 | 1-4-1-3 | 0+616 | 112 | 400 | 60% | Ditto above | 1.5 | 19 | 6 | medium | Ditto above |
| 9 | 1-4-1-4 | 1+216 | 56 | 300 | 60% | Ditto above | 0.95 | 11 | 5 | medium | Ditto above |
| 10 | 1-4-1-5 | 1+216 | 168 | 400 | 60% | Ditto above | 1.5 | 20 | 5 | medium | Ditto above |
| 11 | 1-4-1-6 | 1+216 | 112 | 300 | 60% | Ditto above | 1.5 | 20 | 5 | medium | Ditto above |

**Table : Structures and Distributary canals of Branch canals according to spatial scale for reclaimed area Branch Canal (BC8):**

| No. | Structure name | Location | Max. Discharge ($L^3/s$) | Diameter(mm) | Structure efficiency | Notes | Length feeder (m) | Hydrants No. | | Feeder state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Working | Not working | | |
| 1- | Feeder 1 | | 120 | 500 | 50% | Breakdown & lost head regulator gate | 1.8 | There are no hydrants. Water course system Designed by English company | | Under medium | All feeders are not lined &below elevation, required lining Canal and feeder |
| 2- | Feeder 2 | | 116 | 500 | 50% | Ditto above | 2.3 | | | Under medium | |
| 3- | Feeder 3 | | 118 | 500 | 50% | Ditto above | 2.3 | | | Under medium | Ditto above |
| 4- | Feeder 4 | | 245 | 70 | 50% | Ditto above | 2.3 | | | Under medium | Ditto above |
| 5- | Feeder 5 | | 244 | 70 | 50% | Ditto above | 2.3 | | | Under medium | Ditto above |
| 6- | Feeder 6 | | 310 | 750 | 50% | Ditto above | 3 | | | Under medium | Ditto above |

**Annex 4**

**Structures and Distributary canals from Branch canals according to spatial scale/Branch Canal (BC9)**

| No. | Structure name | Location | Max. Discharge ($m^3/s$) | Structure efficiency | Notes | Canal which branched from | Length of Canal (km) | Convey canal efficiency % | Canal state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1- | BC9 | 0+00 | 2 | 80% | Required maintenance work | Al Dujaila main canal | 2.032 | 60% | medium | Unlined Canal and low elevations below design |
| 2- | BC9/North | 2+032 | 0.75 | 50% | Head regulator damage Gate | BC/9 | 4.5 | 60% | medium | |
| 3- | BC9/South | 2+050 | 1.25 | 50% | Ditto above | Ditto above | 9.5 | 60% | medium | Ditto above |
| 4- | Cross regulator/9 South | 4+400 | 1 | 30% | Regulator collapse | | | | | |
| 5- | First Branch/right | 1+960 | | 40% | no gate and proper regulator | BC9/North | 1.46 | 50% | Under medium | Ditto above |
| 6- | Second Branch/right | 0+300 | | 40% | Ditto above | = | 1.46 | 50% | = | Ditto above |
| 7 | Third Branch/right | 1+250 | | 40% | Ditto above | = | 1.46 | 50% | = | Ditto above |
| 8 | Fourth Branch/right | 0+300 | | 40% | Ditto above | = | 1.46 | 50% | = | Ditto above |
| 9 | Fifth Branch/right | 3+250 | | 40% | Ditto above | = | 1.677 | 50% | = | Ditto above |
| 10 | Sixth Branch/right | 4+350 | | 40% | Ditto above | = | 2.1 | 50% | = | Ditto above |
| 11 | First Branch/left | 1+900 | | 40% | Ditto above | = | 0.5 | 50% | = | Ditto above |

| No. | Structure name | Location | Max. Discharge ($m^3/s$) | Structure efficiency | Notes | Canal which branched from | Length of Canal (km) | Convey canal efficiency % | Canal state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 12 | Second Branch/left | 3+000 | | 40% | Ditto above | = | 0.5 | 50% | = | Ditto above |
| 13 | Third Branch/left | 4+000 | | 40% | Ditto above | = | 0.4 | 50% | = | Ditto above |
| 14 | Fourth Branch/left | 5+000 | | 40% | Ditto above | = | 0.7 | 50% | = | Ditto above |
| 15 | First Branch/left | 0+100 | | 40% | Ditto above | BC9/South | 2.4 | 50% | = | Ditto above |
| 16 | Second Branch/left | 0+200 | | 40% | Ditto above | = | 0.5 | 50% | = | Ditto above |
| 17 | third Branch/left | 1+900 | | 40% | Ditto above | = | 0.5 | 50% | = | Ditto above |
| 18 | fourth Branch/left | 0+520 | | 40% | Ditto above | = | 1 | 50% | = | Ditto above |
| 19 | fifth Branch/left | 1+650 | | 40% | Ditto above | = | 1 | 50% | = | Ditto above |
| 20 | sixth Branch/left | 2+600 | | 40% | Ditto above | = | 1.1 | 50% | = | Ditto above |
| 21 | seventh Branch/left | 3+600 | | 40% | Ditto above | = | 1.3 | 50% | = | Ditto above |
| 22 | eighth Branch/left | 4+600 | | 40% | Ditto above | = | 1.5 | 50% | = | Ditto above |
| 23 | nineth Branch/left | 5+750 | | 40% | Ditto above | = | 1.5 | 50% | = | Ditto above |
| 24 | tenth Branch/left | 6+800 | | 40% | Ditto above | = | 1.2 | 50% | = | Ditto above |
| 25 | eleventh Branch/left | 8+100 | | 40% | Ditto above | = | 0.9 | 50% | = | Ditto above |
| 26 | First Branch/right | 0+700 | | 40% | Ditto above | = | 0.6 | 50% | = | Ditto above |

| No. | Structure name | Location | Max. Discharge ($m^3/s$) | Structure efficiency | Notes | Canal which branched from | Length of Canal (km) | Convey canal efficiency % | Canal state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | Second Branch/right | 0+750 | | 40% | Ditto above | = | 0.6 | 50% | = | Ditto above |
| 28 | Third Branch/right | 1+800 | | 40% | Ditto above | = | 1 | 50% | = | Ditto above |
| 29 | Fourth Branch/right | 2+800 | | 40% | Ditto above | = | 2 | 50% | = | Ditto above |
| 30 | Fifth Branch/right | 3+900 | | 40% | Ditto above | = | 1.8 | 50% | = | Ditto above |
| 31 | sixth Branch/right | 5+000 | | 40% | Ditto above | = | 2.5 | 50% | = | Ditto above |
| 32 | Seventh Branch/right | 6+000 | | 40% | Ditto above | = | 2.8 | 50% | = | Ditto above |
| 33 | eighth Branch right | 7+000 | | 40% | Ditto above | = | 2.8 | 50% | = | Ditto above |
| 34 | Ninth Branch/right | 7+025 | | 40% | Ditto above | = | 0.65 | 50% | = | Ditto above |
| 35 | Tenth Branch/right | 10+000 | | 40% | Ditto above | = | 1.5 | 50% | = | Ditto above |

