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West Irbid Wastewater Project

Final Feasibility Study

05 April 2018
# Issue and Revision Record

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<th>Date</th>
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<th>Checker</th>
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<td>P. Le Gouais</td>
<td>D. Grant J. Westberg A. Sesay</td>
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Document reference: 381789 | 05 | C

Information class: Standard

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<th>Description</th>
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<tr>
<td>°C</td>
<td>Degree Centigrade</td>
</tr>
<tr>
<td>BOD</td>
<td>Biological oxygen demand</td>
</tr>
<tr>
<td>Capex</td>
<td>Capital expenditure</td>
</tr>
<tr>
<td>Company</td>
<td>Water Authority of Jordan</td>
</tr>
<tr>
<td>Consultant</td>
<td>Mott MacDonald</td>
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<td>EBRD / the Bank</td>
<td>European Bank for Reconstruction and Development</td>
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<td>EHS</td>
<td>Environment, Health and Safety</td>
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<td>Environmental and Social Impact Assessment</td>
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<td>Environmental and Social Assessment</td>
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<td>ESAP</td>
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<td>ESHS</td>
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<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FS</td>
<td>Feasibility Study</td>
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<tr>
<td>GoJ</td>
<td>Government of Jordan</td>
</tr>
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<td>GHG</td>
<td>Greenhouse gas</td>
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<tr>
<td>ILO</td>
<td>International Labour Organization</td>
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<tr>
<td>JVA</td>
<td>Jordan Valley Authority</td>
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<tr>
<td>MEICA</td>
<td>Mechanical, electrical, instrumentation, control and automation</td>
</tr>
<tr>
<td>MMA</td>
<td>Ministry of Municipal Affairs</td>
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<td>MoEnv</td>
<td>Ministry of Environment</td>
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</tr>
<tr>
<td>MWI</td>
<td>Ministry of Water and Irrigation</td>
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<tr>
<td>MSW</td>
<td>Municipal solid waste</td>
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<tr>
<td>NTS</td>
<td>Non-Technical Summary</td>
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<td>OHS</td>
<td>Operational health and safety</td>
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<td>Opex</td>
<td>Operational expenditure</td>
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<td>PPE</td>
<td>Personal protective equipment</td>
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<td>PRs</td>
<td>EBRD Performance Requirements</td>
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<td>PS</td>
<td>Pumping station</td>
</tr>
<tr>
<td>SCADA</td>
<td>Supervisory control and data acquisition</td>
</tr>
<tr>
<td>SCE</td>
<td>State Communal Enterprise</td>
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<td>SEP</td>
<td>Stakeholder Engagement Plan</td>
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<td>Technical Report</td>
<td>Feasibility Study Report</td>
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<tr>
<td>UN</td>
<td>The United Nations</td>
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<tr>
<td>WAJ</td>
<td>Water Authority of Jordan</td>
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<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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<td>WTP</td>
<td>Water supply treatment plant</td>
</tr>
<tr>
<td>WWPS</td>
<td>Wastewater pumping station</td>
</tr>
<tr>
<td>WwTP</td>
<td>Wastewater treatment plant</td>
</tr>
<tr>
<td>YWK</td>
<td>Yarmouk Water Company</td>
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1 Introduction

1.1 Background to the Project

The European Bank for Reconstruction and Development (EBRD) “the Bank” is considering the application of finance to support the West Irbid Wastewater Network Project “the Project”. The Project involves upgrading and construction of the wastewater infrastructure system in 15 towns, located in West Irbid, by laying public sewer infrastructure that would serve a catchment area of approximately 21.9 km$^2$ including, where necessary, the installation of waste water pumping stations (WWPS), enabling the towns to connect effectively to the wastewater network and to the existing Wadi Al-Arab wastewater treatment plant (WwTP). The Project developer is the Water Authority of Jordan (WAJ, “the Company”) and are responsible for water and wastewater services in Jordan. The Yarmouk Water Company (YWC), a subsidiary of WAJ will be responsible for the operation of the Project.

To define the Project and inform the financing decision process, Mott MacDonald has been commissioned by EBRD on 4 April 2017 to undertake a Technical Due Diligence of the Project including an Environmental and Social Due Diligence (ESDD). However, a preliminary review concluded that the Project design reports lacked technical evidence to inform the Bank of the technical and economic viability of the Project and were not aligned to the design option set out in the ESDD scope of work. Subsequently the Bank recommissioned Mott MacDonald on 30 July 2017 to undertake additional project development. This includes the preparation of a feasibility study of the Project to examine various options, identify a preferred option and the associated costs and produce terms of reference for detailed design. The revised environmental and social scope is summarised in Section 1.2 below.

The Project is a part of the Bank’s wider engagement with the WAJ aimed at developing and implementing a comprehensive wastewater investment programme to resolve the country’s current issues in the sector, caused by rapid population growth, including that resulting from Syrian refugee influx, which has placed an unprecedented strain on the wastewater system.

1.2 Findings of Previous Inception Report

In May 2017 Mott MacDonald produced an Inception report (Document Reference 381789 | 01 | A) detailing the findings of a technical, financial, environmental and social review conducted for a previous iteration of the West Irbid Wastewater Network Project. This was undertaken as part of EBRD’s Due Diligence process.
2 Project Description

2.1 The Company

The main implementation partner of the project is the WAJ, a state-owned autonomous corporate body under the authority and oversight of the Ministry of Water and Irrigation (MWI) established 1983, pursuant to the Water Authority Law No.34 of 1983. WAJ and MWI work jointly in determining the national water policy, however the responsibility of water and wastewater services in Jordan rests with WAJ.

WAJ has direct responsibility for the provision of water supply and sanitation services and is therefore involved at the management and technical level for investments in the water sector. EBRD and a number of other donors have ongoing programmes with WAJ to support their capacity to react to the Syrian refugee crisis, manage investments and involve the private sector where possible.

WAJ is responsible for the design, construction, operation, maintenance, and administration of public water and wastewater projects. The company provides water and wastewater services directly and indirectly through its subsidiaries listed below:

- Meyahuna (MWC) provides services mainly in the Governorate of Amman
- Yarmouk Water Company (YWC) provides services in the northern governorates of Jordan and
- Aqaba Water Company (AWC) provides services in the southern part of Jordan.

WAJ's mandate includes connecting the public to and maintaining, operating and managing the water and sewer networks. The envisaged project will be operated by the wholly-owned subsidiary, YWC.

YWC provides water and wastewater services in Irbid and three other governorates, reaching approximately 300,000 water and 100,000 wastewater subscribers.

YWC uses groundwater sources, primarily the wells of Al Aqeb, Wadi Arab, Hakama and Al-Ramtha, and a number of natural springs to supply 85 million m$^3$ annually to Irbid, Amman and the King Abdullah Canal (for irrigation). Only a very limited quantity of this water is available as potable supplies to Irbid, which results in residents receiving only periodic supply and relying on domestic tanks to provide continuity.

2.2 Investment Programme

The project will be implemented by WAJ with the support of external funding as described below.

A 20 million Euro European Union (EU) MADAD grant was requested to provide approximately 50 per cent of the capital project costs. The MADAD grant will cover the project’s technical advisor's activities, including support and awareness campaigns as well as the investment costs.

The remainder will be covered by a long-term loan from EBRD and a USD 2.5 million contribution from the Global Concessional Finance Facility (GCFF) and additional grant from EBRD. The EBRD will provide a EUR 25 million sovereign loan to the Government of Jordan (GoJ).
The EBRD will receive the MADAD grant funds and will lend directly to the GoJ via a loan agreement with MWI (the EU grant beneficiary). The EBRD loan funds will be disbursed on a pro-rata basis with MADAD grant funds in line with the construction timeframe and based on completed works as approved by the supervision engineers.

The proposed MADAD investment grant will be an integral part of the project financing plan with no distinction of investment components exclusively financed by MADAD resources.

### 2.3 Details of Project

The EBRD, in association with WAJ, are proposing to extend wastewater collection networks to the communities of West Irbid (Figure 3), covering a total area of $21km^2$. The project consists of constructing and operating a sewerage network system with pumping stations as necessary to connect to an existing Wadi Al Arab WwTP. This will involve the construction of first-time sewerage networks and pumping stations as necessary. The project will ultimately connect around 20,000 households, serving their needs up to the year 2040.

The key components of the proposed project are presented in Section 6 along with various other options that have been considered. The components include the following:

- House connections and local sewerage networks;
- Trunk sewers
- Pumping stations and rising mains
- Connection to the existing Wadi Al Arab WwTP.

Section 2.4 details the overall layout of the proposed scheme.

#### 2.3.1 Location of the project

The project is located in the Irbid Governorate in northern Jordan (shown in Figure 1), approximately 80 km north of Amman. Figure 2 shows the location of the West Irbid area and Figure 3 shows the administrative boundaries of each of the villages within the Project Area.
Figure 3: West Irbid villages administrative boundaries

Source: ACE Engineers Concept Design Report
3 Population and Population Growth

3.1 Former Population Forecast

In the 2016 Final Design Report, ACE based their population estimates for 2040 on data available in 2013 and used a growth rate of 2.1%. The resultant figures for the area under consideration are shown in Table 1 below.

Table 1: Population growth estimates 2013

<table>
<thead>
<tr>
<th>Nr</th>
<th>Village</th>
<th>2013 Population</th>
<th>2040 Population</th>
</tr>
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<tr>
<td>1</td>
<td>Natfeh (unserved area)</td>
<td>1,959</td>
<td>3,342</td>
</tr>
<tr>
<td>2</td>
<td>Kufr Yoba</td>
<td>15,899</td>
<td>27,331</td>
</tr>
<tr>
<td>3</td>
<td>Zahr</td>
<td>6,617</td>
<td>11,356</td>
</tr>
<tr>
<td>4</td>
<td>Jumha</td>
<td>3,011</td>
<td>5,152</td>
</tr>
<tr>
<td>5</td>
<td>Ham</td>
<td>1,496</td>
<td>2,545</td>
</tr>
<tr>
<td>6</td>
<td>Beit Yafa</td>
<td>10,727</td>
<td>18,431</td>
</tr>
<tr>
<td>7</td>
<td>Kufr Asad</td>
<td>11,417</td>
<td>19,616</td>
</tr>
<tr>
<td>8</td>
<td>Qum</td>
<td>1,801</td>
<td>3,069</td>
</tr>
<tr>
<td>9</td>
<td>Qumeem</td>
<td>7,256</td>
<td>12,456</td>
</tr>
<tr>
<td>10</td>
<td>Kufr Aan</td>
<td>3,702</td>
<td>6,341</td>
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<tr>
<td>11</td>
<td>Saydour</td>
<td>2,141</td>
<td>3,656</td>
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<tr>
<td>12</td>
<td>Kherbit Marshed</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Hofa Wasatia</td>
<td>4,931</td>
<td>8,456</td>
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<tr>
<td>14</td>
<td>Kharaj</td>
<td>3,042</td>
<td>5,206</td>
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<tr>
<td>15</td>
<td>Soum (unserved area)</td>
<td>2,480</td>
<td>4,238</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>76,479</td>
<td>131,195</td>
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</table>

Source: ACE report

Note that the village of Soum is already partially served by a sewerage system and the population given is for just the un-served area. About 70% of Natfeh is also served although this is not reflected in the above figures. ACE reports prior to the 2016 Final Design Report reflected this. The 2016 report also excluded the individual consideration of Kherbit Marshed as it is now included as a part of Kufr Asad.

3.2 Updated Population Forecast

Since the projections in Table 1 were carried out, the results of the 2015 census data have been made available. The updated current and predicted 2040 village populations are shown in Table 2 below. The growth rate used was 2.1%, the same as that used by ACE.
### Table 2: Population growth estimates

<table>
<thead>
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<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Natfeh (unserved area)</td>
<td>2,313</td>
<td>694*</td>
<td>1,125</td>
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<tr>
<td>2</td>
<td>Kufr Yuba</td>
<td>22,943</td>
<td>22,943</td>
<td>37,189</td>
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<tr>
<td>3</td>
<td>Zahr</td>
<td>7,677</td>
<td>7,677</td>
<td>12,444</td>
</tr>
<tr>
<td>4</td>
<td>Jumhaa</td>
<td>3,450</td>
<td>3,450</td>
<td>5,592</td>
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<tr>
<td>5</td>
<td>Ham</td>
<td>2,109</td>
<td>2,109</td>
<td>3,419</td>
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<tr>
<td>6</td>
<td>Bayt Yafa</td>
<td>12,804</td>
<td>12,804</td>
<td>20,754</td>
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<td>7</td>
<td>Kufr Asad</td>
<td>14,232</td>
<td>14,232</td>
<td>23,069</td>
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<td>8</td>
<td>Qum</td>
<td>2,274</td>
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<td>Qumeem</td>
<td>8,695</td>
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<td>Kufr Aan</td>
<td>4,077</td>
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<td>Saydour</td>
<td>2,302</td>
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<td>3,731</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Hofa Wastia</td>
<td>7,084</td>
<td>7,084</td>
<td>11,483</td>
</tr>
<tr>
<td>14</td>
<td>Kharaj</td>
<td>3,907</td>
<td>3,907</td>
<td>6,333</td>
</tr>
<tr>
<td>15</td>
<td>Soum (unserved area)</td>
<td>10,667</td>
<td>3,079*</td>
<td>4,991</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>104,534</strong></td>
<td><strong>95,327</strong></td>
<td><strong>154,519</strong></td>
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</table>

Source: 2015 data from Census, Amended and Projected data estimated in Mott MacDonald

* Note: The 2015 populations for Soum and Natfeh have been amended because the areas are already partially served by sewerage. The 2015 population numbers refer to the whole villages, whereas the amended numbers relate to the estimated un-served population. The amended numbers have been calculated using the original ACE numbers and the average growth rate from across the other villages.

** Note: The Kherbit Marshed population is included in that for Kufr Asad.
4 Water Supply and Wastewater Flows

4.1 Water Supply

4.1.1 Current Per-capita Water Supply

From the site visits, discussions with various people, official records, and the results of various focus group meetings, we understand the general scenario with regards water supply is that:

- Most villages and properties in the West Irbid villages receive a piped water supply, however this supply is rationed by limiting the times water is made available from the system. There is a timetable (available on-line) which provides the details. Some key strategic assets, such as hospitals, are provided with a continuous supply, but almost all residential consumers are limited to a supply over a few hours once a week;

- This affects the pattern of consumption as the available supply for the week is limited to the household's storage capacity. Properties typically have one or more roof tanks of $1 - 2 \text{ m}^3$.

- Some households will replenish the water supply during the week by a tanker supply, others may have access to a well, ground tanks or harvest the rainwater during the winter.

- The limited availability of water means that the residents are very careful over its use. Typically, the fresh water is used for flushing, washing and laundry. The grey water is then often used for cleaning floors or watering gardens.

The ACE design reports settled on a current per-capita consumption of 88 litres per capita per day (l/c/d). This consumption pattern was continued through the whole design horizon period to 2040.

The current practices indicate that the existing water consumption rates are less than this. Table 1 of the Water Reallocation Policy, 2016, shows that the supplied water per-capita was 68.6 litres per day. After losses and other non-revenue water is taken into consideration, the net per-capita consumption reduced to 42 l/c/d. Unaccounted-for water is calculated to have been 38% of supply, equivalent to 26.5 l/c/d.

4.1.2 Future Per-capita Water Supply

The National Water Strategy Policy Report, 2016 quotes that in the future, the highest priority is to ensure that all citizens have access to sufficient, safe and affordable water for personal and domestic uses. The residential demand is defined as 120, 100 and 80 l/c/d for major urban centres (Amman), small towns and rural areas respectively.

As the West Irbid villages are considered to be rural areas, and assuming that the recommended water quantities can be delivered in the future, it would be appropriate to adopt the figure of 80 l/c/d for longer-term planning purposes. While for Irbid City a long-term consumption of 100 l/c/d is more appropriate. For Irbid City, an additional 16 l/c/d has been allowed for in the consumption figures to account for commercial, industrial, tourism and contingency. This aligns with the assumed per capita consumption of 116 l/c/d developed by ACE.

Once supplies improve, there is expected to be a ramped increase in water consumption as people's practices and lifestyles gradually change as they become used to reliable water supplies. The model assumes that this ramping up of consumption occurs uniformly between current levels and 2030 as shown in Table 4.
There is a planned water supply expansion programme, the Wadi Arab Water System II, due to increase the potable supplies to the Irbid area by 82,000m$^3$/day. The project was planned in the National Water Strategy to be implemented between 2016-2018. Construction of the project started in mid-2017 and is due to be operational at the end 2019 or start of 2020. However, the project is due to swap water allocation rights with flows going into Lake Tiberius with new flows from the Red/Dead transfer scheme, which as of October 2017 is still out for tender. There is uncertainty over whether if the new Wadi Arab WTP and transmission line is completed before the Red-Dead transfer is completed, whether supplies to the WTP would be prioritised over other uses. The capacity expansion of the water supply system is essential to the success of a sewerage scheme, to help ensure that there are sufficient flows to maintain a self-cleansing velocity.

