Project: Aqaba-Amman Water Desalination and Conveyance (AAWDC)

2025 Environmental and Social Impact Assessment

Chapter 5: Project Description

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5 Project Description

5.1 Introduction

This Chapter provides a technical description of the AAWDC Project Facilities and planned activities during construction, routine and non-routine operations.

An overview of the anticipated discharges, emissions and wastes associated with the Project activities is included in Section 5.7.

This Chapter is based on the current reference case design. The information in this Chapter forms the basis for the impact assessment presented in Chapters 9-12.

The design of AAWDC Project (refer to Figure 5-1) includes:

- Seawater Reverse Osmosis (SWRO) Desalination Plant connected to Intake and Outfall Facilities comprising marine intake and outfall infrastructure, pumping and transfer facilities
- Conveyance system comprising a buried pipeline (approximately 438km long)
- Four pumping stations (booster stations BPS1, BPS2 and BPS3 and pumping station PS ADC)
- Two regulating tank facilities (RGT1 and RGT3) and one break pressure tank (BPT)
- Renewable Energy (RE) facility comprising solar photovoltaic (PV) power plant and supporting electrical substation

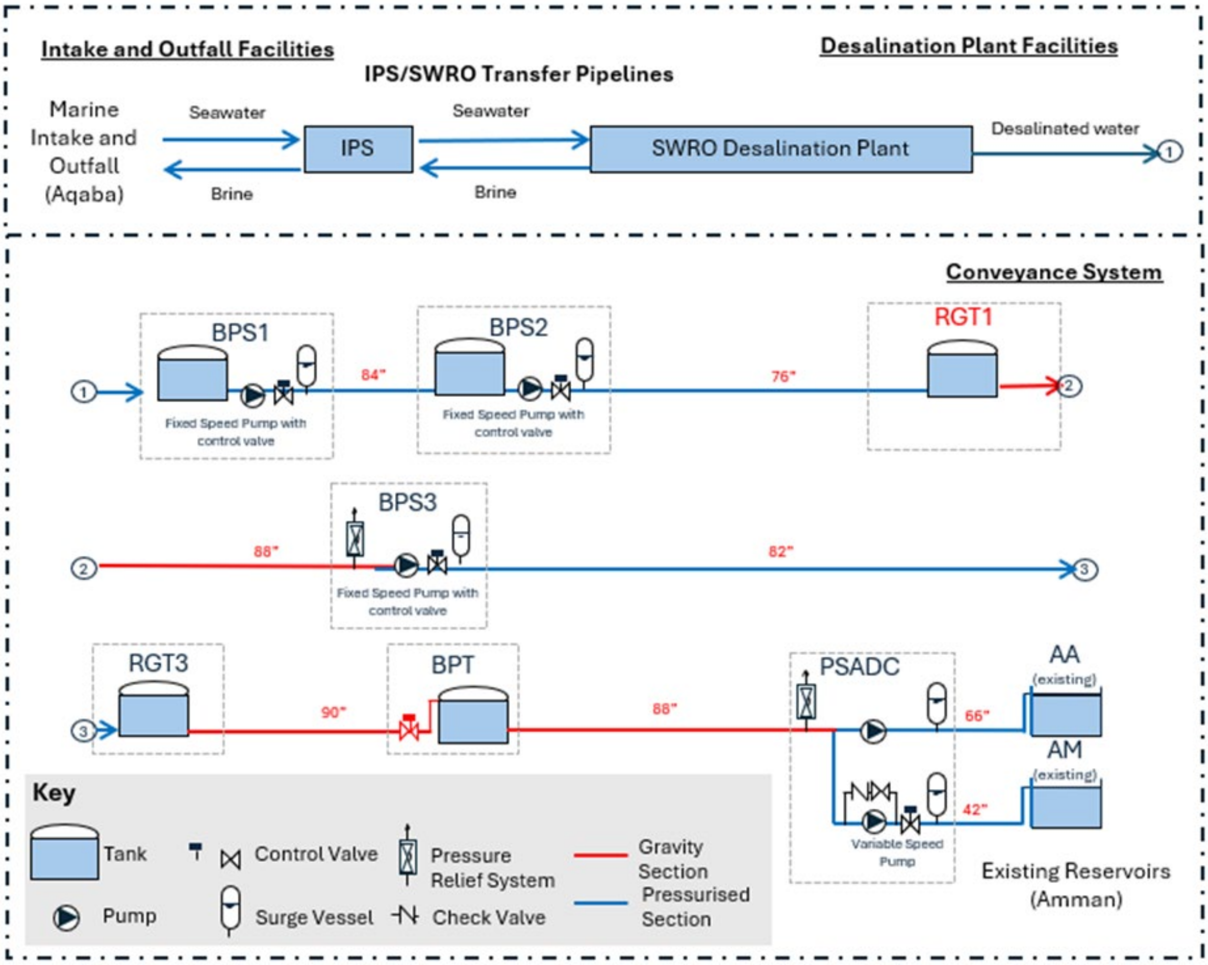
The RE Facility aims to meet the total power demand of the SWRO Desalination Plant and the pump stations within Aqaba Governorate during daylight hours. Outside these hours, the plant and pump stations will rely on electricity provided by NEPCO. The RE Facility will have an installed capacity of approximately 312 MWCD (281 MWp AC), such that the emissions threshold does not exceed 3.2 kgCO_2eq per cubic meter of delivered water.

Since the submission of the 2022 ESIA the following principal changes to the AAWDC Project design have been agreed and are reflected in this Chapter and subsequent facilities assessments:

- Marine Intake and Outfall system revised from velocity cap intake towers and associated pipelines and outfalls located to the south of the existing gas line to an Intake lagoon and outfall located to the north of the existing gas line
- Desalination Plant location revised from a greenfield location in the Aqaba Industrial Zone to a brownfield location in the Aqaba Industrial Zone adjacent to the IPS
- Desalination Plant Pre-treatment system revised from Ultrafiltration System to Dual Media Pressure Filters, and subsequent introduction of a Solids Treatment System
- Desalination Plant Clean-in-Place (CIP) waste disposal route revised from onshore evaporation ponds to treatment and neutralisation prior to discharge with the RO brine via the outfall system
- Number of Conveyance System Booster Pumping Stations reduced from five to three, and number of Regulating Tanks reduced from three to two

The rationale behind these principal design changes is discussed in more detail under Chapter 4 of this ESIA.

Figure 5-1: Overview of AAWDC Project



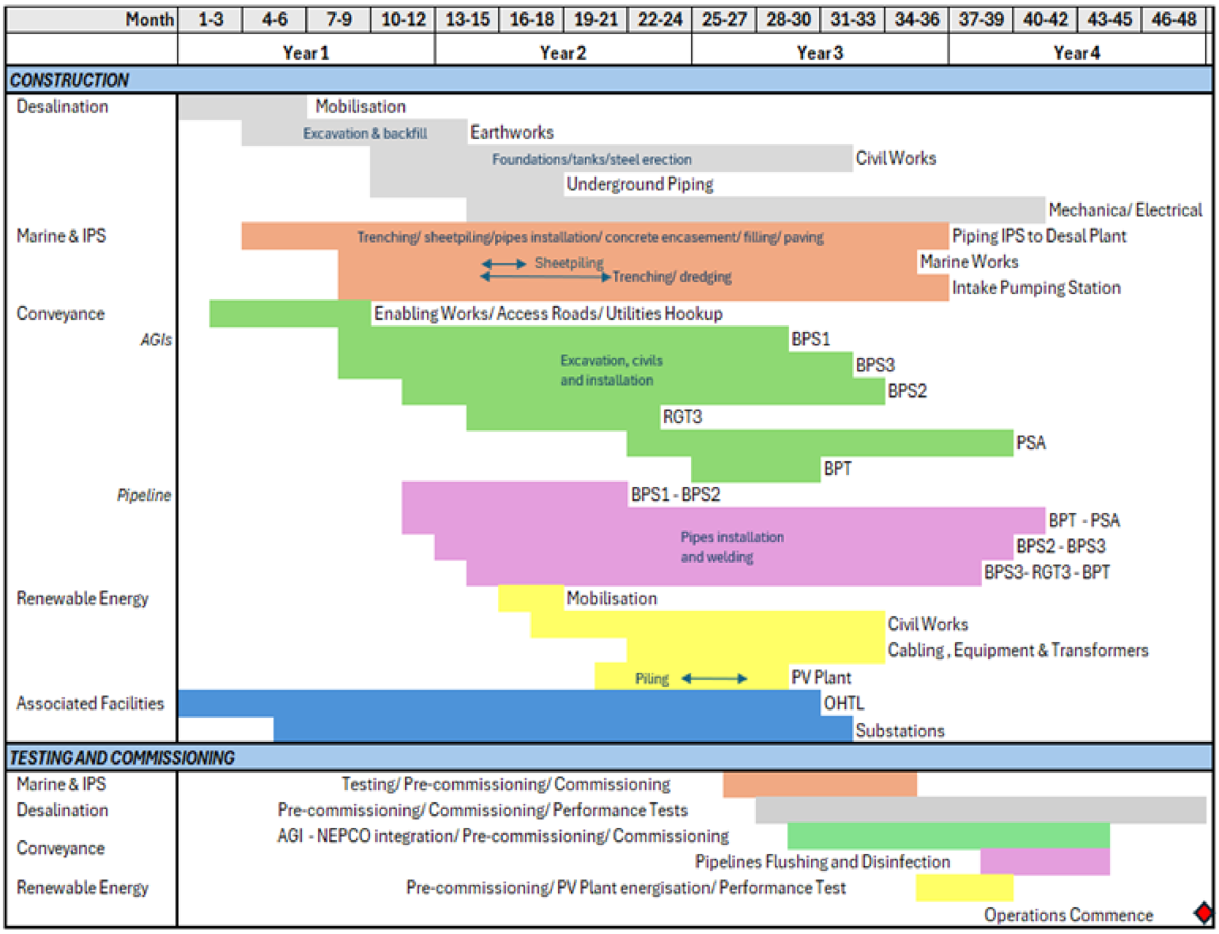
5.2 Project Schedule and Sequencing

The construction schedule is expected to extend to approximately 48 months, with construction commencing in 2Q 2026 and final commissioning and system start-up planned for 2030.

Scheduling of the AAWDC Project construction activities and the electrical and transmission works (including overhead transmission line and substation construction that fall under the responsibility of NEPCO) has been integrated and aligned to ensure that power is available at the relevant Project facilities in line with Project requirements, specifically to support Project facility testing, commissioning and start-up.

An Indicative Project schedule is presented in Figure 5-2.

Figure 5-2: Indicative Project Schedule



5.3 Permanent Facilities

The following sections present an overview of the Project permanent facilities associated with the:

- Intake and Outfall Facilities
- Desalination Plant
- Conveyance System
- Renewable Energy Facility

The locations of the permanent Project facilities are shown in Chapter 1 Figure 1.1.