**Structures and Distributary canals from Branch canals according to spatial scale/Branch Canal (BC6)**

| No. | Structure name | location | Max .Discharge $m^3/s$ | Structure efficiency | Notes | Canal which branched from | Length of Canal Km | Convey canal efficiency % | Canal state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 1- | Bc/6 | 0+00 | 1.5 | 60% | Required Maintenance work | BC6/right side | 12 | 60% | Medium | unlined canal and elevations below design |
| 2- | falah hasan kareem | 7+000 | | 40% | no gate and proper regulator | BC6/right side | 1.5 | 50% | Under Medium | Ditto above |
| 3- | imkhelif kareem dahi | 7+500 | | 40% | no gate and proper regulator | BC6/right side | 0.5 | 50% | Under Medium | Ditto above |
| 4- | hady shahir | 8+250 | | 40% | no gate and proper regulator | BC6/right side | 1 | 50% | Under Medium | Ditto above |
| 5- | hussein abu rageef | 8+900 | | 40% | no gate and proper regulator | BC6/right side | 4 | 50% | Under Medium | Ditto above |
| 6- | kasim bahadly | 8+930 | | 40% | no gate and proper regulator | BC6/right side | 4 | 50% | Under Medium | Ditto above |
| 7 | farhan najim gdheeb | 9+400 | | 40% | no gate and proper regulator | BC6/right side | 1 | 50% | Under Medium | Ditto above |
| 8 | hmood katan bahar | 9+900 | | 40% | no gate and proper regulator | BC6/right side | 1 | 50% | Under Medium | Ditto above |
| 9 | tamur Dhamid | 10+800 | | 40% | no gate and proper regulator | BC6/right side | 2 | 50% | Under Medium | Ditto above |

| No. | Structure name | location | Max .Discharge $m^3/s$ | Structure efficiency | Notes | Canal which branched from | Length of Canal Km | Convey canal efficiency % | Canal state | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | gimagh salman | 10+850 | | 40% | no gate and proper regulator | BC6/right side | 1.5 | 50% | Under Medium | Ditto above |
| 11 | khalil dawood | 12+000 | | 40% | no gate and proper regulator | BC6/right side | 2 | 50% | Under Medium | Ditto above |
| 12 | imkhelif kareem dahi | 7+500 | | 40% | no gate and proper regulator | BC6/left side | 0.5 | 50% | Under Medium | Ditto above |
| 13 | salman mohan eleewy | 7+600 | | 40% | no gate and proper regulator | BC6/left side | 0.4 | 50% | Under Medium | Ditto above |
| 14 | kareem dahi | 8+000 | | 40% | no gate and proper regulator | BC6/left side | 0.3 | 50% | Under Medium | Ditto above |
| 15 | khalaf dukhan | 10+000 | | 40% | no gate and proper regulator | BC6/left side | 0.5 | 50% | Under Medium | Ditto above |
| 16 | kazar barosh | 11+000 | | 40% | no gate and proper regulator | BC6/left side | 2 | 50% | Under Medium | Ditto above |

**Annex 5**

## Main, Branch, Distributary and Collector Drain according to large scale for reclaimed area

| No. | Name of Drain | Type | Length of Drain km | location | Drain efficiency % | Diameter of Head Drain (mm) | Discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|
| 1 | D-1 | Main | 31.65 | 0+000 | 70% | 800 | 2.662 |
| | D-1-4 | secondary | 11.73 | 17+160 | 70% | 500 | 0.51 |
| | D-1-5 | secondary | 1.98 | 5+893 | 70% | 500 | 0.056 |
| | D-1-6 | secondary | 1.97 | 9+690 | 70% | 500 | 0.02 |
| | D-1-4-b | secondary | 1.97 | 5+893 | 70% | 500 | 0.028 |
| | D-1-4-a | secondary | 2.26 | 2+307 | 70% | 500 | 0.028 |
| | D-1-1 | secondary | 2.11 | 11+960 | 70% | 500 | 0.028 |
| | D-1-2 | secondary | 2.13 | 15+026 | 70% | 500 | 0.028 |
| | D-1-3 | secondary | 3.02 | 17+120 | 70% | 500 | 0.032 |
| | D-1-7 | secondary | 2.06 | 31+600 | 70% | 500 | 0.026 |
| 2 | D-2 | Main | 13.93 | 1+550 | 70% | 1000 | 1.126 |
| | D-2-1 | secondary | 3.77 | 3+220 | 70% | 500 | 0.08 |
| | D-2-2 | secondary | 3.37 | 7+000 | 70% | 500 | 0.07 |
| | D-2-C | secondary | 4.68 | 1+326 | 70% | 500 | 0.09 |
| | D-2-16 | secondary | 1.86 | 13+927 | 70% | 500 | 0.057 |
| | D-2-17 | secondary | 1.43 | 12+960 | 70% | 500 | 0.029 |
| | D-2-15 | secondary | 1.84 | 12+935 | 70% | 500 | 0.044 |
| 3 | D-3 | Main | 32.38 | 0+000 | 70% | 3*800 | 2.157 |
| | D-3-1 | secondary | 2.86 | 9+460 | 70% | 500 | 0.018 |
| | D-3-2 | secondary | 1.74 | 12+610 | 70% | 500 | 0.035 |
| | D-3-3 | secondary | 1.48 | 12+611 | 70% | 500 | 0.049 |
| | D-3-4 | secondary | 1.55 | 17+771 | 70% | 500 | 0.049 |
| | D-3-5 | secondary | 2.99 | 19+469 | 70% | 500 | 0.048 |
| | D-3-6 | secondary | 2.1 | 22+487 | 70% | 500 | 0.049 |
| | D-3-7 | secondary | 1.696 | 23+969 | 70% | 500 | 0.037 |
| 4 | D-4 | Main | 11.99 | 0+000 | 70% | 800 | 0.393 |
| | D-4-1 | secondary | 2.1 | 2+793 | 70% | 500 | 0.074 |
| | D-4-2 | secondary | 0.6 | 8+770 | 70% | 500 | 0.017 |
| | D-4-3 | secondary | 0.95 | 12+000 | 70% | 500 | 0.044 |
| | Total length | | 154.196 | Ave. Eff. | 70% | | |