4.2 Wastewater Production

4.2.1 Current Per-capita Wastewater Production

Current wastewater production is restricted by the limited and periodic water supply and available household storage. The disposal of wastewater to sewage treatment plants is further restricted by the limited sewage storage afforded by the prevalence of cess pits of a limited capacity and the costs of having the pits emptied. This encourages the efficient use and re-use of water. Grey water is typically re-used for floor washing etc and then for watering gardens. Sometimes it may be disposed of to the street, especially in winter. Loss of wastewater is also encouraged by allowing exfiltration from the cess pits and the planting of trees nearby to absorb and lose the water through evapotranspiration. It is usually estimated that only about 80% of water supplied is returned to sewer, however with the prevailing added inducements in West Irbid, the figure is much lower. An estimate of 50% return after re-use, evaporation and exfiltration is probably conservative but would result in a current discharge of just 20 l/c/d.

The wastewater is discharged to cess pits, not septic tanks, and these require frequent emptying. All the flow into the pits is stored, except for that which leaks away and is exfiltrated or taken up by vegetation. When the tanks are full, the responsible households, if financially able, contact a tanker haulage contractor to have the tank emptied. This can be as frequent as twice a month but is usually longer. The tankers collect the wastewater and take it to one of several disposal sites, principally at Al Kaider to the east of Irbid, but also to North Shouna WwTP to the west. Pit emptying costs about JD40 to JD60 per visit, depending on the distance to disposal.

Approximately 80 tankers per day use the Al Kaider site, with each tanker visiting two or three times. The tankers typically have a capacity of 9 m$^3$, 14m$^3$ and up to 35m$^3$. Assuming 160 visits per day with an average of 14m$^3$ each, the volume discharged would be 2,240 m$^3$. The official records for Al Kaider show that the volumes received during 2016 were between 1,600 and 2,600 m$^3$/d with an average of 2,000 m$^3$/d.

The records for North Shouna in 2017 show the volumes received were between 600 and 800m$^3$/d, with an average of 700 m$^3$/d.

The total of 2,700 m$^3$/d would equate to a per-capita contribution from a 90,000 population of West Irbid of 34 litres. However, the sites cover an area significantly wider than just West Irbid. Local staff estimated that about half would be from elsewhere, so the per-capita West Irbid contribution is estimated at 17 litres/day.

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1 This is based on the 30 MCM/year that is included in the National Water Strategy
These assessments rely on a lot of estimation, but the two approaches result in similar estimates of between 17 and 20 l/c/d. This current per capita wastewater production is below the flow levels at which piped sewer networks are usually considered to be technically feasible, due to low flow velocities.

The current wastewater production of residents in Irbid is higher. This is currently averages at 55.4 l/c/d being received at Wadi Al Arab WWTP. Based on the current water consumption of approximately 70 l/c/d, this equates to an 80% return.$2$

4.2.2 Future per-capita Wastewater Production

Following completion of the planned water supply expansion, there is expected to be a significant increase in the volume of wastewater produced. This is due to both the increased consumption and higher percentages returning to the network as there will be less incentive to minimise water usage or to recycle the grey water within the household. Added to that, the provision of a sewerage connection to each household is only likely to encourage further wastewater flows to treatment as households would no longer have to pay for the cess pit emptying or construction.

With these considerations, it is probable that wastewater discharges to treatment will increase towards the typical 80% of water supplied, and hence to about 64 l/c/d. Note that the ACE report assumed 70.4 l/c/d, which also include some commercial and industrial discharges and a contingency.

4.3 Current and Future Wastewater Flows

Wastewater flow rates are usually estimated from the population served and the average per-capita water consumption. However, this is not a feasible approach for the determination of current wastewater discharges to treatment due to the restraining factors associated with the prevailing water supply and wastewater disposal practices. The current per-capita wastewater discharge to treatment has been estimated based on both a low level of water supply and a high level of grey-water re-use. This, together with the quantities received from the tanker discharge sites suggest a total of only about 20 l/c/d.

Future discharges assume an improved and un-rationed supply and less incentive for grey-water re-use resulting in a discharge estimated to be 64 l/c/d. The consequent volumes of wastewater for 2015 and 2040, considering the increased population and per-capita discharge are shown in Table 3, broken down by village. Table 4 shows the projected wastewater production for Irbid and West Irbid between 2017 and 2040 and the assumptions assumed.

---

$^2$ JICA - Water Supply Masterplan— January 2015
## Table 3: Population and per-capita discharge

<table>
<thead>
<tr>
<th>Nr</th>
<th>Village</th>
<th>2015 population</th>
<th>Total discharge at 20 l/c/d (m³/d)</th>
<th>2040 population</th>
<th>Total discharge at 64 l/c/d (m³/d)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Natfeh (unserved area)</td>
<td>694</td>
<td>14</td>
<td>1,125</td>
<td>72</td>
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<tr>
<td>2</td>
<td>Kufr Yuba</td>
<td>22,943</td>
<td>459</td>
<td>37,189</td>
<td>2,380</td>
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<td>3</td>
<td>Zahr</td>
<td>7,677</td>
<td>154</td>
<td>12,444</td>
<td>796</td>
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<tr>
<td>4</td>
<td>Jumhaa</td>
<td>3,450</td>
<td>69</td>
<td>5,592</td>
<td>358</td>
</tr>
<tr>
<td>5</td>
<td>Ham</td>
<td>2,109</td>
<td>42</td>
<td>3,419</td>
<td>219</td>
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<td>6</td>
<td>Bayt Yafa</td>
<td>12,804</td>
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<td>20,754</td>
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<td>7</td>
<td>Kufr Asad</td>
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<td>8</td>
<td>Qum</td>
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<td>3,686</td>
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<tr>
<td>9</td>
<td>Qumeem</td>
<td>8,695</td>
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<td>Kufr Aan</td>
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<td>82</td>
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<td>11</td>
<td>Saydour</td>
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<td>46</td>
<td>3,731</td>
<td>239</td>
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<tr>
<td>12</td>
<td>Kherbit Marshed</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Hofa Wastia</td>
<td>7,084</td>
<td>142</td>
<td>11,483</td>
<td>735</td>
</tr>
<tr>
<td>14</td>
<td>Kharaj</td>
<td>3,907</td>
<td>78</td>
<td>6,333</td>
<td>405</td>
</tr>
<tr>
<td>15</td>
<td>Soum (unserved area)</td>
<td>3,079</td>
<td>62</td>
<td>4,991</td>
<td>319</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>95,327</strong></td>
<td><strong>1,907</strong></td>
<td><strong>154,519</strong></td>
<td><strong>9,889</strong></td>
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Source: Mott Macdonald
<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>2027</th>
<th>2028</th>
<th>2029</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
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<tr>
<td>Connected Irbid population ('000)</td>
<td>240</td>
<td>245</td>
<td>250</td>
<td>255</td>
<td>261</td>
<td>266</td>
<td>272</td>
<td>278</td>
<td>283</td>
<td>289</td>
<td>295</td>
<td>302</td>
<td>308</td>
<td>314</td>
<td>349</td>
<td>387</td>
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<td>West Irbid population ('000)</td>
<td>95</td>
<td>97</td>
<td>99</td>
<td>101</td>
<td>103</td>
<td>105</td>
<td>107</td>
<td>109</td>
<td>112</td>
<td>114</td>
<td>116</td>
<td>119</td>
<td>121</td>
<td>124</td>
<td>138</td>
<td>153</td>
</tr>
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<td>Percentage connected (West Irbid) (%)</td>
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<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Total connected population ('000)</td>
<td>240</td>
<td>255</td>
<td>275</td>
<td>306</td>
<td>338</td>
<td>371</td>
<td>379</td>
<td>387</td>
<td>395</td>
<td>403</td>
<td>412</td>
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<td>429</td>
<td>438</td>
<td>486</td>
<td>540</td>
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<tr>
<td>Water consumption - Irbid - l/c/d</td>
<td>69.2</td>
<td>72.8</td>
<td>76.4</td>
<td>80.0</td>
<td>83.6</td>
<td>87.2</td>
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<td>108.8</td>
<td>112.4</td>
<td>116.0</td>
<td>116.0</td>
<td>116.0</td>
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<tr>
<td>Water consumption - West Irbid - l/c/d</td>
<td>42.0</td>
<td>44.9</td>
<td>47.8</td>
<td>50.8</td>
<td>53.7</td>
<td>56.6</td>
<td>59.5</td>
<td>62.5</td>
<td>65.4</td>
<td>68.3</td>
<td>71.2</td>
<td>74.2</td>
<td>77.1</td>
<td>80.0</td>
<td>80.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Percentage returned - Irbid</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
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<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Percentage returned - West Irbid</td>
<td>50%</td>
<td>52%</td>
<td>55%</td>
<td>57%</td>
<td>59%</td>
<td>62%</td>
<td>64%</td>
<td>66%</td>
<td>68%</td>
<td>71%</td>
<td>73%</td>
<td>75%</td>
<td>78%</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
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<tr>
<td>Wastewater - Irbid (l/c/d)</td>
<td>55.4</td>
<td>58.3</td>
<td>61.1</td>
<td>64.0</td>
<td>66.9</td>
<td>69.8</td>
<td>72.7</td>
<td>75.5</td>
<td>78.4</td>
<td>81.3</td>
<td>84.2</td>
<td>87.0</td>
<td>89.9</td>
<td>92.8</td>
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<td>92.8</td>
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<tr>
<td>Wastewater - West Irbid (l/c/d)</td>
<td>20.0</td>
<td>23.5</td>
<td>26.1</td>
<td>28.9</td>
<td>31.8</td>
<td>34.8</td>
<td>38.0</td>
<td>41.3</td>
<td>44.8</td>
<td>48.3</td>
<td>52.1</td>
<td>55.9</td>
<td>59.9</td>
<td>64.0</td>
<td>64.0</td>
<td>64.0</td>
</tr>
<tr>
<td>Flow to treatment Irbid (Ml/d)</td>
<td>13,294</td>
<td>14,278</td>
<td>15,298</td>
<td>16,354</td>
<td>17,448</td>
<td>18,581</td>
<td>19,753</td>
<td>20,967</td>
<td>22,223</td>
<td>23,522</td>
<td>24,866</td>
<td>26,257</td>
<td>27,694</td>
<td>29,181</td>
<td>32,376</td>
<td>35,921</td>
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<tr>
<td>Flow to treatment - West Irbid (m³/d)</td>
<td>-</td>
<td>227</td>
<td>644</td>
<td>1,455</td>
<td>2,453</td>
<td>3,658</td>
<td>4,075</td>
<td>4,523</td>
<td>5,002</td>
<td>5,516</td>
<td>6,064</td>
<td>6,649</td>
<td>7,272</td>
<td>7,935</td>
<td>8,804</td>
<td>9,768</td>
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<tr>
<td>Combined flow to treatment (Ml/d)</td>
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<td>14,505</td>
<td>15,943</td>
<td>17,810</td>
<td>19,901</td>
<td>22,239</td>
<td>23,828</td>
<td>25,490</td>
<td>27,225</td>
<td>29,038</td>
<td>30,930</td>
<td>32,905</td>
<td>34,966</td>
<td>37,116</td>
<td>41,180</td>
<td>45,689</td>
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<td>BOD to treatment (kg/d)</td>
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<td>12,735</td>
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<td>16,897</td>
<td>18,564</td>
<td>18,954</td>
<td>19,352</td>
<td>19,758</td>
<td>20,173</td>
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<td>21,029</td>
<td>21,471</td>
<td>21,922</td>
<td>24,322</td>
<td>26,986</td>
</tr>
</tbody>
</table>

Source: Mott MacDonald
5 Wastewater Treatment

5.1 General
The recommended option, as ultimately designed by ACE, was to drain almost the whole of the West Irbid area towards the north-west and a new treatment plant to be constructed in Al Taybeh. The exceptions were the villages of Natfeh and Soum, which would be connected to the existing trunk sewerage system and drain to the Wadi Al Arab WwTP.

This approach has some logic as the natural drainage pattern of the area is towards the north-west, however it would require the construction of a new WwTP (on land that is still to be acquired) and does not take advantage of any spare treatment capacity at Wadi Al Arab.

It is understood that following the consideration of the additional costs and land acquisition issues associated with the construction of a new WwTP, WAJ is in favour of options which optimise use of their existing assets at Wadi Al Arab.

To this end, the WwTP at Wadi Al Arab has been given a brief assessment, taking into account the improvements currently being tendered. It is to be noted that the plant at Wadi Al Arab has six parallel process streams, but only four of these have ever been used. This means the plant could potentially treat significantly more flow and load if these were brought into service.

5.2 Wadi Al Arab WwTP – existing capacity assessment
The works is an extended aeration system comprising six aeration lanes, two of which have never been in service. Aeration is by surface aeration. A process analysis has been carried out to establish the capacity of the WwTP under different scenarios based on the following (2017) flows and loads:

- Average flow to the works 13,294 m$^3$/d
- Maximum flow to the works 15,690 m$^3$/d
- Design flow to the works 21,000 m$^3$/d
- Design BOD load to the works 12,000 kg/d
- Average BOD concentration to the works 903 mg/l
- Maximum BOD concentration to the works 1,012 mg/l
- Average SS to the works 874 mg/l
- Maximum SS to the works 1,294 mg/l

The required Jordanian effluent quality standard is 60 mg/l BOD and 60 mg/l SS for effluent discharged into rivers and other water surfaces.

The following four scenarios were evaluated:

- Operate four lanes as currently with no primary sedimentation tanks upstream of the aeration lanes.
- Operate four lanes as currently but with primary sedimentation tanks upstream of the aeration lanes.
- Operate all six lanes without primary sedimentation tanks upstream of the aeration lanes.
- Operate all six lanes with primary sedimentation tanks upstream of the aeration lanes.
5.2.1 Analysis findings

- The wastewater BOD and SS are very much stronger than those of a typical domestic wastewater.
- For all the scenarios of operating four aeration lanes only, with or without primary treatment, the works would be significantly organically overloaded, making it difficult to achieve the required effluent quality.
- With all six lanes in service and without primary treatment upstream, there would be a satisfactorily long retention time, however, there is the risk of significant odour generation as the WwTP would still be organically over-loaded and the prevailing ambient temperatures at the site are high.
- With the addition of primary sedimentation tanks to settle out 25% of the BOD and 65% of the SS upstream of the six aeration lanes the plant would have some headroom to take up to a further 35-40% of average flow.
- The aeration basins are about 4.5 m deep. Previous reports indicate that the existing surface aeration system is not effective in mixing the MLSS and oxygen transfer. Surface aerators would normally be installed in shallower tanks.

5.2.2 Conclusions on capacity for existing flows and loads

- The WwTP is organically overloaded for current (2017) flows. Providing primary treatment would reduce the biological load going forward to full treatment. Four primary sedimentation tanks, each 16 m diameter, would be required, or three 18.4 m diameter tanks.
- In addition to installing primary treatment, bringing the two unused aeration lanes into operation would increase flow capacity by up to 40% of average flow.
- The mechanical sludge thickeners should be brought into full operation to reduce the required sludge drying bed capacity and free up some space for the proposed primary sedimentation tanks.
- It has not been possible to undertake a detailed evaluation of the existing surface aeration system due to lack of data. However, its replacement with fine bubble diffused aeration system would improve treatment performance.
- The relatively low effluent quality requirement of 60 mg/l BOD and 60 mg/l SS is too poor to be suitable as a feed to downstream tertiary and disinfection plants.

5.3 Wadi Al Arab WwTP – future capacity assessment

The 2017 incoming flow data to the Wadi Al Arab WwTP is shown in Table 5.

Table 5: Wastewater flow data for Wadi Al Arab WwTP (2017)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AVG</th>
<th>MIN</th>
<th>MAX</th>
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<tr>
<td>INF AVG FLOW m3/d</td>
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<td>12,040</td>
<td>11,642</td>
<td>12,769</td>
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<td>13,294</td>
<td>11,255</td>
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<td>EFF AVG FLOW m3/d</td>
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<td>14,240</td>
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<td>12,901</td>
<td>10,918</td>
<td>15,227</td>
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<td>TSS INF mg/l</td>
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<td>962</td>
<td>628</td>
<td>1,031</td>
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<tr>
<td>TSS EFF mg/l</td>
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<td>79</td>
<td>106</td>
<td>62</td>
<td>39</td>
<td>24</td>
<td>34</td>
<td>54</td>
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<td>106</td>
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<td>TSS REDUCTION %</td>
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<td>BOD5 INF mg/l</td>
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<td>960</td>
<td>990</td>
<td>903</td>
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<td>BOD5 EFF mg/l</td>
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<td>31</td>
<td>35</td>
<td>41</td>
<td>21</td>
<td>64</td>
</tr>
<tr>
<td>BOD5 REDUCTION %</td>
<td>96.5</td>
<td>95</td>
<td>94.2</td>
<td>93.1</td>
<td>96.3</td>
<td>96.8</td>
<td>96.4</td>
<td>95</td>
<td>93</td>
<td>97</td>
</tr>
<tr>
<td>COD INF mg/l</td>
<td>774</td>
<td>1,409</td>
<td>1,692</td>
<td>1,472</td>
<td>1,553</td>
<td>1,970</td>
<td>1,997</td>
<td>1,552</td>
<td>774</td>
<td>1,997</td>
</tr>
<tr>
<td>COD EFF mg/l</td>
<td>67.5</td>
<td>144</td>
<td>192</td>
<td>125</td>
<td>96</td>
<td>44</td>
<td>40</td>
<td>46</td>
<td>44</td>
<td>192</td>
</tr>
<tr>
<td>COD REDUCTION %</td>
<td>91.3</td>
<td>89.4</td>
<td>88.7</td>
<td>91.5</td>
<td>96.8</td>
<td>97.8</td>
<td>97</td>
<td>93</td>
<td>89</td>
<td>98</td>
</tr>
</tbody>
</table>
It can be seen that the influent BOD concentration is high compared to that usually found in domestic wastewater elsewhere. It is understood that this is due to limitations on the water supply and the consequent efficient use and re-use of water at a domestic level.