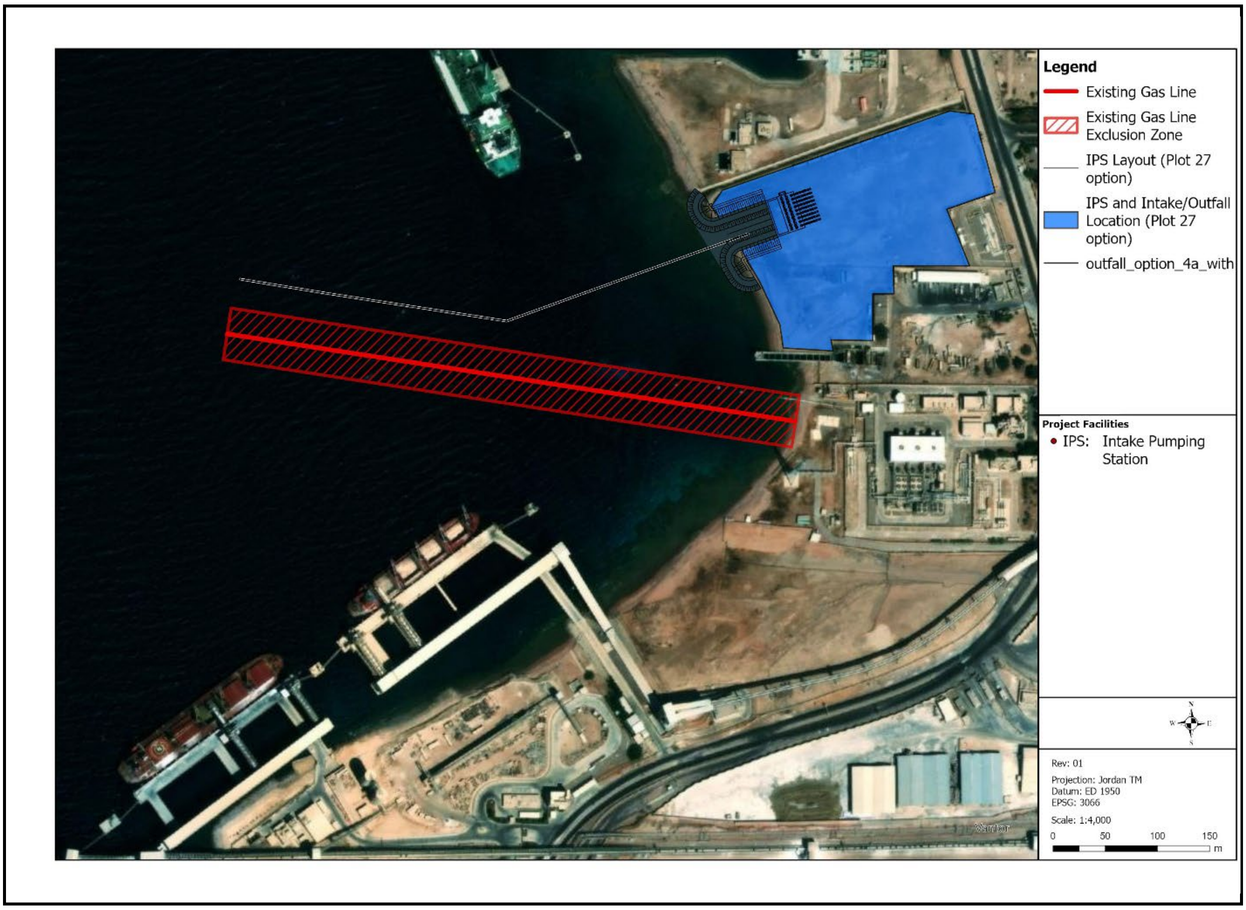
A description of the Project Associated Facilities is included in Section 5.3.5.

5.3.1 Intake and Outfall Facilities

The Intake and Outfall facilities comprise a marine intake lagoon, outfall and diffuser, the Intake Pumping Station (IPS), and seawater and outfall transfer pipelines between the IPS and Desalination Plant. The facilities are designed to extract and transfer seawater from the Gulf of Aqaba to the Project Desalination

Plant and discharge treated liquid effluents to the marine environment. The indicative layout of the Intake and Outfall facilities and IPS is shown in Figure 5-3.

Figure 5-3: Indicative Layout of Intake and Outfall Facilities and IPS



The system is designed to meet the following design flow specifications:

- Intake:
  - 78,480 m^3/hr (based on 100% capacity of Desalination Plant)
  - 89,496 m^3/hr (maximum[1])
- Outfall:
  - 53,330 m^3/hour (based on 100% capacity of Desalination Plant)
  - 85,946 m^3/hr (maximum)
  - 42,120 m^3/ hr (daily average)

5.3.1.1 Marine Intake System

The marine intake system comprises an intake lagoon with a seawall extending 10 m from the current shoreline and an inlet to the adjacent Intake Pumping Station (IPS). The inlet is equipped with an initial 50mm coarse-mesh screen to prevent the intake of large debris and marine life, followed by a 5mm fine-

[1] Maximums relate to capacity allowances made for the purpose of performance testing and maintenance activities where flows are expected to be higher than during routine operations

mesh screen to remove residual debris. The coarse screen is fitted with a fish recovery device, that recovers fish and other marine life for release back into the sea.

The intake will be supplemented with a bubble curtain system located at the mouth of the lagoon. The bubble curtain uses compressed air, diffused through linear tubes, to create a bubble barrier that reduces and prevents jellyfish, oil contaminants, algae concentrations, suspended sediments and planktonic larvae entrainment. The system is generally effective at current speeds of up to 6 m/s. The current design also incorporates a floating oil boom fence across the intake lagoon to prevent potential contamination in the event of 3rd party oil spills in the marine environment.

5.3.1.2 Marine Outfall System

The marine outfall system comprises a single outfall fitted with a subsea multiport diffuser initially laid within a trench and then along the seabed, stabilised by concrete ballast collars spaced at 5m intervals. At the shoreline, the outfall pipeline is designed to connect to an energy dissipation chamber at the IPS to reduce the flow velocity.

Marine Outfall

The current design incorporates a single gravity-driven flow HDPE/GRP outfall, with an external diameter of approximately 3000 mm. Due to the high salinity content of the brine discharge it is not expected that the outfall will be subject to marine fouling by shells/barnacles.

Outfall Diffuser

The purpose of the diffuser, fitted to the end of the outfall, is to optimise the dilution efficiency of the discharged effluent within the receiving body of seawater. The current preliminary design of the diffuser, constructed from HDPE/ GRP, comprises eight risers of 290mm diameter. The risers are equipped with twin ports spaced at 17.4m along the diffuser and vertically oriented at 60°. The diffuser, to be installed at water depths ranging from -50 MSL to -80 MSL, is designed to maintain a discharge flow rate of 11.7m^3/s (based on average flow rates).

5.3.1.3 Intake Pumping Station

Intake Facilities at IPS

Seawater will be received at the IPS via an intake chamber. The seawater will then be routed to nine separate intake channels, each linked to a corresponding upstream pump. The IPS is equipped with eight duty pumps and one additional standby or spare pump. Of the eight duty pumps, two are fitted with Variable Speed Drives (VSDs) to fine-tune pump speeds in response to varying water demand from the Desalination Plant. Each pump has a capacity of 9,900 m3/hr, and four pump discharge lines connect to a main header line. Seawater is sent from this line to the Desalination Plant to provide feed water via two 2.3m diameter seawater transfer lines.

The intake facilities are designed to incorporate chemical dosing systems at the pumping station outlet to control biofouling within the IPS and transfer lines. Dosing is planned for 4 hours, every 6 months per seawater intake transfer line. Dosing chemicals include:

- Sulphuric acid – maximum dosage of 20mg/L
- Sodium hypochlorite – maximum dosage of 10mg/L

Outfall Facilities at IPS

Treated effluents from the Desalination Plant will be sent to the outfall energy dissipation chamber at the IPS via an outfall transfer line from the Desalination Plant and subsequently discharged to sea via the outfall diffuser.

Utilities at IPS

IPS utilities include the following:

- A guardhouse
- Offices
- Maintenance facilities
- Electrical building to house switchgear and control systems, including instrumentation to monitor flow and water quality parameters
- Independent potable water, service water and sewage treatment systems

A power supply of 11kV will be provided from a new substation (to be built and operated under NEPCO's responsibility) to be located within the IPS site boundary.

5.3.1.4 Intake and Outfall Transfer Pipelines

The two buried approximately 1km seawater intake transfer lines and one approximately 1km outfall transfer line will be constructed from HDPE or GRP. The transfer pipelines will predominantly follow the route of the Ports Highway, crossing existing pipelines in the vicinity of the IPS and the Desalination Plant site, the Aqaba Gas Compression station gas pipeline, an existing road and the road tunnel under the highway immediately adjacent to the Desalination Plant site (see Chapter 1 Figure 1-1). At road crossings the pipelines will be encased in reinforced concrete to protect against additional loads.

5.3.2 Desalination Plant

The SWRO Desalination Plant is designed to produce up to 300 million cubic metres (MCM) per year of treated potable water at overall plant recovery rates[2] between 42% and 47%. The system is designed to meet the maximum and minimum daily production rates of 0.847MCM/day and 0.411 MCM/day, respectively, and an hourly maximum production rate of 35,476m^3/hour.

Seawater will be supplied to the Desalination Plant via the seawater transfer pipeline from the intake facilities.

The SWRO Desalination Plant comprises:

- Pre-treatment system:
  - Coagulation
  - Granular Media Filtration System (Single-stage Dual Media Pressurised Filters (DMPF))
  - Backwash System
  - Cartridge Filters

[2] The recovery rate is defined as the proportion of potable water recovered from the total volume of seawater fed to the Desalination Plant

- Reverse Osmosis system:
  - One pass RO system
  - Energy recovery system
  - RO CIP (Cleaning in Place), flushing and neutralisation system
- Post-treatment system:
  - Remineralisation and disinfection systems
- Solids Treatment system
- Chemicals system
- Ancillary and utility systems:
  - Domestic wastewater treatment
  - Bulk chemical storage area/systems
  - Instrumentation and control systems
  - Administration and maintenance buildings

The SWRO Desalination Plant is designed to achieve an annual availability of 98% which means that the plant is designed with an allowance of 2% downtime on an annual basis. To achieve this requirement, the Plant will incorporate redundancy into the design by installing standby units for critical equipment (e.g., pumps, membranes, transformers).

The Desalination Plant is designed to treat seawater as defined by the "design envelope" parameters. These parameters have been selected to accommodate the anticipated variations in the seawater quality at the marine intake, which affects the plant system and performance (refer to Table 5-1).

Table 5-1: Project Design Envelope (Seawater Intake)

Parameter	Unit	Value
Temperature	°C	20–30
Total Dissolved Solids (TDS)	mg/L	40–43
Total Suspended Solids	mg/L	< 10 (96% of the time) Between 10 and 20 (two weeks/year cumulated) Between 20 and 50 (24 hours/year cumulated)
Turbidity (OPTIONAL)	NTU	< 5 (96% of the time) Between 5 and 10 (two weeks/year cumulated) Between 10 and 20 (24 hours/year cumulated)
Total Organic Carbon	mg/L	< 3
$SDI_{75\%}$	%/min	<50
Chlorophyll-a	µg/L	< 2.5
Emulsified Oil and Grease	mg/L	< 0.5 (Dual Media Pressurised Filter)
pH	-	8.0 – 8.5

The plant is designed to produce potable water that meets the project water quality standards provided in Table 5-2.