## Distributary drains for BC8 North and south

| No. | Name of Drain | Type | Length of Drain km | location | Drain efficiency % | Diameter of Head Drain mm | Discharge ($m^3/s$) |
|---|---|---|---|---|---|---|---|
| 5 | Drain NO.26 | secondary | 1.8 | 11+892 | 70% | 700 | 0.05 |
| | Drain NO.25 | secondary | 2.148 | 11+016 | 70% | 750 | 0.053 |
| | Drain NO.23 | secondary | 2.15 | 10+158 | 70% | 700 | 0.049 |
| | Drain NO.19 | secondary | 2.18 | 8+446 | 70% | 700 | 0.048 |
| | Drain NO.15 | secondary | 2.6 | 6+693 | 70% | 750 | 0.052 |
| | Drain NO.11 | secondary | 3.2 | 4+906 | 70% | 700 | 0.049 |
| | Drain NO.6 | secondary | 3.05 | 3+140 | 70% | 800 | 0.055 |
| | Drain NO.4 | secondary | 2 | 1+317 | 70% | 700 | 0.05 |
| | Drain NO.2 | secondary | 3.5 | 0+870 | 70% | 750 | 0.056 |
| | Drain NO.27 | secondary | 1.6 | 12+321 | 70% | 700 | 0.049 |
| | Drain NO.24 | secondary | 1.9 | 11+100 | 70% | = | 0.051 |
| | Drain NO.20 | secondary | 2.4 | 9+301 | 70% | = | 0.053 |
| | Drain NO.18 | secondary | 2.8 | 8+405 | 70% | 750 | 0.055 |
| | Total length | | 31.328 | Ave. Eff. | 70% | | |

**Main, Branch, Distributary and Collector Drain at large scale for semi reclaimed area BC 9, 10 and 11**

| No. | Name of Drain | Type | Length of Drain KM | Drain efficiency % | Notes |
|---|---|---|---|---|---|
| 1 | 2L | main | 17 | 60% | Sediments ,reeds and clogs maintenance work is required |
| 2 | 2LA | branch | 7.3 | 60% | |
| 3 | 2LB | branch | 6.54 | 60% | |
| 4 | 2LC | branch | 9.3 | 60% | |
| 5 | 2LD | branch | 11.55 | 60% | |
| 6 | 2L1/L2 | secondary | 16.6 | 60% | |
| 7 | L2/A | secondary | 1 | 60% | |
| 8 | L2/B | secondary | 1 | 60% | |
| 9 | L2/C | secondary | 1.1 | 60% | |
| 10 | L2/D | secondary | 1.4 | 60% | |
| 11 | L2/E | secondary | 1.1 | 60% | |
| 12 | 2L/F | secondary | 2.7 | 60% | |
| 13 | 2L/G | secondary | 2.85 | 60% | |
| 14 | 2L/4 | secondary | 2.4 | 60% | Sediments ,reeds and clogs maintenance work is required |
| 15 | 2L/L1 | secondary | 1.1 | 60% | |
| 16 | 2L/L2 | secondary | 2 | 60% | |
| 17 | 2L/L3 | secondary | 2 | 60% | |
| 18 | 2L/L4 | secondary | 2 | 60% | |
| 19 | 2L/L5 | secondary | 2 | 60% | |
| 20 | 2L/L6 | secondary | 2 | 60% | |
| 21 | 2L/L7 | secondary | 2 | 60% | |
| 22 | 2L/L8 | secondary | 2 | 60% | |
| 23 | 2L/L9 | secondary | 2 | 60% | |
| 24 | 2L/L10 | secondary | 2 | 60% | |
| 25 | 2L/L11 | secondary | 1 | 60% | |
| 26 | 2L/R1 | secondary | 2.85 | 60% | |
| 27 | 2LB/R4 | secondary | 1 | 60% | |
| 28 | 2LB/R5 | secondary | 1 | 60% | |
| 29 | 2LB/R6 | secondary | 1 | 60% | |
| 30 | 2LB/R7 | secondary | 1 | 60% | |
| 31 | 2LC/L1 | secondary | 1.2 | 60% | |
| 32 | 2LC/L2 | secondary | 1.5 | 60% | |
| 33 | 2LC/L3 | secondary | 1.7 | 60% | |
| 34 | 2LC/L4 | secondary | 1.9 | 60% | |
| 35 | 2LC/L5 | secondary | 2.1 | 60% | |
| 36 | 2LC/R1 | secondary | 2 | 60% | |
| 37 | 2LC/R2 | secondary | 2.2 | 60% | |
| 38 | 2LC/R3 | secondary | 1.5 | 60% | |
| 39 | 2LC/R4 | secondary | 0.6 | 60% | |
| 40 | 2LD/L1 | secondary | 2.4 | 60% | |

| No. | Name of Drain | Type | Length of Drain KM | Drain efficiency % | Notes |
|---|---|---|---|---|---|
| **41** | 2LD/L2 | secondary | 1.8 | 60% | |
| **42** | 2LD/L4 | secondary | 1.5 | 60% | |
| **43** | 2LD/L5 | secondary | 1.5 | 60% | **Sediments and clogs and needs to maintenance work because the network is very old.** |
| **44** | 2LD/L6 | secondary | 1.2 | 60% | |
| **45** | 2LD/L7 | secondary | 0.9 | 60% | |
| **46** | 2L/R2 | secondary | 2.85 | 60% | |
| **47** | 2L/R3 | secondary | 2.85 | 60% | |
| **48** | 2L/R4 | secondary | 2.4 | 60% | |
| **49** | 2L/R5 | secondary | 2.15 | 60% | |
| **50** | 2L/R6 | secondary | 1.6 | 60% | |
| **51** | 2L/R7 | secondary | 1.4 | 60% | |
| **52** | 2L/R8 | secondary | 1.4 | 60% | |
| **53** | 2L/R9 | secondary | 1.4 | 60% | |
| **54** | 2L/R10 | secondary | 1.3 | 60% | |
| **55** | 2L/R11 | secondary | 1.1 | 60% | |
| **56** | 2LA/L1 | secondary | 0.7 | 60% | |
| **57** | 2LA/L2 | secondary | 0.9 | 60% | |
| **58** | 2LA/L3 | secondary | 0.9 | 60% | |
| **59** | 2LA/L4 | secondary | 0.9 | 60% | |
| **60** | 2LA/L5 | secondary | 1 | 60% | |
| **61** | 2LA/L6 | secondary | 1.2 | 60% | |
| **62** | 2LA/R1 | secondary | 1.3 | 60% | |
| **63** | 2LA/R2 | secondary | 1.3 | 60% | |
| **64** | 2LB/L1 | secondary | 1.4 | 60% | |
| **65** | 2LB/L2 | secondary | 2.7 | 60% | |
| **66** | 2LB/L3 | secondary | 2.1 | 60% | |
| **67** | 2LB/L4 | secondary | 1.4 | 60% | |
| **68** | 2LB/L5 | secondary | 1.6 | 60% | |
| **69** | 2LB/R1 | secondary | 1.6 | 60% | |
| **70** | 2LB/R2 | secondary | 1.4 | 60% | |
| **71** | 2LB/R3 | secondary | 1.2 | 60% | |
| | Total length | | 172.84 | 60% | |