The average BOD concentration and the average flow indicate a daily BOD load of 12,000 kg per day is received at the WwTP. Assuming a typical 50g per person contribution, this equates to a population equivalent of 240,000. The average influent flow rate of 13,294 m³/d indicates a per-capita flow contribution of 55 l/d.

Between now and the design horizon of 2040, it can be expected that the population in the areas already served by the WwTP will increase at approximately the prevailing rate of 2.1% per year. This means the 2040 population equivalent could reach over 387,000. It is also the WAJ policy to achieve a per-capita residential water supply of 100 l/d in urban areas.

The increased population numbers, together with an increased water supply will lead to significantly increased wastewater flows. Assuming 80% of water supplied is returned to the sewerage system, the 2040 flow to Wadi Al Arab would rise to 45,689 m³/d.

The average daily flow from the villages in West Irbid is predicted to be nearly 10,000 m³/d.

The build-up of flows and loads to treatment between now and year 2040 is shown in the Table 6 below. This considers the current flow to treatment, natural growth in the existing catchment areas, new areas to be connected in West Irbid and the anticipated per-capita water consumption and discharge.

Table 6: Build-up of flows and loads to treatment between 2017 and 2040

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected Irbid Population</td>
<td>240,000</td>
<td>245,040</td>
<td>250,186</td>
<td>255,440</td>
<td>260,804</td>
<td>266,281</td>
<td>283,411</td>
<td>314,446</td>
<td>348,879</td>
<td>387,082</td>
</tr>
<tr>
<td>West Irbid Population</td>
<td>94,633</td>
<td>96,620</td>
<td>98,649</td>
<td>100,721</td>
<td>102,836</td>
<td>104,996</td>
<td>111,750</td>
<td>123,987</td>
<td>137,564</td>
<td>152,628</td>
</tr>
<tr>
<td>% Connected (West Irbid)</td>
<td>0%</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Total Connected</td>
<td>240,000</td>
<td>254,702</td>
<td>274,848</td>
<td>305,800</td>
<td>337,931</td>
<td>371,277</td>
<td>395,162</td>
<td>438,433</td>
<td>486,443</td>
<td>539,710</td>
</tr>
<tr>
<td>Flow to treatment - Irbid (m³/day)</td>
<td>13,294</td>
<td>14,278</td>
<td>15,298</td>
<td>16,354</td>
<td>17,448</td>
<td>18,581</td>
<td>22,223</td>
<td>29,181</td>
<td>32,376</td>
<td>35,921</td>
</tr>
<tr>
<td>Flow to Treatment - West Irbid (m³/day)</td>
<td>-</td>
<td>227</td>
<td>644</td>
<td>1,455</td>
<td>2,453</td>
<td>3,658</td>
<td>5,002</td>
<td>7,935</td>
<td>8,804</td>
<td>9,768</td>
</tr>
<tr>
<td>Combined flow to treatment (m³/day)</td>
<td>13,294</td>
<td>14,505</td>
<td>15,943</td>
<td>17,810</td>
<td>19,901</td>
<td>22,239</td>
<td>27,225</td>
<td>37,116</td>
<td>41,180</td>
<td>45,689</td>
</tr>
<tr>
<td>BOD to Treatment kg/d</td>
<td>12,000</td>
<td>12,735</td>
<td>13,742</td>
<td>15,290</td>
<td>16,897</td>
<td>18,564</td>
<td>19,758</td>
<td>21,922</td>
<td>24,322</td>
<td>26,986</td>
</tr>
</tbody>
</table>

Source: Mott MacDonald
The current design hydraulic capacity of the WwTP is 21,000 m$^3$/d (assuming six aeration lanes in service). This shows that the current design flow capacity of the Wadi Al Arab WwTP will be reached in year 2022 with average flows and the biological capacity of 12,000 kg/d is already fully utilised. As two of the six process streams are currently out of commission, the works struggles to meet with the effluent quality requirements.

If the proposed improvements to the WwTP are carried out, that is to improve the sludge treatment operation, commission the two additional process streams, adapt to fine-bubble aeration and include primary settlement tanks, then the flow capacity would be expected to increase to the following:

- Average daily flow (ADF) 18,270 m$^3$/d
- Flow to full treatment (FFT) 29,000 m$^3$/d
- BOD load 18,000 kg/d

These modifications would delay the need for an additional treatment plant until 2026, but it is noted that the BOD load capacity is not significantly improved and would still likely be exceeded in the shorter term (2018).
6 Potential Options

6.1 Overview of Options

6.1.1 Option 1.1 - Original Scheme – Version 1

This was the scheme as originally recommended by ACE in their Conceptual Report of April 2015. The scheme collects the wastewater from the currently un-served areas of Natfeh and Soum and directs the collected flows to the existing trunk sewers for transfer to the Wadi Al Arab WwTP.

The remaining villages require a new strategic trunk sewer, pumping station and rising main system to transfer the flows to Wadi Al Arab WwTP. This scheme meets with the requirements to send all flows to the existing treatment plant, but requires the provision of a total of 24 new pumping stations, with their associated capital, operational and maintenance costs.

This option does not address how Wadi Al Arab WwTP would be expanded to meet the future increases in flows and loads.

6.1.2 Option 1.2 – Original Scheme – Version 2

This scheme involves collecting the wastewater from the villages of Natfeh, Bait Yafa, Kufer Yoba, Zahar, Jumha, Kufr Aan, Qumeem, Qum and Hofa and forwarding the flows via a new strategic trunk system to Wadi Al Arab WwTP.

The wastewater from the village of Ham and the un-served area in Soum would use the existing sewer system draining to Wadi Al Arab WwTP.

The wastewater from the villages of Al Kharaj, Kufr Asad, Saydour and Kherbit Marshed would be forwarded to a proposed new WwTP near Al Teybeh to the north-west of the area. This option would address some of the capacity issues at Wadi Al Arab WwTP but would require the development of a new wastewater treatment plant and require the construction of 23 pumping stations.

6.1.3 Option 1.3 – Original Scheme – Version 3 (as designed)

This was the scheme originally selected as the preferred of the three versions of the Original Scheme designed by ACE and presented in their Final Design Report of September 2016. This version collects the wastewater from the currently un-served areas of Natfeh and Soum and directs the collected flows to the existing trunk sewers for transfer to the Wadi Al Arab WwTP.

Most of the remaining villages require a new strategic trunk sewer, pumping station and rising main system to transfer the flows to a proposed new WwTP near Al Teybeh to the north-west of the area. The sewerage system for the village of Beit Yafa is split. One part is included in the proposed system to Al Teybeh, but a significant proportion is drained to a yet-to-be-built system (by others) through Deir Al Se’neh. This option takes the minimum advantage of any current or future spare capacity at Wadi Al Arab WwTP and also relies on a new system to be constructed, by others, through Deir Al Se’neh. Trunk sewers and rising mains are assumed to be laid along existing highways.

The proposed system requires a total of 18 pumping stations to be provided, operated and maintained. This option has been schematically presented in Appendix B in Figure 9.
Since this option was first prepared, the 2015 census population data has become available. The schematic has therefore been amended to incorporate these changes and to address an earlier inconsistency in the summation of the populations through the catchments (Figure 10).

6.1.4 Option 2 - All sewage to Wadi Al Arab WwTP

The locations of the 18 pumping stations identified under Option 1.3, and the gravity nodes from Soum, Natfeh and part of Beit Yafa have been considered as the primary collection points for this option to transfer all flows to Wadi Al Arab with a minimum of pumping. Updated populations (2015 census) and flows have been used in developing options 2 to 5. A schematic of this option is also presented in Appendix B in Figure 11.

In this option, instead of the primary sewer networks following the road network, they have been rerouted along the edge of wadis, following more closely the topography of West Irbid. This has enabled the number of pumping stations to be reduced to five, with one of them being a central collection point in Wadi Al Arab downstream of the WwTP.

The challenges associated with this solution are that there may be some deep excavations in places, the Wadi Al Arab pumping station is substantial and the existing capacity at the WwTP is insufficient to handle all future flows. This will either require the capacity to be expanded at the Wadi Al Arab WwTP (site is constrained) or flows to be diverted to a new WwTP.

6.1.5 Option 3 - Sewage split between Wadi Al Arab WwTP and new WwTP

As an alternative to draining almost all the West Irbid flows to the Wadi Al Arab pumping station, the flows could be transferred from close to Node 8 (Kufur Asad PS2 in the ACE design). This would reduce the average flows from the new West Irbid system to Wadi Al Arab WwTP from 9,487 m$^3$/d to 6,313 m$^3$/d. A pumping station would need to be provided in the area to transfer the flows over the ridge near Doughara to Wadi Al Arab. The pumping station capacity would need to be 146 l/s for a connected population of 98,638 (2040 figure).

The flows of 77 m$^3$/d and 325 m$^3$/d from Natfeh and Soum un-served respectively would still drain to Wadi Al Arab WwTP via the existing system.

The remaining flow, of 3,174 m$^3$/d, from nodes 1, 2, 3, 4 and 5 in Figure 11 (Appendix B) would then drain to a new WwTP in the north-west of the region.

6.1.6 Option 4 – Maximise gravity drainage to a new WwTP

The spare hydraulic and especially the biological capacity at Wadi Al Arab is limited and will be utilised by the assumed increasing flows and loads from the existing connected population and the populations of Soum and Natfeh that can drain directly into the existing network.

This suggests that in the longer term, substantial additional treatment capacity will be required and the scope for expanding Wadi Al Arab WwTP is limited by the terrain. Thus, interim measures to transfer flows by pumping to Wadi Al Arab may become redundant in the medium term as flows are later redirected to a new treatment site in the down-stream catchment area.

The consequent long-term engineering approach would therefore be to plan for the longer term by providing for a new treatment plant in the north-west and draining the flows in that direction, which is also in general accordance with the prevailing topography.

The big advantages are the savings in the provision and operation of several pumping stations, the reduction in problems with anaerobic sewage from lengthy rising mains and the freeing-up
of the spare capacity at Wadi Al Arab for the expansion of the currently served catchments, plus those of Soum and Natfeh. The required capacity in 2040 would be in the order of 3200m$^3$/day.

The main disadvantage is the short-term need for a new treatment plant on a piece of suitable land that needs to be identified and acquired. WAJ have expressed a strong preference for a solution that avoids new treatment facilities at the present time.

6.1.7 Option 5 – Small bore/local sewerage with local treatment

Small-bore sewers are designed to collect the liquid effluent from septic tanks for treatment and disposal elsewhere, rather than in adjacent soakaways. The lack of solids in the waste stream and the flow mitigation provided by septic tanks mean that the pipe diameters and gradients of a small-bore system can be less than those associated with a traditional system. However, the system still requires the long-term operation and maintenance of septic tanks, including periodic sludge removal. Furthermore, this approach would require all new developments to continue to include septic tanks into the long-term. With these considerations, and the fact that the design and operation of the existing tanks means that they are more like holding or cess tanks, rather than proper septic tanks, suggests this is not a feasible solution.

Some of the smaller and more remote communities could be served by a regional community collection network and local treatment system (such as a RBC$^3$ plant). It is possible that there would be some resistance to this approach as any treated discharge to a small wadi/stream may have a negative or perceived environmental impact, although the impact, and public resistance, may be reduced if the effluent was dissipated by an appropriate soak-away/irrigation network.

Excepting the villages of Soum and Natfeh, because they can gravitate to the existing system, the communities which have populations of less than 5,000 by the year 2040 and hence might be considered for a community based collection and treatment solution, are presented in Table 7.

Table 7: Villages with populations of less than 5,000

<table>
<thead>
<tr>
<th>Village</th>
<th>2015 Population</th>
<th>2040 Population</th>
<th>2040 Average Flow m$^3$/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ham</td>
<td>2,109</td>
<td>3,419</td>
<td>219</td>
</tr>
<tr>
<td>Qum</td>
<td>2,274</td>
<td>3,686</td>
<td>236</td>
</tr>
<tr>
<td>Saydour</td>
<td>2,302</td>
<td>3,731</td>
<td>239</td>
</tr>
<tr>
<td>Total</td>
<td>6,685</td>
<td>10,836</td>
<td>694</td>
</tr>
</tbody>
</table>

Source: Census data and Mott MacDonald

Ham is located to the extreme south-east of the area and its small size and remoteness suggest that a local collection and treatment solution would be feasible. Qum is in a more central area and is relatively close to Wadi Al Arab so could be integrated into other systems without too much difficulty.

Saydour is located to the north-west of the area and is close to Wadi Al Arab. A local collection and treatment system here could discharge treated effluent by gravity to the existing discharge pipe from Wadi Al Arab. No pumping would be required.

Providing local collection and treatment for the villages of Ham and Saydour could provide appropriate and cost-effective solutions for these locations which should involve no pumping.

$^3$ Rotating biological contactor.
and just two small package treatment plants to be maintained. However, this would only remove 455 m$^3$/d from the rest of the strategic system.

### 6.2 Option Comparison

Table 8 presents a high-level comparison of the options presented in this section.

Each option has its benefits and risks.

The preferred approach is Option 2 which reduces the number of pumping stations compared to Option 1 (1.1 to 1.3) and takes all flows to Wadi Al Arab WwTP.

Both options 3 and 4 are alternatives to option 2 if Wadi Al Arab WwTP cannot be expanded sufficiently to manage the additional flows and loads from the new West Irbid sewerage and growth within its existing catchment area.

Option 2 has therefore been used as the basis for further cost estimates and financial modelling.
<table>
<thead>
<tr>
<th>Description</th>
<th>Option 1.3</th>
<th>Option 2</th>
<th>Option 3</th>
<th>Option 4</th>
<th>Option 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Original ACE Scheme (Option 3)</td>
<td>Predominantly gravity solution with all sewage to Wadi Al Arab WwTP</td>
<td>Predominantly gravity solution with sewage split between Wadi Al Arab WwTP and new WwTP</td>
<td>Predominantly gravity solution with all sewage to new WwTP</td>
<td>Small bore/local sewerage with local treatment</td>
</tr>
<tr>
<td>Wastewater treatment requirements</td>
<td>New 8,500 m³/d WwTP</td>
<td>Wadi Al Arab capacity increase required to 54,000 m³/d (2040)</td>
<td>New 3,174 m³/d WwTP &amp; Wadi Al Arab WwTP capacity increase to 51,000 m³/d (2040)</td>
<td>New 9,500 m³/d WwTP Wadi Al Arab WwTP would still require increased capacity for existing catchment growth.</td>
<td>As other options but with two local systems</td>
</tr>
<tr>
<td>Pumping requirements</td>
<td>18 pumping stations</td>
<td>5 pumping stations</td>
<td>Reduced pumping requirements</td>
<td>Reduced pumping</td>
<td>Similar to options 2 to 4</td>
</tr>
<tr>
<td>Trunk sewer</td>
<td>Sewers and rising mains generally along highways. DN 300 to 500 - 18 km gravity and 5km pumped trunk sewer, DN 150 to 250 - 280 km gravity mains and 12km pumped / rising mains</td>
<td>Sewers are generally along wadi routes. DN 300 to 500 – 49.6 km gravity trunk sewers, DN 150 to 250 – 8.5 km pumped / rising mains. Local networks as per Option 1.3</td>
<td>Reduced rising mains but increased gravity sewers compared to Option 2</td>
<td>Increased trunk sewer lengths compared to option 2</td>
<td>Similar to other options</td>
</tr>
<tr>
<td>Operational requirements</td>
<td>Significant operational complexity due to the 18 pumping stations. A new WwTP would be required</td>
<td>5 pumping stations,</td>
<td>In addition to Wadi Al Arab WwTP, a new WwTP would be required. Fewer pumping stations than Options 1 and 2</td>
<td>A new WwTP would be required Fewer pumping stations than Options 1 and 2</td>
<td>Similar to other options Fewer pumping stations than Options 1 and 2. Community operation of RBC plants</td>
</tr>
<tr>
<td>Benefits</td>
<td>No need to expand the capacity of Wadi Al Arab WWTP for this scheme, though it will still need to be expanded to meet the long term demands of Irbid City</td>
<td>Lower maintenance burden as fewer pumping stations than Option 1. Power consumption reduced due to fewer, larger, more efficient pump stations.</td>
<td>Would reduce the flows and loads impact on Wadi Al Arab WwTP compared to options 1 and 2</td>
<td>Would not add to the flows and loads to Wadi Al Arab WwTP</td>
<td>Reduced sewerage</td>
</tr>
<tr>
<td>Risks</td>
<td>Sewage is transported considerable distance hence increased risk of septicity. Also, low flows, particularly in early years, may result in need for periodic flushing of smaller sewers.</td>
<td>Sewage is transported considerable distance hence increased risk of septicity. Also, low flows, particularly in early years, may result in need for periodic flushing of smaller sewers. Construction of trunk sewers in wadis carries additional costs and construction risks in comparison to an equivalent length of sewer laid in the road verge. If future WwTP expansion cannot be located at Wadi Al Arab, risk of sections of the trunk sewer and rising main network to be redesigned to be compatible with the new location.</td>
<td>Operations of small WwTPs</td>
<td>Locating suitable land and funding for new WwTP.</td>
<td></td>
</tr>
<tr>
<td>Conclusions</td>
<td>Not preferred due to high operational complexity and cost</td>
<td>Preferred solution provided additional capacity at Wadi Al Arab WwTP can be provided.</td>
<td>Both options 3 and 4 are alternatives to option 2 if Wadi Al Arab WwTP cannot be expanded sufficiently.</td>
<td>Would be of local benefit but only a minor impact on the bigger system.</td>
<td></td>
</tr>
<tr>
<td>Option 1.3</td>
<td>Option 2</td>
<td>Option 3</td>
<td>Option 4</td>
<td>Option 5</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>----------</td>
<td>----------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>associated with 18 pumping stations.</td>
<td>If an option with a second WwTP is selected, Option 3 or Option 4 would be preferred.</td>
<td></td>
<td></td>
<td>If desired, could complement Options 1 to 4.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Mott MacDonald
6.3 Proposed solution (Option 2)

6.3.1 Design considerations

6.3.1.1 Main sizing and target velocities

Gravity pipelines have been sized such that they can carry the design 2040 flows at the minimum recommended gradient to maintain self-cleansing velocities.