Table 5-2: Project Potable Water Quality Design Standards

Parameter	Water Quality Requirement
Turbidity	<2 NTU 100% of the time, <1 NTU 90% of the time
pH	7.8 < pH < 8.5
Total Dissolved Solids (TDS)	< 500 mg/L
Total Hardness	< 300 mg/L
Chloride	< 300 mg/L
Residual Chlorine level at the Delivery Points and Turnouts	1.0 – 1.5 mg/L
Bromide	≤ 1.5 mg/L
Calcium	40 mg/L as CaCO3
Total Alkalinity	0-80 mg/L as CaCO3
Langelier Saturation Index (LSI)	< 0.5

5.3.2.1 Pre-treatment System

The function of the pre-treatment system is to ensure that the raw seawater supplied to the SWRO will not result in damage or abnormally high fouling or scaling to the SWRO membranes and to reduce suspended solids and particulate loads to meet the inlet specifications for the RO system[3]. To achieve this, the pretreatment stage integrates several key processes, including coagulation, filtration, disinfection (for fouling mitigation), and chemical dosing, to effectively condition the feed water.

Coagulation

Coagulation comprises a chemical pre-treatment step that aggregates small particles including dissolved organic matter in seawater so that they can be removed by filtration. The chemicals planned to be introduced to the feed water at the inlet to the pre-treatment system include:

- Ferric chloride or iron chloride (coagulant), an inorganic compound with the formula $FeCl_3$ which reacts with water to form ferric hydroxide that attracts suspended solids and organic matter. It will remain with the treated water and backwash
- PolyDADMAC (Coagulant-Aid), a polymer used as a flocculant to add density to slow-settling flocs (loosely aggregated solids suspended in seawater) and strengthen them so that they do not break up during pre-treatment. The flocculant will remain with the flocculated solids

Dual Media Pressurised Filter (DMPF) System

Feed water, under pressure, is routed through a dual media pressurised filter (DMPF) system comprising units of granular media e.g. sand. The DMPF units are designed to operate in cycles. Backwash pumps

[3] Fouling is the deposition of unwanted matter on membranes or other surfaces. Fouling can comprise colloidal matter, organic matter, minerals and/or the formation of a biofilm comprised of a mixture of microorganisms and organic matter. Scaling is a type of fouling caused by the precipitation of solid salts, oxides, and hydroxides, such as calcium carbonate.

regularly backwash each unit to remove accumulated solids in the filtration media using a combination of air scouring (via low-pressure blower system) and reverse flow of brine. The pre-treatment system includes 64 DMPF units in total, with at least two in backwash or under maintenance at any one time. The DMPF system is designed for a maximum of two backwashes per day, utilising "first pass" brine from the RO system, stored in a dedicated DMPF backwash water tank. The backwash frequency is determined by the levels of suspended solids and particulate loads in the inlet. The backwash wastewater produced during the washing cycle contains suspended solids and iron from the coagulant. Backwash water is directed to the solids treatment system.

Cartridge Filters

After treatment within the DMPF units, the treated water is sent to banks of cartridge filters to remove particles of 5µm or greater. This step acts as the final barrier against suspended solids in order to avoid fouling and potential damage to the RO membranes. The pre-treated water downstream of the cartridge filters will be required to meet a turbidity limit of < 1 NTU. A total of 15 (plus 1 standby) cartridge filter housings will be installed, comprising 950 cartridge elements (each 70 inches in length) per housing.

5.3.2.2 Reverse Osmosis (RO) System

The first-pass reverse osmosis (RO) system is designed to comprise 24 independent racks, each accommodating 400 pressure vessels. The configuration enables one rack to be in active-standby to ensure uninterrupted operation in the event of individual rack failure or during Cleaning-In-Place (CIP) procedures. Each pressure vessel houses seven SW-type spiral-wound 8" membranes, providing a membrane surface area of 440 feet^2 per element.

High-Pressure Pumps

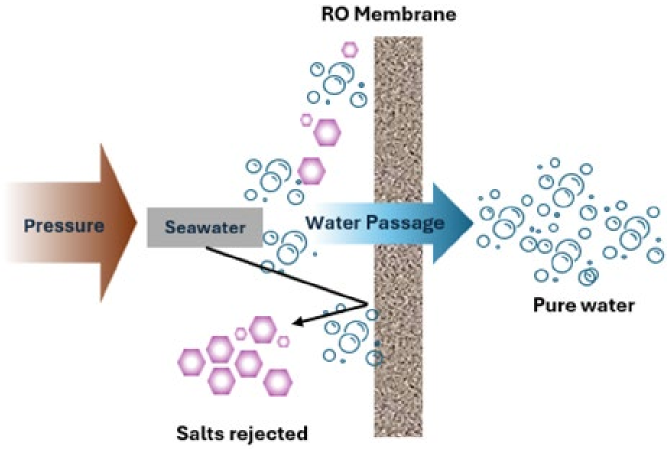
Feed water is supplied to the RO membranes using High-Pressure Pumps (HPPs). Two sets of eight HPPs plus one standby unit are included within the design, providing a capacity of approximately 4,516 cubic meters per hour (m^3/hr) per HPP set. They may be arranged either in a "pump island" configuration with shared inlet and outlet headers or as dedicated pumps for each SWRO train. While the HPPs themselves are not equipped with variable speed drives (VSDs), the associated booster pumps include VFDs to optimise efficiency.

RO Membranes

The purpose of the RO system is to remove dissolved salts, including sodium, chloride, sulphate, bromide, boron, and other constituents in seawater. Pressurised seawater, fed by the HPPs, permeates through the RO membrane, which retains the majority of the salts as a brine on the feed side, whilst the permeate water is sent to the post-treatment facilities (refer to Section 5.3.2.3 below). The application of pressure to the filtered seawater feed forces it through semi-permeable RO membranes producing fresh water with a highly reduced salt content (refer to Figure 5-4).

The overall RO system is designed to maintain permeate production rates with one skid offline for Cleaning-in-Place (CIP) or maintenance. The RO flux (i.e. the rate at which treated water passes through the RO membrane) for the first pass will be designed for an average 13 L/hr/m^2.

Figure 5-4: Illustration of Reverse Osmosis Principle



Brine from the RO system is routed to the brine backwash tank, which is designed to overflow to the outfall facilities. The brine backwash tank provides the water supply for the pre-treatment system filter media backwashing (refer to Section 5.3.2.1 above). The permeate from the RO system is sent to the post treatment system for remineralisation and to the two bypass permeate tanks. Each tank, with a capacity of 2,300m^3, ensures a steady supply of permeate water for service water, flushing and other uses.

Energy Recovery Devices

The retained high pressure RO brine can contain more than half of the energy imparted to the RO feed; therefore, Energy Recovery Devices (ERDs) allow for a significant reduction in the size of the HPPs. The Desalination Plant is designed to route high pressure RO brine to isobaric type ERDs (19 per rack) with a high energy recovery potential (approximately 97%). A VSD booster pump downstream the ERD discharge is used to pressurise the seawater feed to the RO membrane.

Cleaning-in-Place (CIP), Flushing and Neutralisation Systems

The RO system is designed to be maintained periodically by performing chemical cleaning of the RO membranes in-situ without the need for disassembly. The CIP chemical cleaning solutions will vary in pH level, depending on the type and level of fouling on the membranes. The CIP system consists of two dedicated CIP pumps, a mixing/recirculation tank, a filtration system, and associated chemical dosing points and instrumentation. The chemical cleaning solution is heated (to a temperature between 30 and 35 °C) and circulated through the RO membranes to remove fouling and accumulated solids. The cartridge filters serve a dual function – integral to the CIP system and acting as a Local Solids Treatment System to capture solids from the CIP solution. The design is based on an expected CIP chemical cleaning frequency of five times per rack per year, in batches of 300 m^3, as follows:

- One CIP with Citric Acid
- Two CIPs with DBNPA Biocide
- Two CIPs with Caustic Soda

Once the CIP cycle has finished (typically lasting around 8-24 hours), the spent cleaning solution will be neutralised in a dedicated equalisation tank as follows:

- pH of the spent cleaning solution is adjusted to a neutral level ~ pH 7-9

- Biocide DBNPA is neutralised with sodium bisulphite (SBS)

Following completion of the CIP cycle, the RO system will be flushed with RO permeate to remove residual CIP chemicals. In addition to the chemicals used for intermittent CIP cleaning and neutralisation, the RO system design includes provision for the use of an anti-scalant to reduce scale build-up on RO membranes and minimise residual oxidants in the seawater feed that can damage the membranes. Section 5.3.2.5 below provides an overview of the chemicals, design dosage and dosing basis within the RO treatment process.

5.3.2.3 Post Treatment System

To meet the Project potable water standards (refer to Table 5-2), to prevent corrosion within the conveyance system and safeguard potable water transmission pipelines against biological growth, the post-treatment system includes remineralisation of the RO permeate, pH adjustment and disinfection.

Remineralisation

A portion of the total permeate flow is directed to the calcite filters. Before entering the calcite filters, pumps recirculate a portion of the permeate water with carbon dioxide introduced at the calcite filter inlet.

The facility includes 16 calcite filters. During operation, the limestone media is dissolved into the water, increasing its alkalinity and hardness. To maintain filtration efficiency, limestone refill is managed through an intermittent top-up system. The calcite bed within each filter is maintained at a height between approximately 3.7 and 4.1m. The system is designed to achieve a contact time of 15 minutes with a backwash cycle, using remineralised water, to flush the filters for approximately 40 minutes.

pH Adjustment and Disinfection

Downstream of the calcite filters, the remineralised water is treated with caustic soda to adjust the pH to a level that meets the required Langelier Saturation Index (the degree of calcium carbonate saturation in water). To achieve the target chlorine concentration of 1.0 to 1.5 mg/L in the desalinated water, chlorine gas is injected before routing the desalinated water to the conveyance facilities.

5.3.2.4 Liquid and Solid Waste Treatment Facilities

Solids Treatment System

The solids treatment system is designed to remove up to 90% of the incoming solids load from the pre-treatment backwash effluents from the DMPF system.

Backwash effluents are collected in a concrete effluent mixing tank and then routed to a lamellar settling tank for thickening. The sludge produced is transferred to a thickened sludge tank. The thickened sludge is then mechanically dewatered using centrifuges. Coagulants such as polymers or ferric chloride may be added at the thickening or dewatering system inlets, if necessary. Recovered liquids (known as "supernatants") from the thickening process will be routed to the equalisation tank for discharge via the outfall facilities. Effluents from the final centrifugal dewatering system (often referred to as centrate water) are re-circulated upstream to the effluent mixing tank in the Solids Treatment System for further thickening. The final dewatering process is designed to achieve a sludge cake with ≥ 20% dry solids by weight. An estimated volume of 12 tonnes per day of sludge (as sludge cake) is estimated to be generated for off-site disposal.