**Main, Branch, Distributary and Collector Drain at to large scale for semi reclaimed area BC 13 and 14**

| No. | Name of Drain | Type | Length of Drain KM | Drain efficiency % | Discharge $m^3/s$ | Notes |
|---|---|---|---|---|---|---|
| 1 | Western main Drain | main | 42 | 50% | 7 | |
| 2 | Middle Drain | Branch | 16 | 60% | | |
| 3 | L1 | secondary | 1.1 | 60% | | |
| | L2 | secondary | 2 | 60% | | |
| | L3 | secondary | 2.5 | 60% | | |
| | L4 | secondary | 2.9 | 60% | | |
| | L5 | secondary | 2.9 | 60% | | |
| | L6 | secondary | 2.9 | 60% | | |
| | L7 | secondary | 2.4 | 60% | | |
| | L8 | secondary | 2.3 | 60% | | |
| | L9 | secondary | 2.2 | 60% | | |
| | L10 | secondary | 2.1 | 60% | | |
| | L11 | secondary | 2.1 | 60% | | |
| | L12 | secondary | 2.1 | 60% | | |
| | L13 | secondary | 2.1 | 60% | | |
| | L14 | secondary | 2.1 | 60% | | |
| | L15 | secondary | 2.5 | 60% | | |
| | L16 | secondary | 2.1 | 60% | | |
| | R1 | secondary | 0.85 | 60% | | |
| | R2 | secondary | 1.1 | 60% | | **Sediments and clogs needs maintenance work because the network very old and there is no map to fill required information. No field drains in this area** |
| | R3 | secondary | 1.17 | 60% | | |
| | R4 | secondary | 1.08 | 60% | | |
| | R5 | secondary | 1.6 | 60% | | |
| | R6 | secondary | 2.25 | 60% | | |
| | R7 | secondary | 3.3 | 60% | | |
| | R8 | secondary | 3.9 | 60% | | |
| | R9 | secondary | 2.4 | 60% | | |
| | R10 | secondary | 3.7 | 60% | | |
| | R11 | secondary | 2.45 | 60% | | |
| | EL | secondary | 2.4 | 60% | | |
| | FL | secondary | 2.8 | 60% | | |
| | GL | secondary | 2 | 60% | | |
| | AL | secondary | 2 | 60% | | |
| | BL | secondary | 0.75 | 60% | | |
| | AR | secondary | 0.5 | 60% | | |
| | BR | secondary | 1 | 60% | | |
| | DR | secondary | 1 | 60% | | |

| No. | Name of Drain | Type | Length of Drain KM | Drain efficiency % | Discharge $m^3/s$ | Notes |
|---|---|---|---|---|---|---|
| | ER | secondary | 1.4 | 60% | | |
| | FR | secondary | 2 | 60% | | |
| | GR | secondary | 3 | 60% | | |
| | Total length | | 136.95 | 60% | | |

**Annex 6**

## Main, Branch, Secondary and Collector Drains according to spatial scale for reclaimed area

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain (mm) | Discharge $m^3/s$ | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Reclaimed | Semi Reclaimed | Non Reclaimed |
| 1 | D - 3 | Main | 32.38 | | 70% | 3*800 | 2.157 | = | | |
| | D-3-7 | secondary | 1.696 | 23+969 | 70% | 750 | 0.037 | = | | |
| | D-3-7-1 | Collector | 1.472 | 0+293 | 50% | 500 | 0.021 | = | | |
| | D-3-7-2 | Collector | 1.505 | 0+293 | 50% | = | = | = | | |
| | D-3-7-3 | Collector | 1.472 | 0+893 | 50% | = | = | = | | |
| | D-3-7-4 | Collector | 1.46 | = | 50% | = | = | = | | |
| | D-3-7-5 | Collector | 1.472 | 1+493 | 50% | = | = | = | | |
| | D-3-7-6 | Collector | 1.26 | 1+669 | 50% | = | 0.01 | = | | |
| 2 | D-3-6 | secondary | 2.1 | 22+487 | 70% | = | 0.041 | = | | |
| | D-3-6-1 | Collector | 1.372 | 0+601 | 50% | = | 0.02 | = | | |
| | D-3-6-2 | Collector | 0.085 | = | 50% | = | 0.001 | = | | |
| | D-3-6-3 | Collector | 0.958 | 1+332 | 50% | = | 0.014 | = | | |
| | D-3-6-4 | Collector | 0.448 | 1+233 | 50% | = | 0.007 | = | | |
| | D-3-6-5 | Collector | 0.513 | 2+100 | 50% | = | 0.005 | = | | |
| | D-3-6-6 | Collector | 1.068 | = | 50% | = | 0.013 | = | | |
| | D-3-6-6-1 | Collector | 0.355 | 0+084 | 50% | = | 0.003 | = | | |
| 3 | D-3-5 | secondary | 2.99 | 19+469 | 70% | = | 0.048 | = | | |
| | D-3-5-1 | Collector | 1.469 | 0+593 | 50% | = | 0.021 | = | | |
| | D-3-5-2 | Collector | 1.473 | 1+193 | 50% | = | = | = | | |
| | D-3-5-3 | Collector | 1.517 | 1+513 | 50% | = | 0.011 | = | | |
| | D-3-5-4 | Collector | 2.968 | 2+393 | 50% | = | 0.038 | = | | |
| | D-3-5-5 | Collector | 1.538 | 2+990 | 50% | = | 0.017 | = | | |