Rising mains are sized so that the maximum velocity does not exceed 3m/s.

It is appreciated that in the shorter term, low flows may require gravity sewers to be flushed to prevent solids deposition and that longer rising mains could generate problems with septicity. This will need to be checked with network modelling during the detailed design.

6.3.1.1 Collection network

The villages of Soum and Natfeh will drain by gravity to the existing trunk sewer to Wadi Al Arab.

The rest of the strategic collection network has been developed to collect the flows from the 18 collection points/nodes identified in the ACE design (which were proposed to be pumping stations in ACE Option 1.3) and transfer them to Wadi Al Arab with the minimum of pumping.

The local collection networks upstream of the 18 collection points, designed by ACE, have not been changed.

6.3.1.2 Pumping stations

Pumping stations will be of the wet-well submersible type with a minimum of one stand-by pump. Sumps will be sized to ensure the maximum number of pump-starts can be accommodated.

Surge suppression will need to be considered depending on the pumping station and rising main characteristics.

Further discussion is required to determine the preferred pumping station protection measures in the event of a power failure. These may include emergency overflows (which will have an environmental impact), back-up generators (operation and maintenance commitment) and emergency storage.

6.3.1.3 Trunk sewers and rising mains

It is envisioned that the trunk sewers will consist of over 49km of buried pipelines placed along highways and wadis to take the best advantage of the prevailing topography. Pumping stations will be constructed where the flows need to cross catchments to reach the proposed WwTP location. Figures 4 and 5 below show the location of an existing trunk sewer and one of the proposed wadis.
The project will also require around 8.5 km of rising mains. Rising mains will be pumped sections under pressure allowing sewage to be lifted over topographic boundaries, particularly where the elevation of the source is not sufficient for gravity flow and/or the use of gravity conveyance would result in excessive excavation depths.

The proposed layout of the trunk sewers and rising mains is shown in Figure 6.
6.3.2 Pumping stations

Five pumping stations are proposed to be constructed in the project area as detailed in Table 9. The pumping stations will be located in rural areas so potential causes of nuisance can be avoided. The location of the pumping stations shall allow vehicular access for regular operations and maintenance.

Table 9: Summary of the proposed pumping stations

<table>
<thead>
<tr>
<th>Pumping Station</th>
<th>Peak Flow 2040 (l/s)</th>
<th>Static Head (m)</th>
<th>Friction Head (m)</th>
<th>Total Head (m)</th>
<th>Power (kW)</th>
<th>Peaking factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS 1</td>
<td>76</td>
<td>42</td>
<td>10</td>
<td>52</td>
<td>65</td>
<td>2.1</td>
</tr>
<tr>
<td>PS 2</td>
<td>50</td>
<td>35</td>
<td>5</td>
<td>40</td>
<td>33</td>
<td>2.5</td>
</tr>
<tr>
<td>PS 3</td>
<td>58</td>
<td>62</td>
<td>5</td>
<td>67</td>
<td>64</td>
<td>2.5</td>
</tr>
<tr>
<td>PS 4</td>
<td>6.2</td>
<td>26</td>
<td>7</td>
<td>33</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Wadi Al Arab</td>
<td>200</td>
<td>112</td>
<td>43</td>
<td>155</td>
<td>507</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Source: Mott MacDonald

To provide an indication of potential scale, photographs of an existing pumping station in the area are provided in Figures 7 and 8 below. The pipework within the pumping stations should be of ductile iron. Pumping station sub-structures should be reinforced concrete.

Figure 7: Dugra Pumping Station site

Figure 8: Office and generator room

6.3.3 House connections and local sewerage networks

The minimum size of pipe, to avoid blockages will be DN 150.

The following lengths of house connections and local sewerage networks were proposed in the ACE report:

- DN 150 for household connections, approximately 80 km in total;
- DN 200 - 400 for local sewerage, approximately 230 km in total;
The minimum cover over the pipes will generally be 1 m to protect them from surface loads and help avoid conflicts with other services. If this cover proves not to be practicable, then the pipes shall be protected with concrete.

6.3.4 Connection to Wadi Al Arab WwTP
The project will connect into the existing Wadi Al Arab WwTP. This will add an additional flow of 2,300 m$^3$/d in year 2018 increasing to nearly 10,000 m$^3$/d in the year 2040.

6.3.5 Operational requirements
With no additional wastewater treatment provision, operational requirements will be limited to the regular operation and maintenance of the pumping stations and the occasional interventions as necessary for the sewerage network. It is anticipated that sewerage system interventions may be increased in the short-term if flows are low and self-cleansing velocities are not maintained. Such interventions may include flushing or jetting.

6.3.6 Project phasing
The project phasing should commence with Soum and Natfeh, which can drain by gravity to the existing trunk sewer system serving Wadi Al Arab WwTP. Subsequent development should commence at the downstream end of catchments, near the pumping stations and work upstream. This means that as sewerage sub-systems are completed, they can be brought on-line directly without having to wait for intermediate sections to be completed.

One caveat for this is that if it may be that an alternative and more appropriate treatment location may become available. If this is the case then the system development should be delayed to prevent the investment in assets with only an interim design life.

As the success of the sewer scheme is dependent on improvements to the quantity of water supply to residents in West Irbid, if there are delays to the planned Wadi Arab II water supply project, corresponding delays to the wastewater collection network should also be considered.
7  Procurement and Programme Implementation

The proposed programme is outlined in Table 10 and detailed in Sections 7.1 and 7.2 below. This shows that the project will be completed over four years, with the first customers due to be connected in 2019. There is potential at the detailed design stage to assess whether it would be feasible to accelerate the connection of the unserved populations in Natfeh (694) and Soum (3,079) to the existing sewerage network in 2018.

Following discussions with WAJ it is recommended that the pipelines are let using a traditional construction contract to maximise the use of local labour, while pumping stations are procured as a Design and Build (D&B) contract and packaged together. Pumping stations necessarily involve some contractor design and lumping them together should ensure similar/compatible equipment is provided, thus simplifying spares and maintenance requirements.

The proposed programme is based the above procurement methods. A draft ToR for the Technical Advisor (TA) work will be presented in Appendix E.

7.1  Anticipated Pre-construction activities (carried out by TA)

The following activities are planned for the pre-construction phase:

- Technical Assistance: Survey work, design, preparation of tender documents, overseeing the procurement process, and permitting
- Surveying: This will involve the detailed mapping and marking of the Project site to enable groundworks to proceed. Surveying will precede most parts of the enabling works.

7.2  Anticipated Construction activities (carried out by contractor)

7.2.1  Year 1 – from mid- 2018 – (Enabling works)

- Site establishment: This will include the installation of infrastructure to enable human activity on the site at various project sites, including erecting temporary offices and welfare facilities.
- Ground investigations: Ground investigations are carried out to assess the suitability of underlying ground for construction, and to inform designers on choice of materials.
- Site clearance: To facilitate construction activities, it is necessary to remove vegetation, structures, and human influences from the Project site. These operations generally involve the use of heavy plant machinery.
- Utility protection: To ensure that the enabling works do not interfere with existing underground services, and include the production of maps and procedures involving underground scans to ensure all Contractors are aware of the presence of such items.
- Road way / Surface course: Installation of roadway surfacing will be carried out as part of the enabling works, allowing vehicular access to the project sites. This may involve grading, compaction, subbase and drainage construction, asphaltling, paving works or other forms of surfacing.
- Local Network Pipelaying: extensive pipelaying will be carried out, involving excavation of new pipes to carry sewage effluent from the villages.
7.2.2 Year 2 – (2019)
- Local Network Pipelaying: extensive pipelaying will be carried out, involving excavation of new pipes to carry sewage effluent from the villages.
- Trenching: Trenching involves the excavation of Trunk Sewer and Rising Mains trenches.
- Shoring / retaining walls: various steep-sides slopes will be constructed that require support through shoring and retaining walls.
- Foundations: This work will involve the installation of the substructure (concrete and steelwork) that will support the structural load of the Pump stations.
- Junction chambers construction.
- Trunk Sewer Pipelaying.
- Rising mains Pipelaying.
- Earthworks (grading, levelling, compaction & tests, excavation, backfilling, ground improvement) involve the re-profiling and improvement of ground conditions.
- Commissioning of new local networks connected to existing infrastructure.

7.2.3 Year 3 – (2020)
- Pump Stations construction and installation
- Local Network Pipelaying: extensive pipelaying will be carried out, involving excavation of new pipes to carry sewage effluent from the villages.
- Trunk Sewer Pipelaying.
- Rising mains Pipelaying.
- Earthworks (grading, levelling, compaction & tests, excavation, backfilling, ground improvement) involve the re-profiling and improvement of ground conditions.
- Commissioning of pump stations, trunk sewers and rising mains.

7.2.4 Year 4 – (2021)
- Local Network Pipelaying: extensive pipelaying will be carried out, involving excavation of new pipes to carry sewage effluent.
- Earthworks (grading, levelling, compaction & tests, excavation, backfilling, ground improvement) involve the re-profiling and improvement of ground conditions.
- Commissioning pump stations, trunk sewers and rising mains.
## Table 10: Proposed project programme

<table>
<thead>
<tr>
<th>Item</th>
<th>Pre-construction activities (until mid-2018)</th>
<th>Mid-2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of customers able to be connected (cumulative)</td>
<td>0%</td>
<td>0%</td>
<td>30%</td>
<td>70%</td>
<td>100%</td>
</tr>
<tr>
<td>Percentage of CAPEX disbursement</td>
<td>0%</td>
<td>30%</td>
<td>25%</td>
<td>25%</td>
<td>20%</td>
</tr>
<tr>
<td>Notes</td>
<td>Technical Assistance (detailed design, network design review and tendering)</td>
<td>Construction Supervision</td>
<td>Contractor mobilisation</td>
<td>Procurement of long lead items</td>
<td>Enabling works</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction supervision</td>
<td>Procurement</td>
<td>Construction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Construction supervision</td>
<td>Construction</td>
<td>Construction</td>
<td></td>
</tr>
</tbody>
</table>

Source: Mott MacDonald
8 Costs Estimates

8.1 Approach to costing

8.1.1 Overview

Cost estimates (Capex and Opex) have been prepared for the selected option (Option 2). This section provides information on the approach and sources of data used.

**Capex estimates** have been prepared using both local and regional project cost data as well as in-house empirical cost models calibrated for use in Jordan. Construction costs include contractor’s on-costs including preliminaries, risk and profit.

**Capital maintenance/renewals** costs have been estimated based on replacement of mechanical and electrical equipment every 15 years, ICA every 10 years and civil works every 40 years (60 for pipelines).

**Opex** estimates (mainly staff, power and operational maintenance) have been prepared based on the expected performance of mechanical plant (power consumption, maintenance), expected maintenance requirements for the sewerage system (jetting and flushing). The incremental increase in treatment costs (predominantly power) arising due to collection of additional sewage in the project areas has also been estimated and included in the financial model.

All costs are presented in 2017 prices and include a contingency of 15%.

Where required the following exchange rates have been assumed:

- 1 Euro = 0.84 JD
- 1 USD = 0.71 JD

8.1.2 Pipelines

The capital cost estimates for pipelines have been based on a blend of Jordanian project cost data and data from projects elsewhere in the region. The following pipeline unit costs have been used in this study:

<table>
<thead>
<tr>
<th>Dia (mm)</th>
<th>JD/m</th>
<th>Euro/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity sewers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>150</td>
<td>90</td>
<td>108</td>
</tr>
<tr>
<td>200</td>
<td>110</td>
<td>132</td>
</tr>
<tr>
<td>300</td>
<td>140</td>
<td>168</td>
</tr>
<tr>
<td>400</td>
<td>170</td>
<td>204</td>
</tr>
<tr>
<td>500</td>
<td>200</td>
<td>240</td>
</tr>
<tr>
<td>Rising mains</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>100</td>
<td>110</td>
<td>132</td>
</tr>
<tr>
<td>150</td>
<td>135</td>
<td>162</td>
</tr>
<tr>
<td>200</td>
<td>160</td>
<td>192</td>
</tr>
</tbody>
</table>

Source: Mott MacDonald, derived based on data from several sources.
The costs are inclusive of plant labour and materials, and also include the cost of manholes and other structures as may be necessary. The unit costs derived for this study are higher than those originally used in the ACE report and hence represent a more conservative estimate.

8.1.3 Pumping stations

Pumping station costs have been derived using in-house empirical cost models calibrated for use in Jordan. Separate cost models are used to estimate civil works and MEICA and the cost models use total installed motor capacity as the driver value (measured in kilowatts, including both duty and standby pumps).

The cost of the five pumping stations proposed under Option 2 are presented in Section 8.2.

The costs of pumping stations include the costs required for the civil works, mechanical and electrical works and the SCADA works. From the recent examples studied, these were found to make up about 30, 45%, 20% and 5% of the overall cost respectively.

8.1.4 Wastewater treatment plants

The Wadi Al Arab WwTP would be overloaded in the short to medium term if it receives a significant proportion of the flows arising from the proposed sewerage schemes. Hence, either Wadi Al Arab WwTP will need to be substantially expanded or a portion (Option 3) or all (Option 4) of the additional flows will need to be diverted to a new WwTP. A separate study is currently addressing the upgrade of the Wadi Al Arab WwTP, to be implemented using separate funding to that proposed for this sewerage project. Hence, Capex estimates for upgrading the Wadi Al Arab WwTP have not been estimated for this report.

8.2 Cost Estimates

8.2.1 Indicative capital costs

The cost estimates completed to date, based on the above approach were submitted with the financial model. Table 12 presents a summary of these costs.

<table>
<thead>
<tr>
<th>Component</th>
<th>km/Nr</th>
<th>Indicative Cost (euro million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>House Connections (from boundary only), DN 150 mm</td>
<td>80 km</td>
<td>9.0</td>
</tr>
<tr>
<td>Local Sewerage System, DN 200 – DN 400</td>
<td>230 km</td>
<td>31.0</td>
</tr>
<tr>
<td>Trunk sewers and rising mains, DN 200 to DN 500</td>
<td>58 km</td>
<td>9.4</td>
</tr>
<tr>
<td>Pumping Station</td>
<td>5 Nr</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>53.2</strong></td>
</tr>
</tbody>
</table>

Source: Mott MacDonald estimate

8.2.2 Indicative operational costs

The assumed operational costs have been calculated to be the incremental costs associated with this project. These are associated with staffing requirements at the five pumping stations, the maintenance requirements of the network and pumping station, the incremental energy consumption associated with the pumping stations and the incremental treatment costs associated with the increased flows and biological loads to Wadi Al Arab WwTP.

- Staffing – it was assumed that 2 drivers, 4 technicians, 2 engineers and 1 supervisor will be required to operate the 5 pumping stations
● Asset maintenance and repairs – the following standard percentages have been used to estimate annual maintenance costs:
  – 1% of civil capex
  – 5% of M&E capex
  – 10% of SCADA capex
● Annual electricity costs were estimated based on an average electricity consumption of 0.4 kWh/m³ of wastewater produced. This was calculated based on the projected system pumping requirements. The current electricity tariff of 0.09 JD/kWh was used.
● The National Wastewater Masterplan identified that the incremental treatment cost of wastewater in 2020 is expected to be of 0.12 JD/m³.

A summary of these costs is presented in Table 13.