Liquid Effluents to Outfall

Process liquid effluents sent to the equalisation tank and subsequently discharged from the tank to the outfall facilities comprise:

- RO brine including overflow from the brine backwash tank and flushing water
- Supernatant from solids treatment system thickening and dewatering
- Intermittent effluent from the CIP filtration system
- Post-treatment limestone backwash effluents

The flowrate of the effluent sent to the outfall discharge facilities is estimated to be approximately 42,120m^3/hr based on a daily average with an excess salinity of +34.8 psu and an excess temperature of +1 ^{o}C. During CIP operations, the total daily average flow of effluent sent to the outfall facilities comprises approximately 95.3% RO brine, 4.7% supernatant and 0.4% CIP effluent.

5.3.2.5 Chemicals System Dosage and Storage

The anticipated chemicals to be stored on site and used to support the desalination process are summarised in Table 5-3 below, which provides an overview of injection points, function, planned dosing rates and dosing basis. The bulk of chemicals will either be stored in liquid or dry form with service water used to batch up (prepared for use) dry chemicals on demand for treatment via chemical dosing pumps. Carbon dioxide and chlorine will be stored as compressed gas. Up to 15 days of storage capacity will be provided for locally supplied chemicals, whilst 30 days storage will be required for chemicals procured from regional/ international suppliers.

Secondary containment will be provided for all chemical storage tanks. Any incompatible chemicals adequately segregated. Safety showers/eyewash stations will be located both in the chemical storage area and at chemical dosing points.

Table 5-3: Desalination Plant Chemicals, Function, Dosage Design Rates and Dosing Basis

Chemical	Function	Injection Point	Dosage Design Rate	Dosing Basis[1]
Pre-treatment				
Ferric Chloride	Coagulation enhancer	Pre-treatment Inlet	0.9mg/L (typical) 5mg/L (max)	Routine
PolyDADMAC	Coagulant aid	Pre-treatment Inlet	0.1mg/L (typical) 0.3mg/L (max)	Routine
1st Pass Reverse Osmosis				
Antiscalant	Scale inhibitor	1st Pass RO Inlet	0.5mg/L (typical) 1mg/L (max)	Routine
Sodium Bisulphite	Reduces residual oxidants	1st Pass RO Inlet	0mg/L (typical) 0.6mg/L (max)	Routine (when required)[2]
Reverse Osmosis Cleaning-in-Place				
Citric Acid	Dissolves metal oxide and scale	RO CIP System	20g/L per CIP volume	Non routine
Sodium Hydroxide (Caustic Soda)	Removes silt deposits and organics	RO CIP System	1g/L per CIP volume	Non routine
DBNPA	Biocide	RO CIP System	0.2g/L per CIP volume	Non routine
Cleaning-in-Place Neutralisation				
Sulphuric Acid	Neutralises caustic CIP waste	Neutralisation System	1.25g/L per neutralisation volume	Non routine
Sodium Hydroxide	Neutralises acidic CIP waste	Neutralisation System	11.25g/L per neutralisation volume	Non routine
Sodium Bisulphite	Reducing agent	Neutralisation System	0.2g/L per neutralisation volume	Non routine
Post Treatment				

Chemical	Function	Injection Point	Dosage Design Rate	Dosing Basis[1]
Carbon Dioxide	Remineralise treated water	Calcite filters	70mg/L (typical) 80mg/L (max)	Routine
Calcium Carbonate (Limestone)	Remineralise treated water	Calcite filters	136mg/L (typical) 150mg/L (max)	Routine
Calcium Hydroxide (Lime)	pH adjustment	Post calcite filters	3.7mg/L (typical) 6mg/L (max)	Routine
Sodium Hydroxide (Caustic Soda)	pH adjustment	Post calcite filters	1.1mg/L (typical) 1.5mg/L (max)	Routine
Chlorine gas or sodium hypochlorite	Disinfection/sterilisation	Post calcite filters	4mg/L (typical) 6mg/L (max)	Routine
Solids Treatment				
Ferric Chloride	Coagulation enhancer	Solids thickening	0mg/L (typical) 5mg/L (max)	Routine (when required)[2]
Polymer	Enhances the solids thickening and dewatering	Solids thickening	1.2mg/L (typical) 2mg/L (max)	Routine
Ferric Chloride	Coagulation enhancer	Solids dewatering	0mg/L (typical) 5mg/L (max)	Routine (when required)[2]
Polymer	Enhances the solids thickening and dewatering	Solids dewatering	7 kg/T suspended solids (typical) 7 kg/T suspended solids (max)	Routine

Notes:

1. Routine dosing will be undertaken as required based on continuous online monitoring. Non-routine dosing is undertaken only during CIP activities, when the volume of water used (typically 400m3 per CIP event) is dosed. This is generally undertaken 2-3 per year per rack

2. Under normal operating conditions these chemicals are not required but provision is included in the design

5.3.2.6 Desalination Plant Utilities

The design of the desalination plant includes a number of non-process buildings to be used and occupied by the operational workforce including:

- Guard House
- Weighbridge
- Admin Building
- Warehouse & Vehicle Maintenance Shop
- Firefighting Station

Connections with municipal utilities will include potable water supply, sewage and domestic wastewater to meet welfare and sanitary requirements. The Desalination Plant site drainage will connect to the Aqaba Industrial Zone existing drainage network and will be designed in accordance with the following rainfall intensities specified by MWI:

- One in 25-year storm for roads and hardstanding areas
- One in 50-year storage for gutters and downpipes
- One in 100-year storm for erosion protection of Project structures

The site drainage system will segregate hazardous and non-hazardous areas, with any potentially contaminated discharges appropriately treated before being routed to the Aqaba Industrial Zone drainage network. Power for the Desalination Plant site will be provided through tie-in to the new NEPCO substation (see Section 5.3.5) with emergency generators provided onsite for critical system power in the event of primary power failure. These emergency generators are expected to be diesel powered (supported by a diesel day tank) and sized to support critical systems such as control rooms, emergency lighting, critical pumps and safety systems.

5.3.3 Conveyance System

5.3.3.1 Overview

The Conveyance System is designed to convey desalinated water, that meets potable standards, from the Desalination Plant to the Abu Alanda and Al Muntazah reservoirs located in Amman with an offtake for local supply at Aqaba. The system comprises the buried conveyance pipeline and Above Ground Installations (AGIs). The AGIs include pumping stations, two regulating tanks and a break pressure tank (BPT). The pipeline consists of seven sections varying in length between approximately 10 and 153km that extend between each of the AGIs, beginning at BPS1 and ending south of Amman where the route divides into two to reach the Abu Alanda (AA) and Al Muntazah (AM) Reservoirs.

As shown in Chapter 1 Figure 1-1 the planned route of the conveyance pipeline passes through the governates of Aqaba, Ma'an, Tafiela, Karak and Amman with the AGIs located in Aqaba, Ma'an and Amman Governates. Land elevations along the route have been incorporated into the system design, enabling use of gravity sections and positioning the pumping stations at lower elevations from where the water can be pressurised and lifted above the topographic gradient (See Chapter 1 Figure 1-2).

The system is designed to pump desalinated water approximately 22km from BPS1, via BPS2, to the first regulating tank (RGT1) lifting the water over a vertical elevation of approximately 700m. From RGT1 the desalinated water flows under gravity for approximately 30km to BPS3 and is then be pumped approximately 102km to RGT3 which serves as a highpoint reservoir (HPR) at an elevation of approximately 1085m total water level (TWL). From RGT3, the desalinated water flows under gravity for approximately 250km, via the BPT which also acts as a reservoir, to the final pumping station (PS ADC) from where the potable water is supplied to the two existing Amman water reservoirs.

The system is designed to provide a portion of desalinated water as local supply to Aqaba with low and high pressure offtakes from the BPS1 and BPS2 respectively. Emergency tap off stations are provided within sections of the conveyance pipeline at Ma'an, Tafilah, Karak and Madaba. Each tap off station includes a control valve which allows for the immediate shut-off of water flow in case of a leak or emergency. Routine power is provided to the conveyance system facilities through step down substations (33kV to 11kV) provided at BPS2, BPS3 and PS ADC, connecting to new Overhead Transmission Lines (see Section 5.3.5.1 below).

5.3.3.2 Conveyance Pipeline Design Basis

Design Flowrates

The overall conveyance system is designed to supply 250 MCM of water per year to the reservoirs in Amman and 50 MCM of water per year to Aqaba. The pipeline design flowrates shown in Table 5-4 are based on 98% system availability, inclusive of a 1.5% leakage/ utility water allowance, and take into account the high pressure offtake to Aqaba at BPS2.

Table 5-4: Conveyance Pipeline Design Flowrates

	Maximum Design Flowrate (MCM/year)	
Location	Yearly (Average) Operation	Daily Peak Flow
BPS1	310.7	313.8
BPS2 to PSA	258.9	261.6
PSA AM	72.5	73.2
PSA AA	186.4	188.3

Conveyance Pipeline Dimensions and Flow Characteristics

The pipeline will be constructed of steel in sections of varying diameter and wall thickness. The pipeline diameter and wall thickness is determined by the hydraulic design, as well as the requirement to meet internal design pressures (working, test and surge pressure) and to resist buckling and deflection (i.e. changes in shape and curvature) due to external pressures from loading and handling during construction or when buried following construction. The dimensions of the pipeline sections and flow characteristics are provided in Table 5-5 based on the current pipeline routing.

Table 5-5: Conveyance Pipeline Dimensions and Flow Characteristics

Pipeline Section	Pipeline Diameter (Outside Diameter)		Length[1]	Design Flow Velocity	Means of Flow
	Inches	mm	km	m/s	
BPS1 to BPS2	84	2,137	10	2.9	Pumped
BPS2 to RGT1	76	1,930	12	3.0	Pumped
RGT1 to BPS3	88	2,235	30	2.2	Gravity
BPS3 to RGT3	82	2,089	102	2.5	Pumped
RGT3 to BPT	90	2,286	95	2.1	Gravity
BPT to PSADC	88	2,235	153	2.2	Gravity
PSADC to Abu Alanda	66	1,676	20	2.8	Pumped
PSADC to Al Mutazah	42	1,067	20	2.8	Pumped

Notes:

1. All pipeline lengths are indicative and subject to change as routing is refined

2.Wall thickness varies between sections and within sections depending on local conditions between a minimum of 7.14mm and maximum of 16.35mm

Seismic Design

The pipeline seismic design criteria are based on the American Society of Civil Engineering (ASCE) Minimum Design Loads for Buildings and Other Structures as well as the Jordanian Earthquake Resistant Building Code 2005. Where the pipeline is required to cross a fault, the routing is designed to minimise the imposed strain on the pipeline for a given fault offset by crossing the fault at the most favourable angle.

Corrosion Protection

Passive corrosion protection is designed in line with ISO 12944 Guidelines, which represent international best practice for protection of structural steel. Internal and external pipeline corrosion protection will be provided with internal epoxy lining and an external coating of 3-layer HDPE.

Active corrosion protection is provided via an impressed current cathodic protection (ICCP) system. Cathodic protection stations will be positioned along the pipeline route to provide a source of direct current (DC) via a transformer/rectifier and buried anode along the pipeline which suppresses natural corrosive reactions between the pipeline and surrounding soils. Electrical power supply to the cathodic protection stations will typically be sourced from the local grid. A local solar array power unit may power the stations that are remote from the power lines. The cathodic protection system will be monitored via the Supervisory Control and Data Acquisition (SCADA) system (see Control and Leak Detection Systems below).