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain (mm) | Discharge $m^3/s$ | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Reclaimed | Semi Reclaimed | Non Reclaimed |
| | D-3-5-3-1 | Collector | 0.896 | 1+793 | 50% | = | 0.01 | = | | |
| 4 | D-3-4 | secondary | 1.554 | 17+771 | 70% | = | 0.049 | = | | |
| | D-3-4-1 | Collector | 1.11 | 0+299 | 50% | = | 0.019 | = | | |
| | D-3-4-2 | Collector | 1.07 | 0+897 | 50% | = | 0.018 | = | | |
| | D-3-4-3 | Collector | 1.023 | 1+554 | 50% | = | 0.012 | = | | |
| 5 | D-3-3 | secondary | 1.48 | 12+611 | 70% | 0.75 | 0.049 | = | | |
| | D-3-3-2 | Collector | 0.98 | 0+300 | 50% | 500 | 0.014 | = | | |
| | D-3-3-4 | Collector | 0.973 | 0+900 | 50% | = | = | = | | |
| | D-3-3-6 | Collector | 0.969 | 1+480 | 50% | = | 0.009 | = | | |
| 6 | D-3-2 | secondary | 1.74 | 12+610 | 70% | = | 0.037 | = | | |
| | D-3-2-1 | Collector | 1.4 | 1+200 | 50% | = | 0.02 | = | | |
| | D-3-2-3 | Collector | 1.41 | 0+600 | 50% | = | = | = | | |
| | D-3-2-5 | Collector | 1.42 | 0+000 | 50% | = | = | = | | |
| 7 | D-3-0-13 | Collector | 0.94 | 17+340 | 50% | = | 0.014 | = | | |
| | D-3-0-12 | Collector | 0.94 | 16+900 | 50% | = | = | = | | |
| | D-3-0-11 | Collector | 9.35 | 16+600 | 50% | = | = | = | | |
| | D-3-0-10 | Collector | 0.937 | 16+000 | 50% | = | = | = | | |
| | D-3-0-9 | Collector | 0.938 | 15+400 | 50% | = | = | = | | |
| 8 | D-4-3 | secondary | 0.95 | 12+000 | 70% | 500 | 0.044 | = | | |
| | D-4-3-1 | Collector | 1.45 | 0+000 | 50% | = | 0.021 | = | | |
| | D-4-3-3 | Collector | 1.455 | 0+600 | 50% | = | = | = | | |
| | D-4-3-4 | Collector | 1.48 | 0+950 | 50% | = | = | = | | |
| 9 | D-2 | Main | 13.93 | | 70% | 1000 | 1.126 | = | | |
| | D-2-15 | secondary | 1.84 | 12+935 | 70% | 500 | 0.044 | = | | |
| | D-2-15-2 | Collector | 0.94 | 0+600 | 50% | = | 0.014 | = | | |

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain (mm) | Discharge $m^3/s$ | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Reclaimed | Semi Reclaimed | Non Reclaimed |
| | D-2-15-4 | Collector | 0.948 | 1+836 | 50% | = | = | = | | |
| | D-2-15-3 | Collector | 0.944 | 1+200 | 50% | = | = | = | | |
| 10 | D-2-16 | secondary | 1.856 | 13+927 | 70% | 750 | 0.057 | = | | |
| | D-2-16-1 | Collector | 725 | 0+000 | 50% | 500 | 0.011 | = | | |
| | D-2-16-2 | Collector | 1.136 | 0+600 | 50% | = | 0.017 | = | | |
| | D-2-16-3 | Collector | 1.56 | 1+200 | 50% | = | 0.023 | = | | |
| | D-2-16-4 | Collector | 2 | 1+856 | 50% | = | 0.017 | = | | |
| 11 | D-2-17 | secondary | 1.43 | 12+960 | 70% | = | 0.029 | = | | |
| | D-2-17-0 | Collector | 1.6 | 1+430 | 50% | = | 0.023 | = | | |
| | D-2-17-1 | Collector | 0.75 | 0+700 | 50% | = | 0.09 | = | | |

**Drains BC8 from Reclaimed area/ executed from Regeot England Company**

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain mm | Discharge $m^3/s$ | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Reclaimed | Semi Reclaimed | Non Reclaimed |
| 13 | Drain NO.25 | secondary | 2.148 | 11+016 | 70% | 750 | 0.053 | = | | |
| 14 | Drain NO.23 | secondary | 2.15 | 10+158 | 70% | 700 | 0.049 | = | | |
| 15 | Drain NO.19 | secondary | 2.16 | 8+446 | 70% | = | 0.048 | = | | |
| 16 | Drain NO.15 | secondary | 2.6 | 6+693 | 70% | 750 | 0.052 | = | | |
| 17 | Drain NO.11 | secondary | 3.2 | 4+906 | 70% | 700 | 0.049 | = | | |

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain mm | Discharge $m^3/s$ | Notes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Reclaimed | Semi Reclaimed | Non Reclaimed |
| 18 | Drain NO.6 | secondary | 3.05 | 3+140 | 70% | 800 | 0.055 | = | | |

**Main Drains, Branch, secondary/ BC9 semi Reclaimed Area**

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain mm | Discharge $m^3/s$ | Notes |
|---|---|---|---|---|---|---|---|---|
| 19 | 2LD | Branch | 11 | | 60% | | | very old drainage network and there is no maps to get the information<br>there is no field drains collector drains are connected each 500 m |
| 20 | 2LD/L1 | secondary | 2.4 | | 60% | | | |
| 21 | 2LD/L2 | secondary | 1.8 | | 60% | | | |
| 22 | 2LD/L3 | secondary | 1.5 | | 60% | | | |
| 23 | 2LD/L4 | secondary | 1.5 | | 60% | | | |
| 24 | 2LD/L5 | secondary | 1.5 | | 60% | | | |
| 25 | 2LD/L6 | secondary | 1.2 | | 60% | | | |
| 26 | 2LD/L7 | secondary | 0.9 | | 60% | | | |
| 27 | 2LB | Branch | 6.54 | | 60% | | | |
| 28 | 2LB/L1 | secondary | 1.4 | | 60% | | | |
| 29 | 2LB/L2 | secondary | 2.7 | | 60% | | | |
| 30 | 2LB/L3 | secondary | 2.1 | | 60% | | | |
| 31 | 2LB/L4 | secondary | 1.4 | | 60% | | | |
| 32 | 2LB/L5 | secondary | 1.6 | | 60% | | | |
| 33 | 2LB/R1 | secondary | 1.6 | | 60% | | | Sediments and clogs existence, maintenance is required |
| 34 | 2LB/R2 | secondary | 1.4 | | 60% | | | sediments and clogs; maintenance is |