Table 13: Predicted incremental annual operational costs (Euros - 2017 constant prices)

<table>
<thead>
<tr>
<th>Annual Operational costs</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff Cost</td>
<td>32,400</td>
<td>64,800</td>
<td>64,800</td>
<td>64,800</td>
<td>64,800</td>
</tr>
<tr>
<td>Operations and Maintenance (Pumping Stations)</td>
<td>62,400</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
<td>78,000</td>
</tr>
<tr>
<td>Operations and Maintenance (Sewer Network)</td>
<td>6,400</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
<td>8,000</td>
</tr>
<tr>
<td>Wastewater treatment costs</td>
<td>95,100</td>
<td>206,700</td>
<td>292,100</td>
<td>394,500</td>
<td>516,800</td>
</tr>
<tr>
<td>Electricity costs</td>
<td>28,500</td>
<td>62,000</td>
<td>87,600</td>
<td>118,400</td>
<td>155,100</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>123,600</td>
<td>268,600</td>
<td>379,700</td>
<td>512,900</td>
<td>671,900</td>
</tr>
</tbody>
</table>

Source: Mott MacDonald
9 Preliminary Conclusions

9.1 Design as Presented

The design as presented meets the understood requirements of only using the Wadi Al Arab WwTP and delivering the effluent from almost the whole West Irbid Area (though the relatively remote community of Kherbit Marshed remains excluded), with a minimum of pumping stations.

The result however falls short of being fully developed solution for the following reasons:

- While there is, theoretically, spare hydraulic capacity at the WwTP, the spare biological capacity is extremely limited. Even with the proposed improvements the works will not perform adequately for more than the medium term.
- The number of pumping stations has been reduced from 18 to five. However, the Wadi Al Arab pumping station would be quite substantial and with a high pumping head to return the flows to the WwTP.
- The Wadi Al Arab rising main would need to be long (>5km) and this is likely to create problems of long retention times and an anaerobic sewage discharge. In the early years, this would be exacerbated because the flows would be considerably lower than the design capacity, increasing retention times further. As a result, chemical dosing at the pumping station may be required to reduce the risk of septicity.
- The layout as shown does include some locations where the depths of sewers may prove to be excessive when it comes to detailed design. It is possible that if it is not possible to avoid these depths through alternative sewer alignments then a further pumping station may need to be added.

9.2 Variations to consider during detailed design

Alternatives to be considered during detailed design include:

- Restricting the number of villages discharging to Wadi Al Arab WwTP to reduce pressure on an already constrained WwTP.
- Consider a new WwTP to the north-west to where most of the catchment naturally drains. This could then also be used for the other existing developments along the Deir Al Se’Eneh corridor.
- Intercepting the system at node 8 would reduce total pumping of flows.

9.3 Conclusions on feasibility

It would seem that there is both need and an affordability for a new sewerage system to serve the project area and replace the current inadequate system of (often defective) cesspits, which have to be regularly emptied by tankers at considerable expense. The need is also based on imminent increases in water consumption in the project area which will increase pressure on the already deficient existing sanitation system. During both discussions with households and focus groups, most households expressed willingness to connect to the proposed sewerage system.

The proposed sewerage option is technically feasible though there is scope for further optimisation during detailed design.
The most significant issue to be addressed is whether the Wadi Al Arab WwTP will have capacity in the future to take all or a proportion of flows and loads from the newly sewered areas or whether a new WwTP should be built to the north-west of the project area.
Appendices

A. Site Visit Notes ........................................................................................................37
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C. Proposed Layout Drawing ................................................................................44
D. Key design assumptions ......................................................................................45
E. Draft Terms of Reference ....................................................................................48
A. Site Visit Notes
# Record of site visit

**Project title**  West Irbid Environmental and Social Due Diligence  
**Division**  EVC  
**Subject**  WwTW  
**Location**  Irbid  
**Present**  
- Eng Suyfan  
- Yarmouk  
- Hani Nahawi  
- Peter Wreford  
**Project no**  381789  
**Date of visit**  24th Apr 2017  

<table>
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<th>Recorded by</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJW</td>
<td>File</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
</tr>
</thead>
</table>
| 1    | Purpose of Visit  
To see the wastewater treatment works which treats the sewage from western area of Irbid. |
| 2    | Site Photographs  
A series of photographs were taken at strategic points around the site and are stored in the system directory. Some of the photographs are reproduced below. |
| 3    | General  
The works has a reported hydraulic capacity of 22,000 m³/d and receives a current flow of 13,000 m³/d.  
There is a large administrative building on-site, though this was not inspected.  
**Inlet Works**  
The works has a sludge tanker disposal facility but the steep, narrow and winding access road means that it is too difficult for them to access.  
Side overflow weir which looks like it has never been in operation.  
Flow measurement flume with level sensor. Looks in good condition, although weir does appear to be flooded out.  
Two parallel mechanically raked inlet screens and manually raked coarse screen upstream. Manually raked bypass channel open with flow passing in all three channels. Equipment looks new and functional.  
Aerated grit channel looks new and in working condition.  
**Aeration Tanks and Associated Final Settlement Tanks**  
There is a battery of six pairs of aeration tanks with dedicated final settlement tanks arranged along the route of the wadi. Each aeration tank is rectangular with four surface aerators arranged along the centreline. FSTs are circular, half bridge type and subject to chemical dosing. |
Record of site visit continuation sheet

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Observations of each of the units, counting from upstream are:</td>
</tr>
<tr>
<td></td>
<td>Unit 1: Aeration tank with four aerators in operation. Final settlement tank in operation, surface showing a build-up of scum.</td>
</tr>
<tr>
<td></td>
<td>Unit 2: AT with three aerators in operation. FST in operation but with half-bridge not functioning, surface and overflow weir showing a substantial build-up of scum.</td>
</tr>
<tr>
<td></td>
<td>Unit 3: AT with four aerators in operation. FST in operation with half-bridge rotating but scum removal seemingly not functioning, surface and overflow weir showing a substantial build-up of scum.</td>
</tr>
<tr>
<td></td>
<td>Unit 4: AT with four aerators in operation. FST in operation, surface and overflow weir showing a build-up of scum.</td>
</tr>
<tr>
<td></td>
<td>Unit 5: AT and FST out of service.</td>
</tr>
<tr>
<td></td>
<td>Unit 6: AT and FST out of service.</td>
</tr>
<tr>
<td></td>
<td><strong>Tertiary Treatment</strong></td>
</tr>
<tr>
<td></td>
<td>The tertiary plant is some distance down-stream of the main processes. There is a pair of parallel baffle tanks, presumably for chlorine dosing, but not in use.</td>
</tr>
<tr>
<td></td>
<td>Newly installed pair of &quot;Dynasand&quot; filter process, apparently functioning.</td>
</tr>
<tr>
<td></td>
<td>Newly installed UV disinfection plant, but not in operation.</td>
</tr>
<tr>
<td></td>
<td><strong>Sludge Drying Beds</strong></td>
</tr>
<tr>
<td></td>
<td>There are 72 shallow sludge drying beds arranged in four banks upstream of the main works and alongside the wadi. The beds are fed via sludge storage/thickening tanks from which sludge can be withdrawn from various levels within the tank. The drying beds contained sludge at various stages of desiccation.</td>
</tr>
<tr>
<td></td>
<td><strong>Sludge Press Building</strong></td>
</tr>
<tr>
<td></td>
<td>There is a large new sludge press building complete with large lime hoppers. The facility appears to remain unused.</td>
</tr>
<tr>
<td></td>
<td><strong>Photographs</strong></td>
</tr>
</tbody>
</table>

4
Inlet flume

Inlet mechanical screens
Record of site visit continuation sheet

Aerated grit channel

Aeration tank 2 with missing aerator
Record of site visit continuation sheet

Project No. 381789  Date of Visit 24th April 2017

Sedimentation tank 3

Chlorine baffle tank, unused
Record of site visit continuation sheet

Project No.  381789
Date of Visit  24th April 2017

Dynasand tertiary filters

Part of tertiary treatment control room
**Record of site visit**

**Project title**: West Irbid Environmental and Social Due Diligence

**Division**: EVC

**Subject**: Doughara PS

**Project no**: 381789

**Location**: Irbid

**Date of visit**: 16th May 2017

**Present**

- Eng Sufyan PMU
- Hani Nahawi MM
- Peter Wreford MM

---

**Recorded by**: PJW

**Distribution**: File

**Item** | **Text** | **Action on**
---|---|---
1 | **Purpose of Visit**
   To see the existing pumping station which forwards flows from the Doughara village to the wastewater treatment works. |  
2 | **Site Photographs**
   A series of photographs were taken at strategic points around the site and are stored in the system directory. Some of the photographs are reproduced below. |  
3 | **General**
   The operator/supervisor stated that the station receives 300 - 500 m³/d.
   There are two linked wet wells, one for each pump, with volumes of 6m³.
   Each pump has a capacity of 100l/s at 69m head.
   Pumps operate on a duty/standby basis and both pumps are functional.
   The discharge manifold is 150mm ductile iron with valves etc.
   There is an emergency overflow chamber with a capacity of 2 - 300 m³ for use in the event of station failure.
   There is a stand-by generator on-site.
   Hour meters read 01,510.54 (left) and 01,003.50 (right).
   There is an odour control plant on-site. Manufacturer Amtrad Environmental with unit by Colasit, Holland BV. |  
4 | **Comment**
   100 l/s maximum capacity equates to 8,640 m³/d. Note that if the rising main is 150mm, the velocity would be high at 6 m/s.
   The used capacity is less than 500 m³/d, or 5.8 l/s. This represents a population equivalent of 6,757.
   Less than 6% of the pumping station capacity is currently used. |  
5 | **Photographs** |  

---
Record of site visit continuation sheet

Project No. 381789

Date of Visit 16th May 2017

DN 150 mm Discharge Manifold

The Odour Control Equipment
## Record of site visit

**Project title**  West Irbid Environmental and Social Due Diligence  
**Division**  EVC  
**Subject**  Doughara PS  
**Project no**  381789  
**Location**  Irbid  
**Date of visit**  31st July 2017  

### Present

- Eng Sofyan  PMU  Peter Wreford  MM
- Thamar Alayyan  MM  Pierre Gouws  MM

### Recorded by  PJW  
**Distribution**  File

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
<th>Action on</th>
</tr>
</thead>
</table>
| 1    | Purpose of Visit  
Peter’s second visit to see the existing pumping station which forwards flows from the Doughara village to the wastewater treatment works. First visit for Thamay and Pierre. Refer also to notes of previous visit on 16th May. |  |
| 2    | Site Photographs  
A series of photographs were taken at strategic points around the site and are stored in the system directory. Some of the photographs are reproduced below. |  |
| 3    | General  
Refer to previous notes except:  
No staff were present at the site but the gate was unlocked so we could gain access.  
A macerator was found fitted to the inlet line. Model: Franklin Miller Inc. model SS1200 with a Super Shredder S250 Automatic Controller.  
Hour meter readings were: Left pump 01587.54, Right pump 01003.50. These are compared with the previous readings below. |  |
| 4    | Comment  
The hour meter readings were compared with those taken on the previous visit, see below:  

```
<table>
<thead>
<tr>
<th>Date</th>
<th>Pump 1</th>
<th>Pump 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>16/05/2017</td>
<td>1510.54</td>
<td>1003.50 Hrs</td>
</tr>
<tr>
<td>31/07/2017</td>
<td>1587.50</td>
<td>1003.50 Hrs</td>
</tr>
</tbody>
</table>
```

76 Nr days  
76.96 hrs run  
1.01 hrs/day  
100 Cap. l/s  
365 Flow m³/d

The figures suggest one pump is not working and that the other pump is operated manually for one hour per day. |  |
| 5    | Photographs |  |
Record of site visit continuation sheet

Project No. 381789  Date of Visit 31st July 2017

General view of PS with o/flow tank and generator house to the left

Diesel tank and generator building
Record of site visit continuation sheet

Project No. 381789
Date of Visit 31st July 2017

Blinded screen
## Record of site visit

**Project title** West Irbid Environmental and Social Due Diligence  
**Division** EVC  
**Subject** El Ekeder WwTW  
**Project no** 381789  
**Location** Irbid  
**Date of visit** 1st August 2017  
**Present**  
Eng Sofyan PMU Peter Wreford MM  
Thamar Alayyan MM Pierre Gouws MM  

<table>
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</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Text</th>
<th>Action on</th>
</tr>
</thead>
</table>
| 1    | Purpose of Visit  
To see the location where many of the sludge tankers from West Irbid discharge and to speak to the drivers and operators. | |
| 2    | Site Photographs  
A series of photographs were taken at strategic points around the site and are stored in the system directory. Some of the photographs are reproduced below. | |
| 3    | The Site  
The site comprises a large landfill and a series of lagoons for wastewater treatment. The tankers enter and concreted apron area situated at a high-point and discharge the tankers by gravity into a large, central reception pit. The wastewater then flows by gravity to the lagoon system.  
The operator reported that there are about 80 - 100 tankers use the site and each tanker visits two or three times per day. The tankers vary in size between 9m³ to 14m³ and up to 35 m³.  
The trucks pay between 10 and 30 JD per month to use the site.  
The operator estimated that 2,000 - 2,500 m³/d was discharged.  
The tankers collect sludge from Mafraq, Ajlune, Jarash and Irbid. It was guessed that about half the flow would originate from Irbid.  
Some tankers from Irbid also discharge to North Shuna. | |
| 4    | The Tankers  
Tankers each carry the driver and an assistant (sometimes a young boy.  
Tankers fill up from a single tank. Sometimes one tank can fill a tanker twice.  
Costs generally 45 - 60 JD per visit depending on the distance from the household to the site. | |
Thought that some buildings are emptied weekly, some twice a month. The summer is busier due to there being more visitors and increased water consumption. Also, overflows during the wetter winter are not as apparent.

One driver reported that he made three or four visits per day.

### Discussion

Assume

| 90 tankers | 80 tankers |
| 3 visits/day each | 2 visits/day each |
| 270 Visits total | 160 Visits total |
| 10 hrs/day | 10 hrs/day |
| 27 Visits/hr | 16 Visits/hr |
| 2.2 mins between visits | too frequent |
| too frequent | 3.8 mins between visits better |
| 20 m³/tanker | 15 m³/tanker |
| 5400 | too much |
| better | 2400 |

If half from Irbid, then 1,200 m³/d

Population 80,000

Per capita 15 l/c/d

West Irbid sludge is also discharged to North Shuna, where 827 m³/d was received in 2015. If half from W Irbid this would represent a further 5 l/c/d.

### Photographs
Record of site visit continuation sheet

Project No. 381789

Date of Visit 1st August 2017

Sludge tanker with young assistant

Sludge tanker discharging
Treatment lagoons, with landfill in far distance
B. Scheme Schematic Diagrams
Figure 9: Schematic Diagram of Original ACE Option 3 Wastewater Collection Concept

Total Qav 173 m³/d  
Inflow Qav 0 m³/d  
Local Qav 173 m³/d  
Pop Eq 2,455 Nr  
Pk Factor 3.5  
Peak Flow 7.0 l/s

Total Qav 622 m³/d  
Inflow Qav 0 m³/d  
Local Qav 622 m³/d  
Pop Eq 8,836 Nr  
Pk Factor 3.0  
Peak Flow 7.0 l/s

Total Qav 432 m³/d  
Inflow Qav 173 m³/d  
Local Qav 259 m³/d  
Pop Eq 6,136 Nr  
Pk Factor 3.2  
Peak Flow 15.8 l/s

To existing sewer

Total Qav 4,813 m³/d  
Inflow Qav 4,640 m³/d  
Local Qav 173 m³/d  
Pop Eq 68,366 Nr  
Pk Factor 2.1  
Peak Flow 119.3 l/s

To WwTW

Total Qav 7,586 m³/d  
Inflow Qav 5,867 m³/d  
Local Qav 1,719 m³/d  
Pop Eq 107,761 Nr  
Pk Factor 2.0  
Peak Flow 173.3 l/s

To new Al Taybeh System

Total Qav 423 m³/d  
Inflow Qav 423 m³/d  
Local Qav 0 m³/d  
Pop Eq 6,014 Nr  
Pk Factor 3.2  
Peak Flow 15.5 l/s

Gravity MM G3

Soum Unserved

PS Nr 4  
Saydour PS-1

PS Nr 5  
Kufr Asad PS-1

PS Nr 9  
Kufr Asad PS-2

PS Nr 10  
PS Nr 11

Zahar PS-1

Hofa Wasatia PS-2

Beit Yafa PS-2  
PS Nr 16  
PS Nr 17

Gravity MM G2

Beit Yafa 73%  
74%  
75%

Gravity MM-G 1

Natfeh Unserved

PS Nr 13  
Ham PS-1  
Kufr A'an  
Kufr Youba PS-3  
Kufr Youba PS-1

PS Nr 12  
PS Nr 15

Beit Yafa  PS-1 (27%)
Figure 10: Schematic Diagram of ACE Option 3 Wastewater Collection Concept, Corrected and Updated
Figure 11: Schematic Diagram Wastewater Collection Concept Delivering to Wadi Al Arab WwTP
C. Proposed Layout Drawing
D. Key design assumptions

This appendix summarises the key design assumptions and parameters used to develop the options and proposed solution presented in Section 6.

Design assumptions and parameters are generally based on those presented in the ACE Final Design Report\(^4\) (ACE, 2016) which in turn are based on Jordanian standards, unless stated below.