Control and Leak Detection Systems

The pipeline will be monitored and controlled from a central control centre (CC) located in the Control Room at the Desalination Plant. A backup control centre, with the same configuration and function, will be provided at pumping station PSADC.

A common SCADA system for the overall AAWDCP facilities will be implemented to support control of day-to-day operations across the Conveyance System. SCADA systems are digital networks that enable Operators to monitor and control water distribution and treatment processes through the provision of real time data for parameters such as storage tank levels or water pressure.

Leak detection will be provided for the entire Conveyance system pipeline using fibre optic sensing technology, referred to as Distributed Temperature Sensing (DTS). DTS is used to detect changes in temperature, noise, vibration and strain around the pipeline, which in addition to detecting water leaks also allows for the monitoring of ground stability and potential intrusion such as digging activity around the pipeline. Further information on the control of the conveyance system during operations is provided within 5.5.3below.

Pipeline Vent, Drain and Washout Stations

As part of the surge protection and pressure relief systems the conveyance design includes a number of tanks and pressure relief valves at the AGIs (see Section 5.3.3.3 below). In addition, three non-slam type automatic air vents are included in the current design basis (in a 1+1 configuration for redundancy). These valves allow air to enter or leave the system as required during non-routine activities e.g. as a result of surges or during maintenance.

To enable maintenance and associated draining of pipeline sections, the conveyance system design incorporates drain valves and washout stations. These are nominally located at low points of the pipeline route to enable gravity drainage where possible, supplemented with submersible pumps. The number and location of drainage valves are based on an estimated maximum drainage flowrate of 6m/s and a maximum drainage duration of 24 hours, resulting in drainage valves at intervals ranging from 100m to 20km depending on the pipeline section. The precise location of drain valves and washout stations will be subject to design refinement taking into account physical, technical and environmental constraints.

Permanent Easement

Permanent easement restrictions may be required for safety and maintenance reasons; these requirements will be described within the Project Resettlement Action Plan. The permanent Operational RoW along the entirety of the Conveyance Pipeline route is 10 m wide, resulting in a total footprint of approximately 450 hectares.

5.3.3.3 Above Ground Installations

The conveyance system AGIs comprise:

- Pumping stations including booster pumping stations BPS1, BPS2 and BPS3 and pumping station PS ADC
- Tank facilities including regulating tanks RGT1 and RGT3, a break pressure tank (BPT) and tanks at BPS1 and BPS2

Pumping Stations

Pump Design*:* Each of the four pumping stations is designed to pressurise and maintain the average annual flowrate within the pipeline using electric motor driven centrifugal type water pumps. Fixed speed pumps with outlet control valves are specified for the Booster Pumping Stations, BPS1, BPS2 and BPS3, to optimise control and minimise interruptions to pipeline operations. Variable Speed Driven (VSD) pumps are provided at the two independent pump groups at PS ADC (PS ADC- AA and PS ADC-AM) to accommodate variability in flow rates and operating pressures. The design includes one additional standby unit for redundancy in the event of a trip or other non-routine event.

Surge and Pressure Relief Design: The outlets of each pumping station located downstream of the pumps are fitted with surge vessels to provide additional storage capacity, protecting against rapid changes in pressure caused by unplanned or temporary events in the pipeline (e.g. pump trips, startup, sudden valve closures etc.) that could interrupt pipeline operations or lead to damage to the pipeline. For the initial charge of each surge vessel plant and to supply, maintain and control the required air volume in the surge vessels, an air compressor in one duty and one stand-by (1+1) arrangement is provided. In addition to the surge vessels, the inlets to BPS3 and PSA incorporate a pressure relief system (PRS) to limit maximum pressures of water entering the pumping stations in case of an unscheduled or temporary event.

Pumping Station Power: Power consumption at each pumping station is based principally on the capacity and number of pumps required to maintain the average flowrates in the downstream section of the Conveyance System. Table 5-6 below summarises the water pumping capacities and associated annual power demand for each pumping station based on current design assumptions.

Table 5-6: Pump Characteristics and Power Demand Per Pumping Station

Pumping Station	Discharge Capacity per pump (m^3/hr)	No. of pumps (+ stand-by)	Pumping Station Capacity (MCM/y)	Pump Head (m)[1]	Total Power Demand (kWel)[2]
BPS1	7,164	5+1	313.8	305.5	48,340.2
BPS2	4,265	7+1	261.6	506.3	63,223.8
BPS3	4,265	7+1	261.6	518.1	64,664.1
PS ADC-AA	7,166	3+1	188.3	279.7	40,172.8
PS ADC-AM	4,180	2+1	73.2	195.3	
Notes:					
1. Defined as the vertical distance a fluid must be lifted from one point to another					
2. Inclusive of auxiliary power consumers at pumping station including surge plant air compressors and utilities					

Cooling Water System: A cooling water system is provided at each pumping station for the following:

- Main pump/motor units
- Lube oil system for main pump units
- Water-cooled chillers for the VSD pumps

The system uses water from the conveyance pipeline within the primary cooling circuit, which is then subsequently returned into the same line from where it was taken at a location downstream of the take-off point following contact within a heat exchanger where the warmer water circulating through the pumping station forms the secondary (closed) circuit.

Auxiliary Systems: Other facilities at the pumping stations include a chlorination system (see Section 5.3.3.4 below), electrical, instrumentation and control systems, security and monitoring systems, lighting, emergency generator (for critical supply only for up to 24 hours[4]) and a firefighting system comprising a fire water ring mains and fire pump unit. The emergency generator and fire pump unit will be diesel

[4] Estimated rating of up to 800kVA at the four pumping stations

driven and supplied from an onsite diesel day tank when needed. Evaporation ponds are provided at BPS3 and PS ADC to manage potential overflow.

Welfare and Worker Utilities: Worker utilities at the pumping stations will include a guard house and several buildings for maintenance, workshops, offices and welfare facilities such as a prayer room, kitchen and sanitary facilities.

The current design basis includes provision of sewage systems for the collection, removal and treatment of sewage and domestic wastewater at each pumping station. Within urban areas it is assumed that connections will be made to the public sewage system where available and technically feasible. As a minimum it is assumed that septic tanks will be used. Wastes will be handled in accordance with national legislative requirements that may include use of soak away pits.

Stormwater Drainage and Overflow: The current design basis assumes a storm water drainage system with channels, buried pipes and sludge traps is installed at each pumping station. Rainwater is directed from roads and paved areas and the storm water system. In addition, a system for discharge of tank overflow and drain water is included in the design basis for all new tanks at the pumping stations. The design currently assumes storm water and overflow system(s) are extended outside the station (by channel or piping) to a safe water disposal location (e.g. discharge into wadi or existing storm water system with sufficient capacity), subject to agreement with relevant authorities or use of an onsite evaporation pond.

Tank Facilities

The primary function of the BP1 and BPS2 tanks are to provide operational storage for the treated potable water from the Desalination Plant (at BPS1) and act as a reservoir for freshwater distribution to the Aqaba Governate (at BPS2). The purpose of the Regulating Tanks (RGT1 and RGT3) is to regulate system flow to avoid unplanned pump starts and stops during normal operations whilst also providing storage. The Break Pressure Tank (BPT) will provide a similar role to the Regulating Tanks in terms of pressure regulation, albeit with less functionality for flow regulation.

Table 5-7 below summarises the storage capacities and dimensions of the tanks, which will all be constructed of steel.

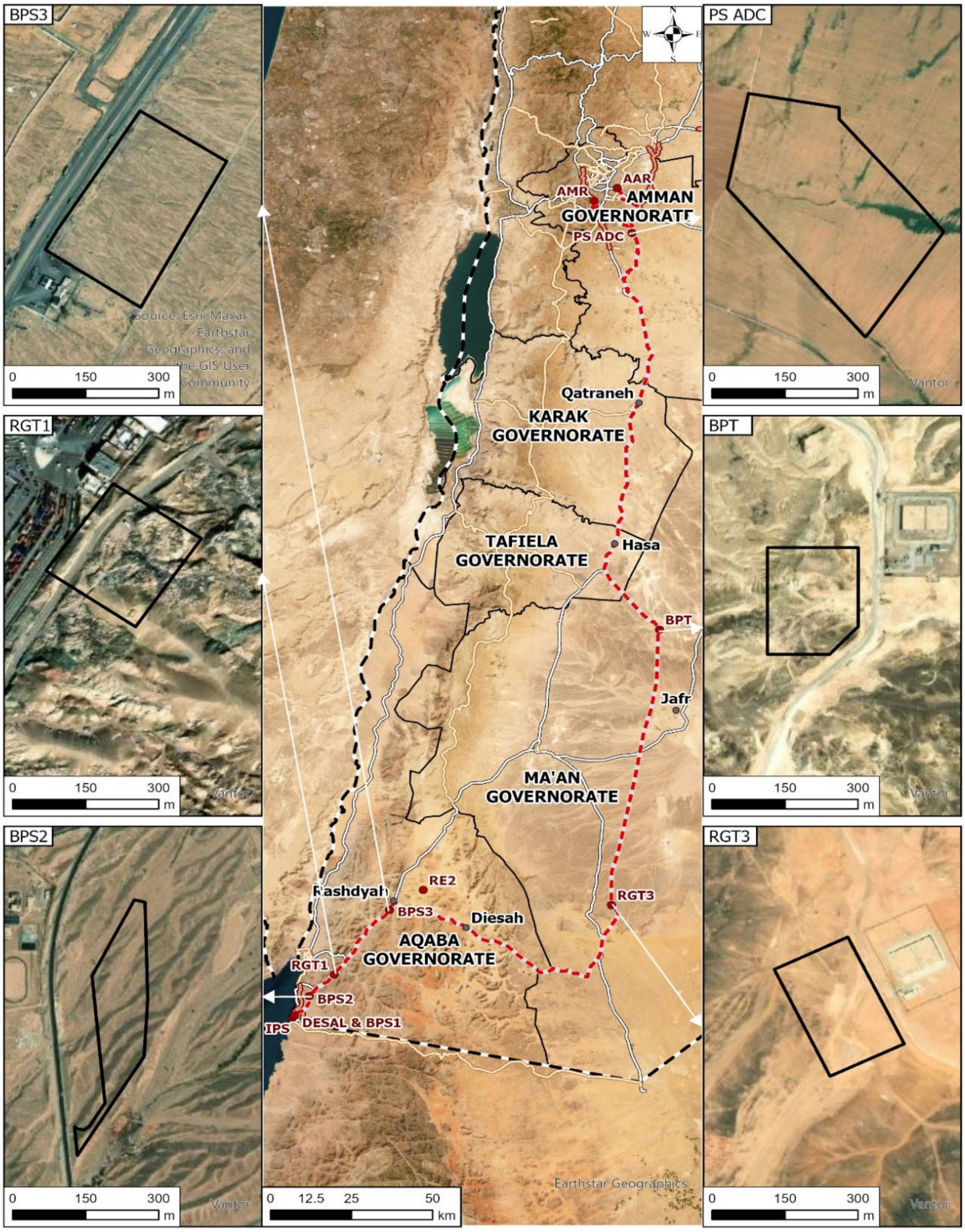
Table 5-7: Tank Capacities and Dimensions

Location	Storage Volume per Tank (m^3)	No. of Tanks (includes standby capacity)	Tank Height (m)	Tank Diameter (m)
BPS1	30,000	2	11.95	57.0
BPS2	30,000	2	11.95	57.0
RGT1	15,000	2	8.35	48.0
RGT3	20,000	2	8.35	56.0
BPT	20,000	2	8.35	56.0
Total (m^3)	115,000			
Total including standby (m^3)	230,000			

Auxiliary systems, welfare and worker utilities and stormwater drainage systems will also be provided as required at RGT1, RGT3 and BPT similar to those specified for the pumping stations as discussed above.