| No. | Name of Drain | Type | Length of Drain KM | location | Drain efficiency % | Diameter of Head Drain mm | Discharge $m^3/s$ | Notes |
|---|---|---|---|---|---|---|---|---|
| **35** | 2LB/R3 | secondary | 1.2 | | 60% | | | required; there is no map to get the information |
| **36** | 2LB/R4 | secondary | 2.4 | | 60% | | | |
| **37** | 2LB/R5 | secondary | 2.15 | | 60% | | | |
| **38** | 2LB/R6 | secondary | 1.6 | | 60% | | | |
| **39** | 2LB/R7 | secondary | 1.4 | | 60% | | | |
| **40** | 2LB/R8 | secondary | 1.4 | | 60% | | | |
| **41** | 2LC/L3 | secondary | 2 | | 60% | | | |
| **42** | 2LC/L4 | secondary | 2 | | 60% | | | |
| **43** | 2LC/L5 | secondary | 2 | | 60% | | | |
| **44** | 2LC | Branch | 9.3 | | 60% | | | |

**Annex 7**

# Distributaries and Intakes in Al- Mussyib Project (Public Benefit)

### 1- Distributaries from branch canals

| No. | Branch name | type | length km | discharge ($m^3/s$) |
|---|---|---|---|---|
| 1 | second pumping/Al-Hilaly | distributor | 4.00 | 1.00 |
| 2 | Al-Labya /Al-Haidari | distributor | 5.00 | 1.40 |
| 3 | Al-Refiya /Old Mussyib | distributor | 3.00 | 0.50 |
| 4 | Al-Taheriya /Old Mussyib | distributor | 7.00 | 1.74 |
| 5 | Al-Hilaly 10 | distributor | 5.40 | 0.50 |
| 6 | Zubaidy 22/10 | distributor | 2.40 | 1.15 |
| 7 | Zubaidy 18 | distributor | 3.00 | 1.00 |
| 8 | Al-Esawy 1 | distributor | 1.60 | 0.66 |
| 9 | Al-Labya 1 | distributor | 2.80 | 0.60 |
| 10 | Al-Akair 1 | distributor | 5.00 | 0.50 |
| 11 | Al-Hilaly 2 | distributor | 7.00 | 0.40 |
| 12 | Zubaidy 2 | distributor | 8.00 | 0.85 |
| 13 | Zubaidy 24 | distributor | 6.60 | 0.40 |
| 14 | Hilala 26 | distributor | 2.00 | 0.80 |
| 15 | Hilaly 28 | distributor | 3.20 | 0.90 |
| 16 | Hamiyar 2 | distributor | 4.50 | 0.43 |
| 17 | Hilaly 32 | distributor | 3.00 | 0.50 |
| 18 | Kharbana 4 | distributor | 4.50 | 0.53 |
| 19 | Mansouri 4 | distributor | 3.00 | 0.66 |
| 20 | Kharbana 75 | distributor | 7.00 | 0.53 |
| 21 | Ajrish 6 | distributor | 7.00 | 0.66 |
| 22 | Ajrish 8 | distributor | 7.00 | 0.68 |
| 23 | Imam 9 | distributor | 2.00 | 0.70 |
| 24 | Hilala /Hilaly | distributor | 8.00 | 8.00 |
| 25 | Zubaidy 12/A | distributor | 2.50 | 0.90 |
| 26 | Zubaidy 20 | distributor | 3.30 | 1.00 |
| 27 | Zubaidy 22 | distributor | 7.20 | 1.00 |
| 28 | Hilaly 9 | distributor | 3.60 | 1.00 |
| 29 | Hilala 9 | distributor | 3.60 | 0.43 |
| 30 | Ajrish 5 | distributor | 1.60 | 0.75 |
| 31 | Somood River | distributor | 7.00 | 7.00 |
| | | **total** | **140.80** | **37.17** |

**2- Distributaries and intakes from Mussyib main canal**

| No. | Branch name | type | length km | discharge ($m^3/s$) |
|---|---|---|---|---|
| 1 | Al-mansouri | Intake from musaib main canal | 4.50 | 0.75 |
| 2 | Al-Imam | distributor from musaib main canal | 7.50 | 0.42 |
| 3 | AL-Kharbana 7 | distributor from musaib main canal | 2.50 | 0.80 |
| 4 | Al-Rashaid | distributor from musaib main canal | 0.25 | 0.45 |
| 5 | Ajrish | distributor from musaib main canal | 4.50 | 0.50 |
| 6 | Abbas Aboob | Intake from musaib main canal | 1.00 | 1.60 |
| 7 | livestock pumping system | Intake from musaib main canal | 2.00 | 0.50 |
| 8 | Roomy river/Mansouri | Intake from musaib main canal | 1.00 | 0.66 |
| 9 | Esawy farm river | Intake from musaib main canal | 4.00 | 1.00 |
| | | **total** | **27.25** | **6.68** |

***SUMMARY TABLE***

| | |
|---|---|
| no. of distributors from branches canals | **31** |
| total length of distributors from branches canals | **140.80** |
| total length of Distributors and intakes from musaib main canal | **27.25** |
| total length of distributors and Intakes in Al- Musaib Project (public Benefit) | **168.05** |

**Annex 8**

## Branch Drains in Mussyib Project

| | Drain Name | Length (km) |
|---|---|---|
| | **a. Branch drains of the south drain** | |
| 1 | drain/13 Al-haidary | 5 |
| 2 | drain/1 Ajrash | 1.5 |
| 3 | drain/4 Zubaidy | 1.5 |
| 4 | drain/1 Zubaidy | 4.5 |
| 5 | drain/10 Kharbana | 4.5 |
| 6 | drain/14 | 3.3 |
| 7 | drain/18 | 3 |
| 8 | drain/30 | 5.5 |
| 9 | drain/3 | 3.5 |
| 10 | drain/4 Muajreen | 6.5 |
| 11 | drain/5 Zubaidy | 1.75 |
| 12 | drain 1/1 | 2.5 |
| 13 | drain/8 kharbana | 4.5 |
| 14 | drain/2 | 2 |
| 15 | drain/15 | 8.5 |
| 16 | drain/16 | 4.5 |
| 17 | drain/17 | 12 |
| 18 | drain/19 | 12 |
| 19 | drain/22 | 7 |
| 20 | drain/23 | 7.5 |
| 21 | drain/25 | 6 |
| 22 | drain 18/4 | 5.5 |
| 23 | drain/6 Ajrash | 5.5 |
| | **sub-total length** | **118.05** |
| | | |
| | **b. Branch drains of the north drain** | |
| 1 | drain /3 Abu Shair | 1.25 |
| 2 | drain 5/2/3 Hamir | 2.5 |
| 3 | drain /3 | 6 |
| | **sub-total length** | **9.75** |
| | | |
| | **c. Branch drains of the great drain** | |
| 1 | drain/1 rashayd farm | 1.5 |
| 2 | drain/10 zubaidy | 1 |
| 3 | drain/11 zubaidy | 2.5 |
| 4 | drain /12 zubaidy | 0.5 |
| 5 | drain/13 zubaidy | 3.5 |
| 6 | drain/15 zubaidy | 4 |
| 7 | drain/17 zubaidy | 4 |