D.1 Note on Peaking Factor

Ace used the formula shown below, whereas the conventional power is 1/5, not 1/6. This gives a lower peak factor and has been used in this re-assessment.

\[
P.F. = \frac{5}{(P/1000)^{1/6}}
\]

Also, ACE have summed the peak flows from each village rather than recalculating according to the overall population total. This will reduce the peak flow from 38,427 m\(^3\)/d to that shown above.

D.2 Key Parameters from ACE Report

(Note that table numbers refer to the numbering within the ACE report)

Table 2.2 Project villages total areas and served areas

<table>
<thead>
<tr>
<th>Village</th>
<th>Village Area (km(^2))</th>
<th>Area to be served (km(^2))</th>
<th>Percentage of Served Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natfeh-Unserved</td>
<td>1.04</td>
<td>0.23</td>
<td>22.12</td>
</tr>
<tr>
<td>Kufr Yoba</td>
<td>11.90</td>
<td>2.90</td>
<td>24.37</td>
</tr>
<tr>
<td>Zahr</td>
<td>5.33</td>
<td>1.60</td>
<td>30.08</td>
</tr>
<tr>
<td>Jumha</td>
<td>4.72</td>
<td>0.49</td>
<td>10.36</td>
</tr>
<tr>
<td>Ham</td>
<td>5.03</td>
<td>0.24</td>
<td>4.81</td>
</tr>
<tr>
<td>Beit Yafa</td>
<td>11.60</td>
<td>1.96</td>
<td>16.86</td>
</tr>
<tr>
<td>Kufr Asad</td>
<td>24.11</td>
<td>1.92</td>
<td>7.96</td>
</tr>
<tr>
<td>Qum</td>
<td>2.10</td>
<td>0.57</td>
<td>27.24</td>
</tr>
<tr>
<td>Qumeem</td>
<td>4.52</td>
<td>1.31</td>
<td>28.89</td>
</tr>
<tr>
<td>Kufr Aan</td>
<td>3.27</td>
<td>0.58</td>
<td>17.83</td>
</tr>
<tr>
<td>Saydour</td>
<td>6.91</td>
<td>0.84</td>
<td>12.10</td>
</tr>
<tr>
<td>Kherbit Marshed</td>
<td>No Data</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td>Hofa Wasatia</td>
<td>8.42</td>
<td>1.75</td>
<td>20.74</td>
</tr>
<tr>
<td>Kharaj</td>
<td>4.24</td>
<td>1.58</td>
<td>37.24</td>
</tr>
<tr>
<td>Soum-Unserved</td>
<td>2.91</td>
<td>0.27</td>
<td>9.14</td>
</tr>
<tr>
<td>Totals</td>
<td>96.10</td>
<td>16.23</td>
<td></td>
</tr>
</tbody>
</table>

\(^4\) Final design report, Wastewater collection, treatment and reuse project for Liwa’a al-Wasatia and East Irbid villages, Tender (2/MWI/ Kuwaiti grant / 2014), Associated Consulting Engineers (ACE) and Orient Engineering Consultancy & Design (Orient), September 2016
### Table 2.3 Population of west Irbid villages for years 2013 and 2040

<table>
<thead>
<tr>
<th>Village</th>
<th>Population 2013</th>
<th>Population 2040</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jordanian</td>
<td>Syrian Refugees</td>
</tr>
<tr>
<td>Natfeh-Unserved</td>
<td>1,689</td>
<td>270</td>
</tr>
<tr>
<td>Kufur Yoba</td>
<td>14,084</td>
<td>1,815</td>
</tr>
<tr>
<td>Zahr</td>
<td>5,827</td>
<td>790</td>
</tr>
<tr>
<td>Jumha</td>
<td>2,624</td>
<td>387</td>
</tr>
<tr>
<td>Ham</td>
<td>1,276</td>
<td>220</td>
</tr>
<tr>
<td>Beit Yafa</td>
<td>9,485</td>
<td>1,242</td>
</tr>
<tr>
<td>Kufur Asad</td>
<td>10,097</td>
<td>1,320</td>
</tr>
<tr>
<td>Qum</td>
<td>1,546</td>
<td>255</td>
</tr>
<tr>
<td>Qumeem</td>
<td>6,396</td>
<td>860</td>
</tr>
<tr>
<td>Kufur Aam</td>
<td>3,237</td>
<td>465</td>
</tr>
<tr>
<td>Saydour</td>
<td>1,851</td>
<td>290</td>
</tr>
<tr>
<td>Kherbit Marshed</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td>Hofa Wasatia</td>
<td>4,331</td>
<td>600</td>
</tr>
<tr>
<td>Kharaj</td>
<td>2,652</td>
<td>390</td>
</tr>
<tr>
<td>Soum-Unserved</td>
<td>2,150</td>
<td>330</td>
</tr>
<tr>
<td>Natfeh-Unserved</td>
<td>67,245</td>
<td>9,234</td>
</tr>
</tbody>
</table>

### Table 2.5 Water Consumption for Irbid

<table>
<thead>
<tr>
<th>Item</th>
<th>Urban Area</th>
<th>Rural Area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>l/c.d</td>
<td>l/c.d</td>
</tr>
<tr>
<td>Basic Water</td>
<td>100</td>
<td>80</td>
</tr>
<tr>
<td>Commercial</td>
<td>3</td>
<td>2.4</td>
</tr>
<tr>
<td>Industrial Water</td>
<td>5</td>
<td>1.6</td>
</tr>
<tr>
<td>Tourism Water</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Contingency</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Per Capita Consumption</td>
<td>116</td>
<td>88</td>
</tr>
</tbody>
</table>

Percentage returned to sewer = 80%
### Table 3.2 Average and Peak Flow for 2013 and 2040

<table>
<thead>
<tr>
<th>Village</th>
<th>2013</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Flow (m³/d)</td>
<td>Average Flow (m³/d)</td>
</tr>
<tr>
<td>Natfeh-Unserved</td>
<td>138</td>
<td>71</td>
</tr>
<tr>
<td>Kufr Yoba</td>
<td>1,119</td>
<td>1,924</td>
</tr>
<tr>
<td>Zahr</td>
<td>466</td>
<td>799</td>
</tr>
<tr>
<td>Jumha</td>
<td>212</td>
<td>363</td>
</tr>
<tr>
<td>Ham</td>
<td>105</td>
<td>179</td>
</tr>
<tr>
<td>Beit Yafa</td>
<td>755</td>
<td>1,298</td>
</tr>
<tr>
<td>Kufr Asad</td>
<td>804</td>
<td>1,381</td>
</tr>
<tr>
<td>Qum</td>
<td>127</td>
<td>216</td>
</tr>
<tr>
<td>Qumeem</td>
<td>511</td>
<td>877</td>
</tr>
<tr>
<td>Kufr Aan</td>
<td>261</td>
<td>446</td>
</tr>
<tr>
<td>Saydour</td>
<td>151</td>
<td>257</td>
</tr>
<tr>
<td>Kherbit Marshed</td>
<td>No Data</td>
<td>No Data</td>
</tr>
<tr>
<td>Hofa Wasatia</td>
<td>347</td>
<td>595</td>
</tr>
<tr>
<td>Kharaj</td>
<td>214</td>
<td>367</td>
</tr>
<tr>
<td>Soum-Unserved</td>
<td>175</td>
<td>298</td>
</tr>
<tr>
<td>Natfeh-Unserved</td>
<td>3,449</td>
<td>9,071</td>
</tr>
</tbody>
</table>
E. Proposed Terms of Reference
1. **BACKGROUND**

The European Bank for Reconstruction and Development (the “EBRD” or the “Bank”) is providing finance to the Hashemite Kingdom of Jordan (“GoJ”) for the upgrade and construction of the wastewater infrastructure system in 15 towns, located in West Irbid. The system will comprise the laying public sewer infrastructure to serve a catchment area of approximately 21.9 km$^2$ including, where necessary, the construction of pumping stations, to enable the towns to connect effectively into the existing wastewater network and to the existing / expanded wastewater treatment plant (“WWTPs”) at Wadi Al Arab (the “Project”).

The transaction is a part of the Bank’s wider engagement with the Water Authority of Jordan (“WAJ” or the “Client”) aimed at developing and implementing a comprehensive wastewater investment programme to resolve current issues in the sector, caused by the rapid population growth, and the Syrian refugee influx which has placed an unprecedented strain on the wastewater system.

To improve current wastewater disposal practices, which are primarily based on a system of cesspits and tanker emptying, the Project will confirm connection to treatment from a number of feasible options. The options include enabling the towns to connect to the existing Wadi Al-Arab WWTP and extension of this WWTP, (part of the Wadi Al-Arab wastewater catchment system). Additional WWTP capacity will be provided by other entities under separate contracts. The Project will complement a planned co-investment by Kreditanstalt für Wiederaufbau (KfW) and Agence Française de Développement (AFD) to rehabilitate the water network and extend the wastewater network in other parts of Irbid, primarily East Irbid.

The Irbid governorate is located 83 km north of Amman, the area of which extends to the Syrian and Israeli border, the northern region adjoins the Golan Heights. The proximity of Irbid to the Syrian border resulted in a significant number of Syrian refugees resettling in the city of Irbid and in the towns surrounding it. The consequent population growth placed an unprecedented strain on the existing wastewater infrastructure, particularly in the towns lying to the West of Irbid which suffer from inefficient wastewater collection infrastructure. The provision of effective wastewater disposal is a prerequisite for good social welfare and environmental care. Of the 15 target towns in West Irbid with a total population of over 100,000, approximately 18% are Syrian refugees.

Improvements will be achieved by providing first time sewerage to residents and thus address urgent socio-economic needs of both the local population and the refugee community in the Project area. The improvements are likely to circumvent potential health issues and related economic losses in the Project area.

Commercial, institutional and industrial activities in all 15 towns are limited and most of the wastewater is produced by domestic households. The existing wastewater disposal system consists of cesspits or septic tanks that generally serve each property and are usually located...
within the vicinity of the residences. Once filled, the cesspits are emptied by sewage tankers in an unsafe and inefficient manner.

**Figure 1 - Shows the project development area and project components.**
Jordanian and Syrian Population by Area/Town (census 2015)

<table>
<thead>
<tr>
<th>Service Area No.</th>
<th>Name of Area/town</th>
<th>Jordanian</th>
<th>Syrian</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Natfeh (partially served by a network)</td>
<td>1775</td>
<td>509</td>
<td>2284</td>
</tr>
<tr>
<td>2</td>
<td>Kufr Yuba</td>
<td>16905</td>
<td>5619</td>
<td>22524</td>
</tr>
<tr>
<td>3</td>
<td>Zahr</td>
<td>6882</td>
<td>698</td>
<td>7580</td>
</tr>
<tr>
<td>4</td>
<td>Jumhaa</td>
<td>3098</td>
<td>239</td>
<td>3337</td>
</tr>
<tr>
<td>5</td>
<td>Ham</td>
<td>1744</td>
<td>260</td>
<td>2004</td>
</tr>
<tr>
<td>6</td>
<td>Bayt Yafa</td>
<td>10849</td>
<td>1796</td>
<td>12645</td>
</tr>
<tr>
<td>7</td>
<td>Kufr Asad + Kherbet Mershed</td>
<td>11063</td>
<td>3026</td>
<td>14089</td>
</tr>
<tr>
<td>8</td>
<td>Qum</td>
<td>2067</td>
<td>171</td>
<td>2238</td>
</tr>
<tr>
<td>9</td>
<td>Qumeem</td>
<td>6874</td>
<td>1402</td>
<td>8276</td>
</tr>
<tr>
<td>10</td>
<td>Kufr Aan</td>
<td>3741</td>
<td>271</td>
<td>4012</td>
</tr>
<tr>
<td>11</td>
<td>Saydour</td>
<td>2213</td>
<td>86</td>
<td>2299</td>
</tr>
<tr>
<td>12</td>
<td>Hofa Wastia</td>
<td>5183</td>
<td>1861</td>
<td>7044</td>
</tr>
<tr>
<td>13</td>
<td>Kharaj</td>
<td>3525</td>
<td>365</td>
<td>3890</td>
</tr>
<tr>
<td>14</td>
<td>Soum (partially served by a network)</td>
<td>7948</td>
<td>2555</td>
<td>10503</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>83867</strong></td>
<td><strong>18858</strong></td>
<td><strong>102725</strong></td>
</tr>
</tbody>
</table>

2. Objectives

Following the Project Feasibility Study (West Irbid Wastewater Project, October 2017, Mott MacDonald Limited) and a proposed further study to investigate the improvement of the Wadi Al Arab WWTP (to be delivered by KfW), the Bank is now seeking to engage a consultant (the “Consultant”), to confirm the Feasibility Study treatment option, prepare a preliminary design, a detailed design and tender documents, to achieve and maintain compliance with national, EBRD and EU standards, relevant for the network and pumping infrastructure components to the treatment location. The Consultant will also supervise construction and support WAJ during the Defect Notification Period.

The phasing of the project will include:

**Phase 1 Technical Note Confirmation** – With reference to all other component studies, confirm the findings of the Feasibility Study with respect to treatment location and treatment capacity/upgrade. Confirm and agree the contract vehicle/strategy, based on FIDIC and EBRD Guidelines for Procurements, for the procurement of the network and pumping infrastructure components to the treatment location. Following review and Client approval undertake preliminary design stage.

**Phase 2 Detailed Design and Preparation of Tender Documents** - Following review and client approval, progress to detailed design and preparation of the tender documents. Prepare
and undertake an Environmental and Social Impact Assessment (ESIA). Support in preparation of documents required as per the Environmental and Social Action Plan (ESAP).

Phase 3 Support to Tendering Process – Following review and client approval, assist with the tendering process including responding to queries, tender evaluation, finalisation of the contract documents and award. Review of the contractors associated documents required under the ESAP.

Phase 4 - Construction supervision and administration.

Phase 5 - Post completion duties during the Defects Notification Period.

The objectives for Phase 2 to 5 of the Consultants assignment are to:

(i) facilitate the timely and effective procurement of the Project components by rendering support to WAJ in the preparation of requirements and technical specifications and the evaluation of tenders;

(ii) support WAJ with aspects of construction supervision, administration and post completion duties;

(iii) support WAJ with the ESAP and Stakeholder Engagement Plan (SEP) implementation, monitoring of environment, health and safety performance, and implementation of the Labour and Employment Plan (LEP) to ensure inclusive procurement.

The Consultant shall ensure that WAJ has access to best practices and international standards and that, as a minimum, designs fully comply with the Jordanian construction norms and the requirements of the ESAP, the SEP and take into account the relevant environmental, health and safety and social performance parameters and standards, required by the EBRD Performance Requirements and relevant EU standards.

To achieve these objectives, the Consultant is expected to take into account the information provided in the Feasibility Study and other component studies.

WAJ has designated a “focal department”, which will take the responsibility of acting as the dedicated counterpart on the working level for the overall project implementation. This department is the Programme Management Unit (“PMU”). Moreover, WAJ will nominate, for the purposes of the Project execution, a member of this department as Project Manager to work with the Consultant. It will be the Consultant’s duty to maintain close contact on all aspects of work. As a matter of principle, all formal communications relating to the work will be directed for the attention of the PMU Project Manager.

3. SCOPE OF SERVICES

3.1 The General consultancy assignment scope of services will comprise the following:

• Support and assist WAJ with meeting the Bank’s requirements for evaluating, monitoring and reporting the project in line with the Bank’s reporting procedures;

• Preparation of an Environmental and Social Impact Assessment (ESIA) following the preliminary design for local permitting purposes;

• Supervise and monitor environmental, health and safety performance during construction in line with environmental and social management plans stipulated in the ESIA, EBRD Performance Requirements and the ESAP;

Supervise, support and monitor implementation of the ESAP by the Client and Contractors.
Supervise, support and monitor implementation of the SEP by the Client.
Regularly monitor and report on progress.

3.2 The Phase 1 consultancy assignment scope of services will comprise the following:
- Review all other relevant component studies and confirm the findings of the Feasibility Study with respect to treatment location and treatment capacity/upgrade and agree with WAJ / the Bank, to enable the basis of the network and pumping station preliminary design to go ahead;
- Confirm and agree with WAJ / the Bank, the contract vehicle/strategy, within Bank guidelines;
- Prepare a Project Implementation Plan, detailing the procurement / contracting strategy, structure of tenders and time schedule for implementation.
- Following review and Client of the above, undertake preliminary design for the network and pumping stations. Preliminary design will be prepared in accordance with all currently applicable legal regulations, standards and norms applicable under the Jordanian laws and with the view to achieve and maintain compliance with the EU standards for the infrastructure (when appropriate).