The location of the BPS2, BPS3, PS ADC, BPT, RGT1 and RGT3 plots are provided within Figure 5-5.

Figure 5-5: Locations of BPS2, BPS3, PS ADC, BPT, RGT1 and RGT3 Plots



Connections to Existing Reservoirs

Valves, metering and monitoring equipment including dual redundant automated devices (Programmable Logic Controllers (PLCs) will be installed to control and monitor the water levels and inlet conditions of the potable water sent to the existing reservoirs of Abu Alanda and Al Muntazah in Amman.

5.3.3.4 Chlorination Design Basis

To ensure potable water quality, the Conveyance System is equipped with disinfection stations at selected sites for disinfectant application and monitoring of residual chemical concentrations.

Fixed automated disinfection stations are provided at process tanks (reservoirs) and pumping stations that are controlled remotely via the SCADA system (refer to Section 5.3.3.3). Mobile disinfection units will also be used at specific locations along the conveyance pipeline with direct injection into the pipeline. Chlorine will be used to disinfect the conveyance pipeline and will be added via dosing pumps at a maximum rate of 3.2 mg/l to prevent corrosion. Downstream water quality monitoring along the Conveyance System will take place at the delivery points in Amman (Abu Alanda and Al Muntazah), at Aqaba turnout and at any turnout along the pipeline route (Ma'an, Tafilah, Karak, Madaba) when they are in operation. Monitoring will be used to ensure a minimum residual free chlorine concentration of 0.2 mg/l in the pipeline.

5.3.4 Renewable Energy Facility

The RE Facility will comprise a solar photovoltaic (PV) power plant to be constructed on a 485-hectare (ha) site near Al-Qweira, about 65km northeast of the new SWRO Desalination Plant (refer to Chapter 1 Figure 1-1).

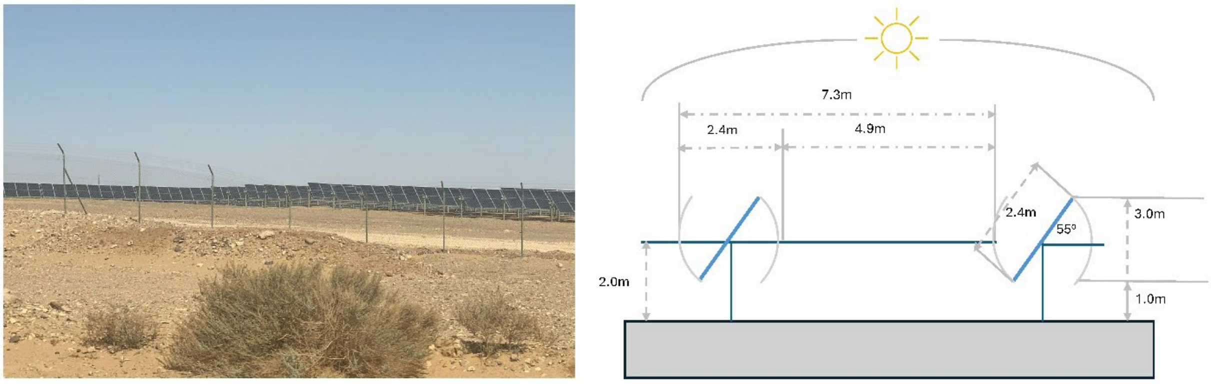
The RE Facility is designed with an installed PV capacity of 312 MWDC (281MWp AC) sufficient to meet the total power production demand of the SWRO Desalination Plant and the pumping stations with supply provided via tie-in to the electrical transmission network which includes new Overhead Transmission Lines (refer to Section 5.3.5.1 below). The RE Facility consists of the following main components:

- Solar PV modules and associated single axis tracking mounting structures
- Power conversion equipment
  - Inverters
  - Low and Medium Voltage Switchgear
  - Transformers
- Control systems
  - SCADA equipment
  - Power Plant Controller (PPC)
- Substation (under NEPCO’s scope)
- Associated building and structures for housing of equipment and personnel.
- Access Roads

5.3.4.1 Solar PV Modules

The primary component of a PV system are solar cells. These convert solar radiation (the sun's energy) into direct current (DC) electricity using semiconductors through a photo-electric effect. A PV plant contains many cells connected in modules which are then connected in strings to produce the required output. The solar PV modules within the RE Facility design will be mounted on single axis tracker supporting structures (see), which enable the solar PV module to move and follow the sun's path across the sky, thereby allowing the PV panel to absorb more sunlight during the day. The single axis tracking provides one axis of rotation, with a tilt angle of +/- 55° depending on the orientation of the sun with tracking dynamically controlled via automated control systems (see Section 5.3.4.3 below). The tracking design will ensure a maximum ground coverage ratio (GCR) of 33% (the proportion of land occupied by the PV modules). Figure 5-6 shows a single axis tracking example and cross section.

Figure 5-6: Single Axis Tracking System Design Example and Cross Section



The design of the RE Facility comprises approximately 440,000 solar PV modules, installed in 26 blocks at a fixed separation distance of 4.9m between each module.

5.3.4.2 Power Conversion Equipment

The electrical output from the solar PV modules will be converted from direct current (DC) to alternating current (AC) for onward transmission using inverters. The RE Facility design includes approximately 1000 inverter units mounted on rails and distributed throughout the site. The total installed PV inverter capacity (MVA) is 287.1 MVA. The design includes three transformer stations across the PV solar plant to house the transformers to control the AC voltage, low and medium voltage switchgear and safeguard equipment against any faults.

5.3.4.3 Control Systems and Cabling

Management of the solar PV plant is conducted using an automated PPC system that manages the plant power output and stable integration with the supply to the AAWDCP facilities. In addition, a SCADA system collecting real time data to remotely monitor and analyse the entire Solar PV plant operations is integrated into the design. The independent SCADA systems of both the RE Facility and Conveyance system will be connected by fibre optic cable. The control of the solar modules and tracking system will draw on real time monitoring from 6 weather stations to be installed across the site, along with pyranometers, which measure the total solar radiation reaching the plant. The purpose of these systems is to optimise the solar energy capture and support the overall power system efficiency.

Cabling will include electrical cabling (DC and AC), communication and network cables with DC cables used for the connection from PV module to the inverters and AC cables used to connect output of inverters to the substation. The cable type and size will vary depending upon the design and connection interfaces.

5.3.4.4 RE Facility Substation

A new substation will be located within the footprint of RE Facility site to be built and operated by NEPCO. The principal function of the substation will be to uplift the output voltage of the supply from the RE Facility to 132kV to enable the electricity generated by the solar PV plant to be efficiently transmitted and safely supplied via the OHTL to the AAWDCP facilities.

5.3.4.5 Associated Infrastructure and Supporting Facilities

Auxiliary systems provided at the RE Facility site will include a security system, firefighting system and emergency diesel generator, sized to enable safe shutdown of the RE Facility if required. The current design incorporates water tanks, distributed across the plant as part of the firefighting system based on a ratio of approximately 60m³ of water per 40 hectares of land, which corresponds approximately to 12 tanks of 60m³ for the 485-hectare site. The water will likely be delivered to the site by tanker from a water supplier. The sizing and ratio estimates for these tanks currently include capacity for water to be used for panel washing to remove dust build up and maintain energy output efficiency. No details on expected annual water consumption due to solar panel washing are currently available. The Project is also considering dry panel cleaning systems, typically using brushes or compressed air, instead of a water-based system. Storage areas and onsite buildings will be provided to support operational and maintenance activities.

The solar PV plant site includes internal access tracks and an external perimeter access road to facilitate inspection and maintenance work. The plant perimeter will be fenced for security purposes and gates provided for access. A drainage system will be installed across the solar PV plant to ensure flow of water across and away from the site. The civil engineering design for the site takes into account the requirement to avoid flooding in the event of 1 in 100-year storm event. A minimum clearance height (freeboard) of 300mm above determined maximum flood levels is required for electrical equipment, including inverters and power control units, and the base of the substation and other buildings on site.

5.3.5 Associated Facilities

5.3.5.1 Overhead Transmission Lines and Substations

The electrical and transmission works required to enable the provision of power to the AADWC Project facilities from the new RE Facility and the national grid connections will be designed, built, and operated by the National Electrical Power Company (NEPCO), under MWI's supervision. The scope of these works includes the provision of the following:

- New step-down substations at BPS2, BPS3 and PS ADC
- New substation supplying the Desalination Plant and BPS1
- New substation within the IPS site boundary supplying the IPS
- Overhead Transmission Lines (OHTL) comprising:

    - One approximately 70km-long 132kV OHTL connecting the RE Facility to the new NEPCO substation near Aqaba
    - One approximately 10km 132kV OHTL connecting the new NEPCO substation at Aqaba with the substation at BPS2
    - Two 10km-long 132kV OHTL connecting PS ADC to the national grid south of Amman
    - One 1km 132kV OHTL connecting the BP3 to the existing Aqaba-Qweirah OHTL
    - One 1km 400kV OHTL connecting the new NEPCO substation near Aqaba to the existing Aqaba-Ma'an 400kV OHTL

Figure 5-7 shows the current planned routing of the new OHTL between the RE Facility, BPS2 and new substation at Aqaba. Figure 5-8 shows the new OHTLs south of Amman connecting PS ADC to the national grid. The OHTLs will comprise the following components:

- Foundation and Towers
- Conductor cable, insulators and earth wiring
- Fittings and hardware
    - Suspension clamps
    - Dampers
    - Spacers
    - Arcing horns

Figure 5-7: Current Routing of OHTLs Between RE Facility, BPS2 and New Aqaba Substation