| | Drain Name | Length (km) |
|---|---|---|
| 8 | drain/19 zubaidy | 3.5 |
| 9 | drain/13 zubaidy | 6.35 |
| 10 | drain/21 zubaidy | 3.5 |
| 11 | drain/23 zubaidy | 3.5 |
| 12 | drain/25 zubaidy | 3.5 |
| 13 | drain/27 zubaidy | 3.5 |
| 14 | drain/29 zubaidy | 4 |
| 15 | drain/3 | 1.5 |
| 16 | drain/4 rashayd | 5.2 |
| 17 | drain 3/1/4 Imam | 4 |
| 18 | drain/5 zubaidy | 7 |
| 19 | drain /15 rashayd farm | 1.25 |
| 20 | drain 5/5/7 agair | 1.5 |
| 21 | drain 6 | 3.5 |
| 22 | drain 7 rashayd | 1.5 |
| 23 | drain 8 rashayd | 3.25 |
| 24 | drain 9 zubaidy | 1.75 |
| 25 | drain 1 | 6 |
| 26 | drain 3 | 6 |
| 27 | drain 5 | 7 |
| 28 | drain 7 | 11.45 |
| 29 | drain 9 | 9 |
| 30 | drain 27 | 0.75 |
| | **sub-total length** | **115.5** |

**Annex 9**

**Structures and distributary canals of Branch canals according to spatial scale Alakear Canal**.

| Name of canal | Type |
|---|---|
| DC1 | Distributary |
| S.D.C 1.1 | Sub-Distributary |
| S.D.C 3.1 | Sub-Distributary |
| DC2 | Distributary |
| S.D.C 2.2 | Sub-Distributary |
| DC3 | Distributary |
| S.D.C 1.3 | Sub-Distributary |
| DC4 | Distributary |
| DC5 | Distributary |
| DC6 | Distributary |
| DC7 | Distributary |
| S.D.C 1.7 | Sub-Distributary |
| DC8 | Distributary |
| DC9 | Distributary |
| S.D.C 1.9 | Sub-Distributary |
| DC10 | Distributary |
| DC11 | Distributary |
| DC. Of AK P.S garden | Distributary |

**From main canal Al Mussyib Canal**

| Name of canal | Type |
|---|---|
| D.C Al Hezaza Canal | Distributary |
| S.D.C al Hezaza | Sub-Distributary |

**Collector drains branching from B.D5**

| Name of collector | No. of field drain |
|---|---|
| C.D6/7 | 2 |
| C.D7/5 | 6 |
| C.D5/5 | 7 |
| C.D3/5 | 15 |
| C.D1/5 | 14 |
| C.D7/AK/N | 10 |
| C.D5/7 | |
| C.D7/20/AK/M | 2 |
| C.D5/AK/N | 4 |
| BD5 | 4 |
| Total F.D/B.D5 | 64 |

**Collector drains discharging into B.D7**

| Name of collector | No. of field drain |
|---|---|
| C.D11/10/7 | |
| C.D10/7 | 6 |
| C.D8/7 | 8 |
| C.D6/7 | 24 |
| C.D1/6/7 | 6 |
| C.D1/4/7 | 32 |
| C.D4/7 | 32 |
| C.D2/7 | 31 |
| C.D3/AK/N | 15 |
| C.D5/AK/N | |
| C.D1/AK/N | 5 |
| B.D7 | 8 |
| F.D2/10/7 | 10 |
| **Total F.D/B.D7** | 177 |

**Field drains discharging into Collector drains (C.D)**

| Name of C.D | Field drain |
|---|---|
| C.D1/5 | F.D1/1/5 |
| | F.D2/1/5 |
| | F.D3/1/5 |
| | F.D4/1/5 |
| | F.D5/1/5 |
| | F.D6/1/5 |
| | F.D7/1/5 |
| | F.D8/1/5 |
| | F.D9/1/5 |
| | F.D10/1/5 |
| | F.D11/1/5 |
| | F.D12/1/5 |
| | F.D13/1/5 |
| | F.D14/1/5 |
| C.D7/AK/N | F.D1/7/AK/N |
| | F.D2/7/AK/N |
| | F.D3/7/AK/N |
| | F.D4/7/AK/N |
| | F.D5/7/AK/N |
| | F.D6/7/AK/N |
| | F.D7/7/AK/N |

| Name of C.D | Field drain |
|---|---|
| | F.D8/7/AK/N |
| | F.D10/7/AK/N |
| | F.D12/7/AK/N |
| C.D7/20/AK/M | F.D N/AK/7/15 |
| | F.D2/15/5 |
| C.D5/AK/N | F.D1/5/AK/N |
| | F.D3/5/AK/N |
| | F.D5/5/AK/N |
| | F.D5/AK/N |
| C.D6/7 | F.D6/5/5 |
| | F.D2/9/5 |
| C.D5/5 | F.D1/5/5 |
| | F.D2/5/5 |
| | F.D3/5/5 |
| | F.D4/5/5 |
| | F.D5/5/5 |
| | F.D7/5/5 |
| | F.D9/5/5 |
| C.D7/5 | F.D1/7/5 |
| | F.D3/7/5 |
| | F.D5/7/5 |
| | F.D7/7/5 |
| | F.D9/7/5 |
| | F.D11/7/5 |
| B.D5 | F.D1/5/15 |
| | F.D3/5/15 |
| | F.D5/5/15 |
| | F.D7/5/15 |
| C.D3/5 | F.D1/3/5 |
| | F.D2/3/5 |
| | F.D3/3/5 |
| | F.D4/3/5 |
| | F.D5/3/5 |
| | F.D6/3/5 |
| | F.D7/3/5 |
| | F.D8/3/5 |
| | F.D9/3/5 |
| | F.D10/3/5 |
| | F.D11/3/5 |
| | F.D12/3/5 |
| | F.D13/3/5 |