3.3 The Phase 2 consultancy assignment scope of services (detailed design and preparation of tender documents) will comprise the following main tasks:
- One of the goals of the preliminary design is for WAJ, as investors in the construction of the wastewater transfer system, to achieve as soon as possible the issuance of the zoning permit and to start the procedure of permanent and temporary land expropriation, if applicable. (Once preliminary design has been agreed and comments returned from the Bank/WAJ the geodetic survey will be undertaken).
- Prepare and undertake an Environmental and Social Impact Assessment (ESIA) for local permitting purposes in line with local and EBRD standards, which will address gaps identified in the Project Environmental and Social Assessment (West Irbid Project ESA, November 2017), ESIA should include the following plans as a minimum;
  - Construction Environmental and Social Management Plan (CESMP) Framework
  - Ecological Survey and Biodiversity management plan
  - Livelihood Restoration Plan
  - Labour and Employment Plan (LEP) including estimating employment numbers disaggregated by gender, age and occupation
- Prepare detailed design and tender documents for the wastewater network and conveyance infrastructure in consultation and coordination with relevant stakeholder (i.e. Ministry of Public Works and Housing, Municipality of West Irbid). The tender documents shall include employment and procurement guidelines as outlined in the LEP developed as part of the ESIA;
- Prepare qualification requirements, technical specifications, Bill of Quantities and tender documents using the Bank’s standard tender documents for procurement of works and in accordance with the Banks’ Procurement Policies and Rules (PP&R). For the purpose of this ToR, it is assumed that the network and pumping station infrastructure will be procured using the FIDIC conditions of contract for construction works designed by the Employer (Red Book), to be confirmed at Phase 1 of the Project implementation;
• Support the Client in the implementation of the ESAP including the preparation of various documents required by the ESAP.

3.4 The Phase 3 consultancy assignment scope of services (tendering process, evaluation, finalisation and award) will comprise the following main tasks:

• Assist WAJ with the whole procurement process including replying to bidders, evaluating tenders, monitoring the evaluation process and ensuring that the evaluation report is in line with the Bank’s Procurement Policies and Rules (PP&R), using the Bank’s standard evaluation report format. Assistance will include responding to queries, assisting with preparing the tender evaluation report, finalisation of the contract documents and award. Tender assessment will include the Contractor’s associated management plan requirements under the ESAP;
• Support WAJ with meeting Bank’s requirements with regards to tender awarding and contract signing.

3.5 The Phase 4 consultancy assignment scope of services (contact supervision and administration) will comprise the following main tasks:

• Construction supervision of the Project components, acting as the “Engineer” for the contract(s);
• Supervise and monitor environmental, health and safety performance during construction in line with environmental and social management plans stipulated in the Environmental and Social Impact Assessment (ESIA);
• Supervise, support and monitor to ensure that the aspects of the Environmental and Social Action Plan (ESAP) and implemented during construction of the works;
• Supervise, support and monitor to ensure that the aspects of the Stakeholder Engagement Plan (SEP) and implemented during construction of the works;
• Regularly monitor and report on progress.

3.6 The Phase 5 consultancy assignment scope of services (post completion duties during the Defects Notification Period) will comprise the following main tasks:

• Assist and support WAJ with necessary post completion duties during the Defects Notification Period.

3.7 Preliminary Design
The preliminary design shall include but not be limited to:

• A flow survey of existing flows (as required);
• A site survey and topographical maps of the area, to scale 1:10,000 to 1:25,000, showing existing facilities of the wastewater system, locations of wastewater treatment plant and pre-treatment plants, locations of discharge of permitted effluents, alignment of the main sewerage network and key facilities on the network, collectors pumping stations and rising mains;
• A site survey and topographical maps of the new sewer network to scale 1:1,000 and 1:2,500 to 1:10,000 showing the sewer conveyance network main network infrastructure including, pre-treatment, pumping and receiving wastewater treatment facilities – Note the design shall include inspection and access points as appropriate for gravity sections and air valves etc in chambers for pressurized sections;
• Longitudinal sections of the new sewer transmission main in a suitable scale, cross-sections of sewers and structures at key nodes and/or crossings;
• Preliminary hydraulic calculations to design the required engineering capacity and performance of the new wastewater network and conveyance infrastructure including its technical interface with the WWTP (assumed to be Wadi Al-Arab WWTP);
• Prepare schematic drawings in ground-plan and typical cross-sections;
• Basis of Design Report to include: technical justification for the design / construction materials selection of the proposed main wastewater networks and conveyance infrastructure (e.g. pumping stations, pumped and gravity mains, emergency overflows, connections.) including measures (if any) to protect the integrity of assets over its operational life (i.e. cathodic protection), pumping station general arrangements and pipe material selection;
• The Basis of Design Report will include (at high level as applicable) engineering calculations, investigative findings from surveys and include an explanation of the intended operational functionality (design) of the wastewater transfer system including the infrastructure components, power requirements including indicative load schedules, standby power arrangements, power availability, means of control;
• The Design Report will include an identification of key construction and operational risks, design assumptions and approaches for reducing, removing or mitigating these risks;
• A high level provisional schedule of quantities and cost estimate of designed works, with costs divided by facility (per unit), earthworks (per meter), crossings, include also for preparatory groundworks (such as temporary pipeline easement), reinstatement, asset protection and general administration (site buildings, materials compounds etc);
• Geotechnical Report on the findings from preliminary borehole surveys previously undertaken along the proposed pipeline route, including a plan for more detailed geological and geo-mechanical ground investigations suggesting the number, depth and locations for detailed boreholes necessary for the preparation of the Detailed Design;
• High level scoping report to inform the ESIA and Environmental and Social Management Plans
• Prepare a stakeholder meeting presentation of the draft preliminary design.

After completion, the Consultant shall submit a draft preliminary design to WAJ. WAJ will then organise a joint meeting(s) with all stakeholders. During this meeting(s), the Consultant will provide all necessary explanations related to the Preliminary design of the wastewater system. Draft Preliminary design will also be subject to expert review. The Consultant will carefully consider all comments received from the expert (auditor) before submitting the final version of the preliminary design no later than 21 days after receipt of comments from the expert (auditor) and WAJ.

During the preliminary design the Consultant shall:
• review and take into account the development needs and plans of the municipality;
• consider the specific conditions existing in the municipality, which could have an impact on the construction of the sewage system (such as other existing below-ground infrastructure);
• use the available space and existing facilities of the system in the best practicable way taking into account the existing underground infrastructure;
• strictly follow all technical regulations, standards and norms of Jordan;
• implement technically and financially feasible solutions that are easy to maintain and manage; and
• carry out all necessary tests in the field.
• take into account the relevant environmental, health and safety and social (“EHSS”) performance parameters and standards, based on EBRD Performance Requirements.
3.8 Geodetic report of incomplete expropriation of land

The main objective of the geodetic survey is to provide the conditions for obtaining the Zoning permit for construction of the transfer system and to resolve property issues.

In preparing the survey, the Consultant is required to adhere to all input parameters from the Preliminary Design of sewerage network, incorporating a minimum buffer zone width of 4m (2m either side of the network centreline).

The Geodetic survey report must contain the following:

- General documentation;
- Terms of Reference;
- Technical description;
- Trigonometric form no. 25 for traverse points and for coordinates of points of expropriation belt;
- Sketch of traverse grid;
- Sketch of the survey prepared on the updated cadastral map in the scale of 1:1,000;
- Trigonometric form no. 27;
- Table with the following data for all land plots included in the Preliminary Design; data to be obtained from the cadastral register for the municipality:
  - title deed,
  - cadastral municipality under the new cadastral records,
  - number of land plot under the new cadastral records,
  - surname, father’s name and name of the plot owner,
  - name of the land plot,
  - field crops and classification of land,
  - total area,
  - expropriation area,
  - land plot number under the old cadastral records,
  - land registry certificates for land plots.
- Other attachments, if needed.

While drafting the geodetic report the Consultant shall:

- strictly follow and respect the rules, norms and standards of Jordan concerning the preparation of the geodetic report;
- carry out the necessary works on the ground, record and insert into the map the objects that are located in the expropriation area but are not shown on the cadastral maps.

Although land acquisition may not be a significant issue for the project, relevant plans need to be prepared to demonstrate compliance with EBRD’s PR5 on land acquisition. All land acquisition shall be dealt with as per the prevailing Jordanian Law and compensation procedures.

No physical displacement is expected to occur as a result of the Project, however, there may be minor loss of agricultural crops. Servitude agreements need to be established for the proposed pipeline routes and pump station locations. Alternative access past the Project site construction areas will be available. A Livelihood Restoration Plan needs to be developed to provide detail on the affected land parcels and method of compensation for lost assets during the preparation of the ESIA. Should physical displacement be necessary a Resettlement Action Plan (RAP) must be developed in line with PR 5.
Before submitting the final version of the geodetic report, the Consultant shall submit to the Client’s (WAJ) engineering team, the draft geodetic survey report for review and approval. In addition, the Consultant shall perform on-site inspections together with the parties authorised by WAJ.

### 3.9 Detailed design

Following the acceptance of the Preliminary Design, the Consultant shall prepare the detailed design of the wastewater networks and related infrastructure system. One of the goals of the detailed design is to provide early information to enable WAJ to obtain any necessary clearances, licenses, permits and certificates for the project construction, as soon as practicable.

At the start of the Detailed Design, to inform the level and type of design, the Consultant shall update the Project Implementation Plan/Procurement Strategy with emphasis on the packaging of contracts and how the works should be split into individual contract lots, aiming at a time-optimized implementation schedule, as well as present and future operation and maintenance and financing aspect of the project into consideration.

The detailed design shall include, but not be limited to:

- Additional surveys as required (geotechnical etc);
- Geodetic survey report with all geodetic elements necessary for the design and its implementation;
- ESIA Report and ESMPs;
- Requirements for permitting, stakeholders, land, compensation (resettlement), progress and design review meetings.
- Basis of Design Report with a description of the designed conveyance system to include, design assumptions, key construction delivery and operational risks, and approaches for reducing, removing or mitigating risks;
- Detailed hydraulic calculations and sizing of the conveyance pipework and pumping stations;
- Structural and pipework designs, as appropriate, showing calculations, drawings, etc;
- Topographical map of the new sewer pipeline at the scale of 1:1,000 and 1:2,500 showing the new sewer conveyance pipeline and infrastructure including pre-treatment, pumping and receiving wastewater treatment facilities including house connection sheets;
- Detailed longitudinal sections of the conveyance pipeline, showing the sewer pipe (gravity and pumped sections), pumping stations, and overflows with hydraulic information, pipe diameters, pipe depth and levels. Horizontal scale to be 1:1,000 to 1:5,000, and vertical scale 1:100 to 1:500;
- Detailed drawings of pumping stations and interface with the wastewater treatment plant, pipe crossings, overflows, thrust blocks etc, to a scale 1:20 to 1:100;
- Drawings of intersections of the new conveyance pipeline with other underground and above-ground installations, depending on the available information, sketches of intersections of pipelines with local, regional and main roads, as well as details of intersections according to the requirements of owners of other installations and road managers;
- Standard details for pipe laying, materials (pipes, fittings, valves);
- Bill of Quantities and cost estimates including overall quantity of materials with 5% surplus for contingencies, including other associated equipment and devices;
- Indicative works programme and expenditure profile;
• Specification for pipe laying and materials (pipes, bedding, fittings and valves, fill and cover) and requirements for:
  o delivery of materials,
  o phased construction and the build of associated works,
  o delivery and installation of mechanical and electromechanical equipment
  o testing and commissioning,
  o pipeline protection.

During Detailed Design preparation, the Consultant shall:
• Strictly follow technical regulations, norms and standards of Jordan;
• Apply technically feasible, financially efficient, sustainable solutions;
• Take into account the presence of surrounding historical buildings, protected environment and prepare, if necessary, special measures for their protection;
• Carry out all necessary tests in the field; and
• Optimise requirements for routine operation and maintenance.

3.10 Project Implementation Plan / Procurement Strategy
The Consultant shall support WAJ with the establishment of an appropriate procurement strategy, including prequalification of applicants if needed, single or two-stage tendering procedures, the need for pre-tender meetings, conditions of contract (assumed FIDIC Red Book), warranty obligations and delivery schedule.

To that effect the Consultant will prepare a Project Implementation Plan and update if needed, to demonstrate a realistic schedule for the entire procurement process. Particular attention will be provided by the Consultant to the proposed delivery schedule ensuring it is in line with best international practice.

3.11 Preparation of Tender Documents
The consultant shall prepare the Tender Documents for all works and services needed to be carried out, using the Bank’s standard tender documents for procurement of Works and FIDIC contract.

The tender documents shall consist but not limited to the following elements (assuming FIDIC Red Book):

- Instruction to Tenderers (Invitation to Tender, Tender Data, Appendix to tender, Requirements, etc.)
- Condition of Contract (Particular conditions, Contract Agreement form, templates of all required bonds and declaration of undertaking form)
- Specifications (General and Particular)
- Bill of Quantities
- Drawings
- Supplementary Reports (Geotechnical etc).

3.12 Support during the Procurement Process
The Consultant will provide support to WAJ throughout the procurement process. To this end, the Consultant will carry out the following activities:
• Draft and ensure that all procurement notices are placed in a timely manner in accordance with the Banks’ Procurement Policies and Rules PP&R;
• Ensure that all approvals and no-objections are applied for in a timely manner;
• Carry out the administration of the tender process, ensure that appropriate records are kept, documentation is properly stored, recorded and managed, and confidentiality is maintained;
• Prepare draft responses to Tender clarification enquiries, arrange for approval and issue and record the same;
• Prepare any amendments to tender documents as may be required and obtain no-objection prior to issue;
• Arrange any pre-tender meetings, if needed, and record same;
• Advise WAJ’s tender committee of the rules and procedure for tender opening;
• Arrange public tender opening and prepare corresponding minutes.

The Consultant will take the lead in organising and managing the evaluation process. To this end, the Consultant will, *inter alia*:

• Give guidance on the composition of the Evaluation Committee and to the Evaluation Committee as required;
• Provide draft detailed evaluation report for the consideration of the Evaluation Committee. Compile the Evaluation Report in the required format (to be provided by EBRD), including all technical and financial analyses, records of consultation with external parties by the Evaluation Committee and clarifications requested and received;
• Arrange for meetings of the Evaluation Committee, attend as an advisor and record these meetings, presenting the minutes for approval by WAJ;
• Document the Evaluation Committee’s deliberations in relation to the Evaluation Report and compile the agreement there into the Evaluation Report prior to seeking all approvals;
• Prepare revisions or additional information to the Evaluation Report that may be requested by the Bank;
• Ensure that all queries and complaints are promptly attended to as appropriate and copy such inquiries as appropriate to the Bank.

The Consultant will provide support to WAJ during contract finalisation. To this end, the Consultant will, *inter alia*:

• Prepare a brief for WAJ indicating all the items to be resolved in the clarifications pre-contract, if any;
• Attend pre-contract discussions, if any, and document the discussions, updating the contract documents if necessary and seeking all necessary approvals;
• Advise on the validity of performance and other contract-related securities;
• Circulate the Contract as required by the Bank’s Procurement Policies and Rules PP&R;
• Draft notifications for WAJ to unsuccessful Tenderers;
• Ensure that all queries and complaints are promptly attended to as appropriate and copy such inquiries and responses as appropriate to the Bank. The Consultant may be required by the Bank to participate in ‘de-briefings’ as a result of complaints.
3.13 Construction and Implementation Supervision
WAJ will ask the Consultant to act as the Engineer, according to FIDIC Conditions of Contract, for the supervision of Works. The Consultant will coordinate and liaise with WAJ, Local Authorities (when necessary), Contractors and other relevant institutions.

Within two weeks after the issuing of the letter of acceptance to the winning bidder(s), the Consultant will commence his duties related to construction supervision. The Consultant shall act as the representative of WAJ on all the construction activities for this programme and carry out the duties of the Engineer as defined in the Contract. He shall provide adequate and competent procurement support and site supervision staff with sufficient experience to ensure that the procurement, construction and commissioning are carried out to the quality, quantity, cost and programme agreed in the Contract.

For all contracts the Consultant will have the following obligations:

- Upon Commencement of the Works, in accordance with the conditions of contracts, execute and deliver Commencement Certificates and obtain the countersignatures of the Contractors.
- If the Contractors do not receive possession of the site from time to time in accordance with the contracts, or if a Contractor does not receive a Commencement Certificate within any period stipulated in a contract, assess whether the Contractor is likely to suffer delay and/or incur extra cost and notify the Client accordingly.