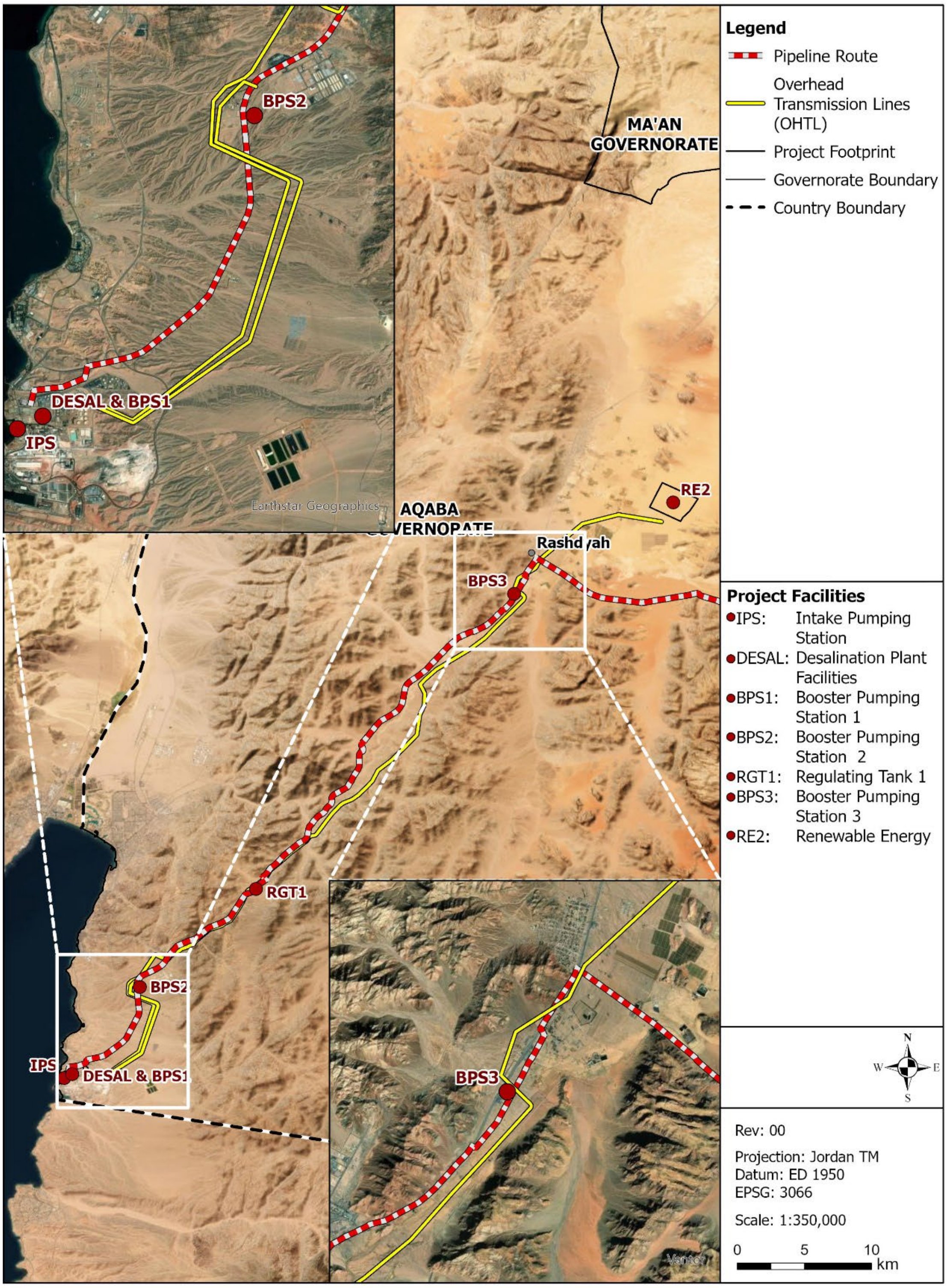
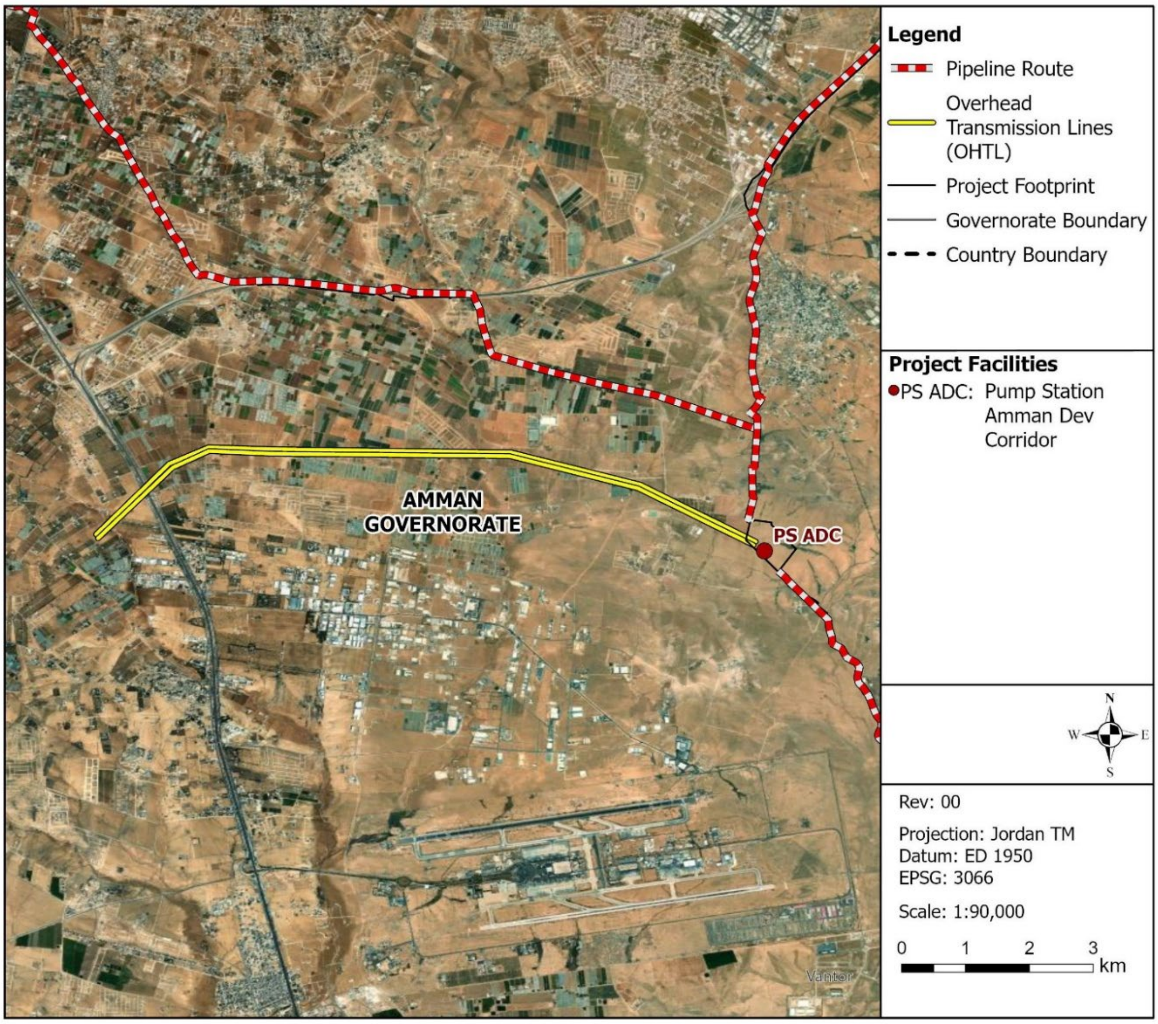


Figure 5-8: Current Routing of OHTLs South Of Amman Connecting PS ADC to the National Grid



Towers

The OHTL design incorporates towers, comprising vertical lattice-steel structures designed to withstand the mechanical load of the suspended OHTL and environmental factors such as wind and rain. The towers are bolted to pre-installed concrete foundations and fitted with appropriate anti-theft and anti-climbing devices to ensure asset integrity and safety.

While the towers will be of a vertical lattice structure, the design will be tailored to the characteristics and topography of the installation site, the spacing between towers, and safety considerations, namely the clearance distance required to prevent electrical arcing from live conductors to ground. Tower heights will range between approximately 46.9m and 49.4m with the base dimensions ranging from 9.9m x 7.5m to 17.3m x 17.3m.

Table 5-8 below summarises the preliminary number of towers estimated to be required for each of the new OHTLs.

Table 5-8: Estimated Number of OHTL Towers

OHTL	Approximate Length of OHTL (km)	Number of Towers
400kV OHTL connecting the new NEPCO substation near Aqaba to the existing Aqaba-Ma'an 400kV	1	5
132kV OHTL connecting the RE Facility to the new NEPCO substation near Aqaba	70	210
132kV OHTL connecting the new NEPCO substation at Aqaba with the substation at BPS2	10	40
132kV OHTL connecting the BP3 to the existing Aqaba-Quwera OHTL	1	5
132kV OHTL connecting PS ADC to the national grid south of Amman x 2	10 x 2	70

Conductor Cables and Insulators

The tower design incorporates conductor cables which carry the electrical current and insulators. The conductors are composed of a combination of aluminium and steel wiring and are grouped in bundles to reduce power loss, noise and increase transmission capacity.

Porcelain or polymer-based insulators are used to electrically isolate the live conductors from the grounded tower structure, whilst earthing wires connected from the top of the transmission towers to the ground protect the conductors from lightning strikes.

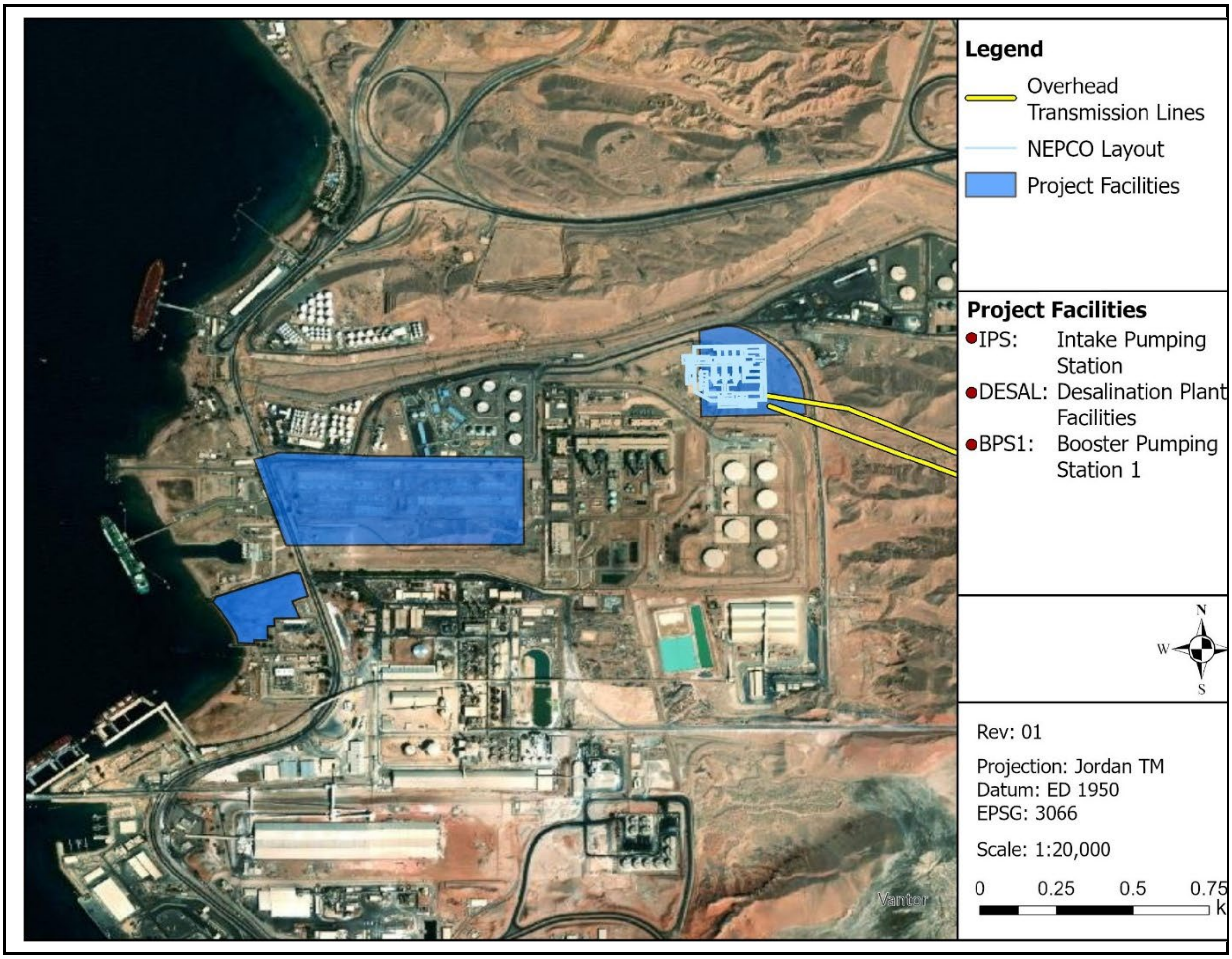
OHTL Right of Way

A permanent Right of Way (RoW) will be established along the OHTL routes to be kept clear of obstructions and vegetation to ensure safety, provide access for maintenance, and maintain the required safe clearance between the conductors and the ground or any objects. The extent of the RoWs will be kept to the minimum required to meet safety distances as per Jordanian 'Sanitary Rules to Ensure Electrical Safe Distances' (No. 1 of 2003), below 400 kV and 132 kV OHTLs. Agricultural activities will be permitted within these safety distances.