| Name of C.D | Field drain |
|---|---|
| | F.D14/3/5 |
| | F.D15/3/5 |
| C.D3/AK/N | F.D1/3/AK/N |
| | F.D2/3/AK/N |
| | F.D3/3/AK/N |
| | F.D4/3/AK/N |
| | F.D5/3/AK/N |
| | F.D6/3/AK/N |
| | F.D7/3/AK/N |
| | F.D8/3/AK/N |
| | F.D9/3/AK/N |
| | F.D10/3/AK/N |
| | F.D11/3/AK/N |
| | F.D12/3/AK/N |
| | F.D13/3/AK/N |
| | F.D14/3/AK/N |
| | F.D15/3/AK/N |
| C.D1/AK/N | F.D1/1/AK/N |
| | F.D3/1/AK/N |
| | F.D5/1/AK/N |
| | F.D7/1/AK/N |
| | F.D9/1/AK/N |
| C.D2/7 | F.D1/2/7 |
| | F.D2/2/7 |
| | F.D3/2/7 |
| | F.D4/2/7 |
| | F.D5/2/7 |
| | F.D6/2/7 |
| | F.D7/2/7 |
| | F.D8/2/7 |
| | F.D9/2/7 |
| | F.D10/2/7 |
| | F.D11/2/7 |
| | F.D12/2/7 |
| | F.D13/2/7 |
| | F.D14/2/7 |
| | F.D15/2/7 |
| | F.D16/2/7 |
| | F.D17/2/7 |
| | F.D18/2/7 |
| | F.D19/2/7 |

| Name of C.D | Field drain |
|---|---|
| | F.D20/2/7 |
| | F.D21/2/7 |
| | F.D22/2/7 |
| | F.D23/2/7 |
| | F.D24/2/7 |
| | F.D25/2/7 |
| | F.D26/2/7 |
| | F.D27/2/7 |
| | F.D28/2/7 |
| | F.D29/2/7 |
| | F.D30/2/7 |
| | F.D31/2/7 |
| C.D4/7 | F.D1/4/7 |
| | F.D2/4/7 |
| | F.D3/4/7 |
| | F.D4/4/7 |
| | F.D5/4/7 |
| | F.D6/4/7 |
| | F.D7/4/7 |
| | F.D8/4/7 |
| | F.D9/4/7 |
| | F.D10/4/7 |
| | F.D11/4/7 |
| | F.D12/4/7 |
| | F.D13/4/7 |
| | F.D14/4/7 |
| | F.D15/4/7 |
| | F.D16/4/7 |
| | F.D17/4/7 |
| | F.D18/4/7 |
| | F.D19/4/7 |
| | F.D20/4/7 |
| | F.D21/4/7 |
| | F.D22/4/7 |
| | F.D23/4/7 |
| | F.D24/4/7 |
| | F.D25/4/7 |
| | F.D26/4/7 |
| | F.D28/4/7 |
| | F.D30/4/7 |
| | F.D32/4/7 |

| Name of C.D | Field drain |
|---|---|
| | F.D34/4/7 |
| C.D8/7 | F.D2/8/7 |
| | F.D4/8/7 |
| | F.D6/8/7 |
| | F.D8/8/7 |
| | F.D10/8/7 |
| | F.D12/8/7 |
| | F.D14/8/7 |
| | F.D16/8/7 |
| F.D2/10/7 | F.D1/2/10/7 |
| | F.D2/2/10/7 |
| | F.D3/2/10/7 |
| | F.D4/2/10/7 |
| | F.D5/2/10/7 |
| | F.D6/2/10/7 |
| | F.D7/2/10/7 |
| | F.D8/2/10/7 |
| | F.D9/2/10/7 |
| | F.D10/2/10/7 |
| C.D1/4/7 | F.D1/1/4/7 |
| | F.D2/1/4/7 |
| | F.D3/1/4/7 |
| | F.D4/1/4/7 |
| | F.D5/1/4/7 |
| | F.D6/1/4/7 |
| | F.D7/1/4/7 |
| | F.D8/1/4/7 |
| | F.D9/1/4/7 |
| | F.D10/1/4/7 |
| | F.D11/1/4/7 |
| | F.D12/1/4/7 |
| | F.D13/1/4/7 |
| | F.D14/1/4/7 |
| | F.D15/1/4/7 |
| | F.D16/1/4/7 |
| | F.D17/1/4/7 |
| | F.D18/1/4/7 |
| | F.D19/1/4/7 |
| | F.D20/1/4/7 |
| | F.D21/1/4/7 |
| | F.D22/1/4/7 |

| Name of C.D | Field drain |
|---|---|
| | F.D23/1/4/7 |
| | F.D24/1/4/7 |
| | F.D25/1/4/7 |
| | F.D26/1/4/7 |
| | F.D27/1/4/7 |
| | F.D28/1/4/7 |
| | F.D29/1/4/7 |
| | F.D30/1/4/7 |
| | F.D31/1/4/7 |
| | F.D33/1/4/7 |
| C.D6/7 | F.D1/6/7 |
| | F.D2/6/7 |
| | F.D3/6/7 |
| | F.D4/6/7 |
| | F.D5/6/7 |
| | F.D6/6/7 |
| | F.D7/6/7 |
| | F.D8/6/7 |
| | F.D9/6/7 |
| | F.D10/6/7 |
| | F.D11/6/7 |
| | F.D12/6/7 |
| | F.D13/6/7 |
| | F.D14/6/7 |
| | F.D15/6/7 |
| | F.D16/6/7 |
| | F.D17/6/7 |
| | F.D18/6/7 |
| | F.D19/6/7 |
| | F.D21/6/7 |
| | F.D23/6/7 |
| | F.D25/6/7 |
| | F.D27/6/7 |
| | F.D29/6/7 |
| C.D1/6/7 | F.D1/1/6/7 |
| | F.D3/1/6/7 |
| | F.D5/1/6/7 |
| | F.D7/1/6/7 |
| | F.D9/1/6/7 |
| | F.D11/1/6/7 |
| B.D7 | F.D2/7 |

| Name of C.D | Field drain |
|---|---|
| | F.D4/7 |
| | F.D6/7 |
| | F.D8/7 |
| | F.D10/7 |
| | F.D12/7 |
| | F.D12/A/7 |
| | F.D14/7 |
| C.D10/7 | F.D1/10/7 |
| | F.D3/10/7 |
| | F.D5/10/7 |
| | F.D7/10/7 |
| | F.D2/10/7 |
| | F.D4/10/7 |