The Consultant will have the following obligations:

- Obtain a copy and keep a file of any applicable standards, rules or regulations of all the relevant authorities and public bodies and companies, whose property or rights are affected or may be affected in any way by the Project. Monitor and report to the Client on obtaining compliance with the specified consents by the Contractors.
- Assist in any negotiation with any owners, lessors, adjoining owners, public authorities, licensing authorities and others for the purchase by WAJ of the additional land under the Contract.
- Liaise as necessary with utility companies and other bodies, as appropriate, and assist in and co-ordinate such liaison as necessary.
- In line with a schedule drawn up and maintained by WAJ of all necessary statutory licenses, permits and approvals necessary for the design, implementation and operation of the Project (the Schedule should identify the dates for submissions and approvals, and the person or persons responsible for making application for such licenses, permits and approvals either on their own account or on behalf of WAJ or the Contractors). The Consultant shall, check that such applications are made on time and assist in negotiations with other parties, as necessary from time to time.
- Coordinate with and assist the Client to ensure that all permits required are obtained on time
- Identification of hazards for the construction stage. This must comprise.
- Review and assess the likelihood of these construction stage hazards / risks (as prepared by the Contractors) and the potential consequences, to include: procedural, environmental and social risks, occupational and public health and safety, technical and quality risks, the risk of cost overrun, delays and risk to third parties.
- Identify possible additional mitigation measures and communicate proactively and continuously measures to manage and reduce/eliminate hazards/risks.
The Engineer will prepare and submit to the Client monthly Progress Reports. Each monthly progress report will include:

- Brief summary information about any events or circumstances which, in the Engineer’s opinion, may create sufficient grounds for any time, claim and/or cost overrun under a Contract and the Engineer’s recommendation of the measures being (or to be) adopted to overcome such events or circumstances and the contractual basis thereof;
- Comparison in the form of a chart showing the Contractors’ original cumulative cash-flow estimate, in monthly periods, of all payments to which the Contractors will be entitled under the Contracts and the actual payments certified by the Engineer up to the end of the reporting period. In the event of the cumulative amount of the actual monthly payment certificates being lower than the Contractors’ estimates, the Engineer will accompany the chart with a supporting report and provide:
  - Details of any events or circumstances that have caused the discrepancy;
  - Assessment of the significance of such events or circumstances, including the Engineer’s opinion on whether these may jeopardise the completion in accordance with the Contracts;
  - Report on the measures being (or to be) adopted to overcome delays in respect of each event or circumstances and the contractual basis thereof;
- Comparison of the actual percentage completion of delivery compared with the planned for each critical path item identified in the Contractor’s programme; where any delivery is behind the programme, the Engineer will comment on the likely consequences and state the remedial action being (or to be) taken;
- Comparison of the actual percentage completion of delivery compared with the planned for each main item of Plant and Materials, if not included in the list of critical path items;
- Information about the use of provisional sums and an appropriate justification thereof;
- Photographs showing the status of manufacture and of progress on the site;
- List of new quality assurance documents, reports on test results and certificates of materials;
- Safety statistics, as provided by the contractors, including details of any hazardous incidents and activities relating to environmental aspects and public relations;
- List of all notices, consents, approvals, certificates or determinations given or issued by the Engineer within the reported period; and
- Other information, as may be required by the Client.

The Consultant shall attend site meetings and endeavour to ensure that at all times outstanding problems are settled in order to avoid any delay or extra expenditure (having regard, however, to the terms of the Contracts and the limitations on the authority of the Engineer). In addition, the Consultant shall:

- Attend interface co-ordination meetings and assure that all interfaces are properly managed and that interface problems are addressed and solved.
- Keep full and proper records of all meetings and discussions attended or conducted by the Engineer and make the same available for inspection by the Client forthwith on request.
- On request of WAJ, attend meetings to resolve differences of opinion on general or technical matters.
- Ensure that the Client receives timely notice of and is permitted to attend all site meetings and other meetings with the Contractors.
• Notify the Contractors if the Engineer objects to any person who has conducted himself as incompetent or negligent; notify and advise the Client if this is the case and agree on any action to be taken.

• Advise the Client on the general organisation of the Contractors’ resources at the Site, including management and programming systems, manpower, plant and equipment.

In addition to payment requirements of the Contractors’ Works in accordance with the Conditions of Contracts, the Consultant shall:

• Collate and prepare quarterly budgets showing sums anticipated to fall due from WAJ/Client to the Contractors, dates and amounts of invoices and certificates under the Contract programme expected to be achieved in the quarter and deliver the same to the Client forthwith.

• Maintain Project accounts and prepare final Project accounts.

The Consultant will assist the Client to comply with the procedures agreed with the EBRD. Unless, in the opinion of the Consultant, an emergency occurs affecting the safety of life or of the Works or of adjoining property, the Consultant will provide a preliminary report to the Client on any prospective variation, outlining the basis for the consultant’s valuation of the variation, including but not limited to the following:

• The consultant’s opinion on the extent, if any, of applicability to the varied Works of the rates and prices set out in the Contract: when expressing an opinion, the consultant will take into account the actual or expected currencies of cost (and the proportions thereof) of the inputs of the varied work without regard to the proportions of various currencies set out in the Contract;

• The quantity and the value of the varied Works that can be determined using the rates and prices set out in the Contracts;

• The quantity and the consultant’s estimate of the value of the varied Works, which can be determined using the rates and prices set out in the contract as the basis for valuation: the Consultant will provide a detailed breakdown of the rates and prices set out in the Contract and identify the price components that the Consultant used or intends to use for the valuation of the varied works;

• The quantity and the consultant’s estimate of the value of the varied Works, which can only be determined using the rates and prices agreed between the Consultant and the Contractor. The consultant will provide to the Client with an appropriate justification of the basis for the agreement.

In case of a variation, the Consultant will follow the procedures and conditions stipulated within the FIDIC Conditions and subject to the EBRD prior consent:

3.14 Defects Notification Period

WAJ will ask the Consultant to act as the Engineer, according to FIDIC Conditions of Contract, for the first initial 6 month period of the construction contract(s)’ Defects Notification Period. The Consultant will coordinate and liaise with WAJ, Local Authorities (when necessary), Contractors and other relevant institutions.

The Consultant will have the following obligations and continue to assist WAJ with the following:
- Obtain a copy and keep a file of any applicable standards, rules or regulations of all the relevant authorities and public bodies and companies, whose property or rights are affected or may be affected in any way by the Project. Monitor and report to the Client on obtaining compliance with the specified consents by the Contractors.
- Assist in any new or existing negotiation with any owners, lessors, adjoining owners, public authorities, licensing authorities and others for the purchase by WAJ of the additional land under the Contract.
- Liaise as necessary with utility companies and other bodies, as appropriate, and assist in and co-ordinate such liaison as necessary.
- In line with a schedule drawn up and maintained by WAJ of all necessary statutory licenses, permits and approvals necessary for the design, implementation and operation of the Project (the Schedule should identify the dates for submissions and approvals, and the person or persons responsible for making application for such licenses, permits and approvals either on their own account or on behalf of WAJ or the Contractors). The Consultant shall, continue to check that any such continuing applications are made on time and assist in negotiations with other parties, as necessary from time to time.
- Coordinate with and assist the Client to ensure that all permits are/have been obtained.
- Identification of hazards for works undertaken during the Defects Notification Period, as per the construction supervision period.

The Engineer will prepare and submit to the Client monthly Progress Reports. Each monthly progress report will include:
- Brief summary information about any events or circumstances occurring on site which, in the Engineer’s opinion, warrant discussion and inclusion in the monthly report.
- Comparison of the actual percentage completion of defects compared with the planned items identified in the Contractor’s programme. Where any delivery is behind the programme, the Engineer will comment on the likely consequences and state the remedial action being (or to be) taken;
- Comparison of the actual percentage completion of delivery items required to resolve defects, compared with the planned list of items;
- Photographs showing the status any defects and the progress on the site;
- List quality assurance documents, reports on test results and certificates of materials, etc, as required from the contractor to close out defects;
- Safety statistics, as provided by the contractors, including details of any hazardous incidents and activities relating to environmental aspects and public relations;
- List of all notices, consents, approvals, certificates or determinations given or issued by the Engineer;
- List and provide information relating to any remaining contractual payments and issues; and
- Other information, as may be required by the Client.

The Consultant shall continue to attend site meetings and endeavour to ensure that at all times outstanding problems are settled in order to avoid delay or extra expenditure (having regard, however, to the terms of the Contracts and the limitations on the authority of the Engineer). In addition, the Consultant shall:
- Attend interface co-ordination meetings and assure that all interfaces are properly managed and that interface problems are addressed and solved.
- Keep full and proper records of all meetings and discussions attended or conducted by the Engineer and make the same available for inspection by the Client forthwith on request.
• On request of WAJ, attend meetings to resolve differences of opinion on general or technical matters.
• Ensure that the Client receives timely notice of and is permitted to attend all site meetings and other meetings with the Contractors.

At the end of the 6 months of the Defects Notification Period, the Consultant shall provide the Client with a comprehensive handover report. The report shall detail all outstanding issues/defects and provide the Client with a clear road map for the successful completion of the project at the end of the Defects Notification Period.

3.15 Environmental, Health, Safety and Social (EHSS) performance
In preparation of the technical requirements and specifications for tender documents the Consultant shall take into account the relevant environmental, health and safety and social performance parameters and standards, based on EBRD Performance Requirements and applicable EU standards. The Consultant shall also define and incorporate into technical specifications and requirements for tender documents of the relevant Environmental and Social Action Plan (ESAP) requirements that tenderers will be required to adhere to.

The Consultant shall ensure that the Labour Conditions of the EBRD version of Standard tender document, works contract, as well as the requirement for complying with the EBRD Environmental and Social Action Plan (ESAP), the Stakeholder Engagement Plan (SEP) and any other relevant action plans prepared during the due diligence for this project (reference Mott MacDonald’s West Irbid Wastewater reports – Inception Report, May 2017 and Feasibility Study October 2017, and Environmental & Social Assessment November 2017), are included in the tender documents and contracts. The Consultant will prepare the specifications and drawings as an integrated part of the tender documents.

Once drafted, WAJ will submit the Tender Documents to the Bank for the Bank’s “no objection”. The Consultant will be expected to incorporate any amendments required by the Bank in order to give its “no objection”.

4. IMPLEMENTATION TEAM / TIMESCALE / DELIVERABLES

The Consultant shall report on all aspects of the Assignment to the Bank’s Operation Leader (the “OL”) Esther Griffies Weld (GriffieE@ebrd.com) and liaise with the Client.

It is envisaged that the Client will provide the Consultant with access to, or copies of all, relevant information (all or most in English although some tbc are expected to be in Arabic). The Consultant will make a detailed review of this information, either in the local language, or by translating, or agreeing with the Client the translation of, the information into English.

The Consultant will work with a variety of stakeholders.

The EBRD’s Resident Office in Amman shall be the point of contact for logistical issues (tel) +962 65635033.
### Team Composition and Qualification Requirements of the Key Experts

<table>
<thead>
<tr>
<th>Position</th>
<th>Qualifications</th>
</tr>
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<tbody>
<tr>
<td><strong>Team Leader</strong></td>
<td>Chartered Engineer with a Bachelor or Master degree and at least 15 years professional experience, of which 10 years in wastewater collection, with at least one project similar in size and scope of work, minimum 5 years’ experience as a project manager or Team leader.</td>
</tr>
<tr>
<td><strong>Senior Hydraulic Engineer</strong></td>
<td>Chartered Engineer with a Bachelor or Master degree and at least 10 years professional experience, of which 5 years in wastewater project, and experience as a hydraulic modeller.</td>
</tr>
<tr>
<td><strong>Contract Management Specialist</strong></td>
<td>Chartered Engineer with a Bachelor or Master degree and at least 10 years professional experience, of which 5 years in similar wastewater project and experience in contract preparation and tender process.</td>
</tr>
<tr>
<td><strong>Mechanical Engineer</strong></td>
<td>Chartered Mechanical Engineer with a Bachelor or Master degree and at least 10 years of professional experience, of which 5 years in similar wastewater project.</td>
</tr>
<tr>
<td><strong>Electrical Engineer</strong></td>
<td>Chartered Electrical Engineer with a Bachelor or Master degree and at least 10 years of professional experience, of which 5 years in similar wastewater projects.</td>
</tr>
<tr>
<td><strong>Geotechnical Specialist</strong></td>
<td>Chartered Engineer with a Batchelor or Master degree and at least 8 years professional experience, of which 5 years in similar projects.</td>
</tr>
<tr>
<td><strong>Resident Engineer</strong></td>
<td>Chartered Engineer with a Batchelor or Master degree and at least 10 years professional experience, of which 5 years in similar pipeline and pumping station infrastructure construction experience.</td>
</tr>
<tr>
<td><strong>Environmental Specialist</strong></td>
<td>Environmental specialist with a Batchelor or Master degree and at least 10 years professional experience, of which 5 years’ experience in ESIA’s to EBRD PR’s or similar standards for linear projects (including Biodiversity &amp; Water Resources).</td>
</tr>
<tr>
<td><strong>Social and Gender Specialist</strong></td>
<td>Social and gender specialist with a Batchelor or Master degree with at least 10 years professional experience, including experience in Jordan, public consultation in the local context, inclusive labour and procurement policies and/or land acquisition &amp; resettlement expertise, in similar water / wastewater related projects.</td>
</tr>
</tbody>
</table>

**DURATION**

The timescale for the Project is as follows:

- **Phase 1.1** - Confirmation of Feasibility Study recommendation and contract strategy plan: After 3 weeks from mobilisation.
- **Phase 1.2** - Preliminary Design: After 4 months from end of Phase 1.1.
• Phase 2.1 - Detailed Design (to draft submission): After 6 months from end of Phase 1.2.
• Phase 2.2 - Tender Documents preparation (to draft submission): After 3 months from the end of Phase 2.
• Phase 3 – Support to Tender Process: After 3 months from the end of Phase 2.2
• Phase 4 - Construction Supervision and administration: 1 month during the contract award and start up period and 2 years construction contacts.
• Phase 5 - Post completion duties during the Defects Notification Period: 6 months input during the Defects Notification Period from issue of the Taking Over of the Works Certificate.

The delivery time period for each Phase shall only commence following comments and approval from WAJ / EBRD for the previous Phase.

**DELIVERABLES**
The Consultant will submit the following report deliverables to the Client:

- **Phase 1:**
  - Technical Note (confirmation of Feasibility Study recommendation and highlighting issues to be agreed)
  - Project Implementation Plan (Procurement Strategy)
  - Preliminary Design:
    - Surveys and drawings
    - Schedule of quantities and costings
    - Geotechnical report
    - Basis of Design Report
    - Scoping report

- **Phase 2** - Detailed design and preparation of the tender documents:
  - Updated Project Implementation Plan (Procurement Strategy)
  - Geodetic Survey
  - ESIA report and ESMPs
  - Detailed Design
    - Surveys and drawings
    - Schedule of quantities and costings
    - Geotechnical report
    - Basis of Design Report
    - BOQ, indicative works programme
    - Specification

- **Phase 3** – Tendering process:
  - Tender Evaluation Report.
  - Draft and Finalised Tender Documents.

- **Phase 4** - Construction Supervision:
  - **Periodic Construction Supervision Progress Reports** (5 copies to WAJ and 2 copies to EBRD). The Monthly and Quarterly (summarising) Reports during implementation period shall contain information on the state of progress and the construction programme as well as cost and financing. Special regards shall be given to current problems and the reasons for deviations from time and cost schedules. The reports shall contain all circumstances that might jeopardize the achievement of the programme overall objective and purpose or the progress of its implementation. It shall include detailed suggestions for measures to be undertaken by the Consultant, the Client or other stakeholders for rectification.
The periodic report shall also consider the implementation of the environmental and occupational health and safety measures. Moreover, the reports shall include staff assignments of the Consultant. Monthly and Quarterly Reports shall be submitted within two weeks after the end of the reporting period.

- **Annual environmental and social reports**: (5 copies to WAJ and 2 copies to EBRD). The annual report should document the environmental, social and health and safety performance of the Project, including contractors, and provide an update on ESAP implementation. The report will be compiled together with WAJ.

- **Final Project Report** (5 copies to WAJ and 2 copies to EBRD). The Final Project Report shall be submitted after completion of construction and issuing the Taking over Certificates. It will summarise all important information and data for the project implementation. Moreover, it shall contain among others a comparison between the Project results and the Project objectives. The Consultant shall present all information required for the Final Follow-Up Evaluation Report including:
  - Short description of the Project;
  - Project measures and their results;
  - Comparison of planned and implemented measures and reasons of deviations;
  - Comparison of planned and actual time schedule and reasons of deviations;
  - Total project cost (subdivided in consulting costs and costs of individual measures);
  - Project financing;
  - Major risks for sustainability of the project measures;
  - Recommendation for future operation of the facilities.

One part of the Final Project (Completion) Report will compare the situation before implementation and after completion of project measures.

The Client (WAJ) will examine the submitted documentation and provide comments if necessary within two weeks. Within one week from receipt of WAJ’s comments the Consultant shall make necessary changes and amendments to documentation and return to WAJ.

All deliverables will be in English, in both hard copies (4x) and in electronic form.

**CONSULTANT SERVICES FINANCIAL PROPOSAL**

The Financial Proposal shall be broken down in two sections and priced as follows:

- Phases 1-3 will follow a Lump Sum approach which requires bidders to advise the staffing schedule and man-month inputs needed to complete the tasks outlined.
- Phases 4-5 will follow a time-based approach with minimum key positions and man-months specified in order that bidders do not underestimate minimum inputs required and to ensure a comparable baseline is established.

**DONOR VISIBILITY**

Given the assignment is funded through the EBRD’s donor funded technical cooperation program, the Consultant will be required to support WAJ to ensure visibility of these resources.
Support on these visibility aspects can be obtained from the Bank’s Communications Department. Measures could include but not be limited to:

- All documents produced by the Consultant should mention donor support and bear the logo of the donor, when appropriate.
- Donor support to the project should be acknowledged in any public communication (press releases, launch of facilities)
- Local representatives of donors should be invited to any public event organised to promote the project (press conferences, inaugurations, possibly stakeholder participation programs)

Please contact Lucia Sconosciuto (email: SconosciL@ebrd.com; tel: +44 20 7338 8155) for further information on donor visibility only. Some donor visibility guidelines can also be provided by the Bank to Consultants at the start of an assignment.