Main NEPCO Substation at Aqaba

The new step-down substation at Aqaba will provide electrical power to the new AADWC Project Desalination Plant and intake and outfall pumping and transfer facilities. The substation will be constructed and operated by NEPCO. It will comprise capacitors, switchgear and other electrical equipment and plant, in addition to a firefighting system, control room and maintenance areas. The location and preliminary layout of the substation are provided in Figure 5-9 below.

Figure 5-9: Indicative Layout of New Substation at Aqaba



5.3.5.2 Upgrades at Existing Abu Alanda and Al Muntazah Reservoirs

At the time of writing the design of required upgrades to the existing water storage reservoirs, if any, has not been finalised. However, it is most probable that, at least, the Al Muntazah storage reservoir will require expansion. The scope and scale of the upgrades required is not currently defined.

Land use features in proximity to the existing reservoir at Al Muntazah include community and recreational facilities, an event space for parties and weddings, a local access road (inclusive of Conveyance Pipeline RoW) and associated utility lines for power and communications.

At Abu Alanda land use features in proximity to the existing reservoir include industrial and commercial (such as retail, hospitality and vehicle repair) buildings on either side of a four-lane main road.

5.4 Construction

5.4.1 Intake and Outfall Facilities and Desalination Plant

5.4.1.1 Marine Construction Works

The construction works for the installation of the intake and outfall infrastructure in the marine environment will involve the following:

- Pre-survey activities and mobilisation
- Construction of new intake lagoon, including seawall revetment structures
- Construction of a temporary jetty to enable excavation of the outfall trench
- Excavation and trenching in nearshore waters to enable installation of the outfall
- Levelling and bedding preparation before installation of the outfall
- Installation of marine outfall and diffuser
- Backfilling and protection of trenched areas

The detailed construction methodologies have yet to be fully defined. Description of the anticipated activities is based on the information available at the time of writing, best estimates and typical methodologies adopted by similar analogous projects.

Pre-Survey Activities and Mobilisation

Prior to construction commencing, marine surveys and site investigation works will be conducted to confirm seabed conditions, including bathymetry, geotechnical conditions, and inform detailed construction planning.

Mobilisation activities will include establishing temporary site facilities including laydown and welding areas, maintenance workshops, plant compound and temporary facilities for site workers as well as ensuring relevant fencing and marine exclusion zones are in place. Concrete ballast structures to stabilise the outfall and the diffuser on the seabed, formed of pre-cast concrete, will be stored onshore until required for installation.

It is envisaged that temporary service connections to municipal utilities will be made for the provision of power, water, sewage and telecommunications to the site for the duration of the construction period.

Construction of Intake Lagoon

The intake lagoon will be excavated at the shoreline to a depth of - 4MSL using construction techniques that avoid turbidity impacts on the adjacent nearshore waters. A temporary sheet-piled cofferdam may be required to prevent seawater ingress during excavation work. A sediment curtain will be deployed around the perimeter of the lagoon construction works. Revetment structures using imported rock and aggregate materials will be installed to stabilise the side walls of the lagoon and create a seawall defence on the seaward side of the lagoon to prevent erosion from wave and tidal action.

Outfall Trenching

Installation of the outfall will require trenching in the nearshore waters. The outfall is designed to be installed in a nearshore trench i.e. up to ten metres water depth, for protection against wave action, and then laid directly onto the seabed beyond -10 MSL.

A five metre wide temporary jetty will be installed to allow excavators access to the nearshore to create a trench for the outfall. The temporary jetty will be constructed from imported aggregate. Sediment curtains will be installed around the jetty and trenching area, effectively creating a sealed perimeter between the active work zone and its surroundings. The sediment curtains will remain in place until all turbidity generating activities are completed, i.e. post backfilling, and turbidity levels have subsided to acceptable levels. All excavated material will be recovered to a temporary onshore storage location in compliance with AZEZA environmental and social requirements, before being used for backfilling. No excavated materials will be disposed of to sea. The temporary jetty will be removed once trenching and backfilling work is completed.

Installation of Marine Outfall

The installation method for the marine outfall will depend on the final outfall material selection. The current base case assumes High Density Polyethylene (HPDE), whereby sections are welded and assembled into long lengths onshore with "complete" strings towed to the site location by barge. The long lengths of outfall, along with the ballast weights, would then be floated and towed to the final location and alignment before then sinking into final position within the pre-prepared trench or directly onto the prepared seabed as appropriate. Support vessels and the towed barge will be anchored during the outfall installation.

Installation of Diffuser

The diffuser will be assembled onshore into lengths (including associated ballast blocks and flanged riser connection pieces) then towed via barge to its location and sunk into position at its pre-prepared seabed alignment, supported by diver teams to position and secure in place. Ballast blocks will be used to stabilise and prevent the diffuser structure from "rolling" thus ensuring that the risers remain vertical and the ports are aligned at the correct angle to support dispersion.

Backfill and Protection

The trench, in the nearshore area up to a water depth of 10 m, will be backfilled to protect the outfall and overlaid with concrete mattresses on the seabed.

At the outfall landfall, shoreline protection will be installed as part of the overall intake lagoon revetment structure, which will include rock fill and rock protection layers.

5.4.1.2 Intake Pumping Station (IPS) Construction

The construction works for the intake pumping station (IPS) will involve the following:

- Installation of retaining walls, foundations and temporary cofferdam
- Excavations and foundations for pumping station pits
- Groundworks and site levelling
- Installation of IPS permanent plant, equipment and structures (including connections to marine and transfer pipelines)
- Backfill and removal of temporary cofferdam

At the shoreline of the IPS, installation of the permanent diaphragm reinforced concrete wall and foundation system and sheet pile retaining walls will be undertaken to create a temporary cofferdam. The pump station pit will then be excavated to a depth of -10m, resulting in an estimated 65,400 m^3 of excavated material. The pit will then be dewatered using pumps to create a stable, dry working area for installing the concrete substructure and foundation, including the weir chamber. The collected effluent from dewatering will be returned to sea, subject to testing to ensure it meets ASEZA's suspended solids requirements. Groundworks, levelling and surfacing across the IPS plant areas will be undertaken as required. Backfilling operations will be conducted around the cofferdam working platform using excavated materials. The IPS mechanical and electrical equipment including the permanent intake pumps and associated housing structures will then be installed.

The temporary sheet piling and backfill between the temporary and permanent diaphragm concrete wall will be removed and the connections for the intake and outfall pipelines will be bored through the diaphragm wall enabling the marine pipelines to be joined via a flange connection.

Construction plant and equipment used at the IPS is expected to include specialised foundation equipment (such as diaphragm walls, piling, sheet piling, ground anchors, and grouting/injection systems), a dewatering system, excavators, concrete breakers, cranes, a concrete batching plant, crusher, welding sets and cutting and grinding tools. Vehicles (e.g. trucks) associated with the IPS and marine works will move to and from the IPS site via the existing public highway.

5.4.1.3 Intake and Outfall Transfer Pipelines Installation

Construction works for the transfer pipelines between the IPS and Desalination Plant will comprise trenching of the pipeline routing using similar techniques and plant as used for the main conveyance pipeline, taking into account relevant operating constraints and space restrictions (see Section 5.4.2.1).

For the majority of the route the transfer pipelines will follow the Ports Highway. Special crossings will be required to cross existing pipelines in the vicinity of the IPS and the Desalination Plant site, the Aqaba Gas Compression station gas pipeline, an existing road and the road tunnel under the highway immediately adjacent to the desalination plant site. For the majority of the route the transfer pipelines are expected to be laid in a trench with a sand bed of 0.75m depth and backfill providing a minimum cover of 2m. Where additional protection is required, e.g. at the road crossing, the pipelines will be provided with additional reinforced concrete encasement of 0.45m.

5.4.1.4 Desalination Plant Construction

The key Desalination Plant construction and installation activities will include:

- Pre-construction surveys and mobilisation activities
- Groundworks, excavations and subsurface works
- Erection of permanent structures and mechanical and electrical works

Pre-Construction Surveys and Mobilisation Activities

Pre-construction surveys will include geotechnical and soil investigations, topographic surveys and existing utilities surveys to refine detailed layout and permitting including traffic management and security.

Mobilisation activities will include establishing access, safety and security arrangements e.g. gates, fencing and signage and setting up temporary facilities to support construction including:

- Temporary site offices
- Temporary workshops and storage warehouses
- Welfare facilities for the construction workforce (to include changing, toilet and catering facilities and first aid station)

- Space for the storage of construction materials and construction equipment/plant/vehicles
- Designated areas for fuel, oil and chemicals storage/handling

It is envisaged that temporary service connections to municipal utilities will be made for the provision of power, water, sewage and telecommunications to the site for the duration of the construction period with diesel generators provided for back up supply.

Groundworks, Excavations and Subsurface Works

Groundworks will commence with the clearance of existing soil/aggregate stockpiles and existing foundations prior to removal of topsoil and vegetation. Roads, parking areas, and building areas will be excavated or filled with all graded surfaces sloped to avoid ponding.

Structural excavations will be carried out across the site for areas intended for paving, roads, foundations, sumps, retaining walls and any other in-ground or below ground facilities required to support structural loads. This will include excavations as are necessary for the equalisation tank which will require an excavation depth of around 10m. The tank, constructed of concrete, will be installed, hydrotested, and then the excavated area backfilled ahead of further mechanical and electrical installation work.

Trenching will be undertaken across the site for the installation of underground pipework and cabling as well as drainage ditches and channels. A site drainage system will be provided to convey stormwater runoff from the site into drainage channels that connect to the existing Aqaba Industrial Zone drainage network. The site drainage will be designed to avoid runoff flowing into excavations and route any water generated during excavation i.e. when working at or below the depth of the water table to the drainage system. The requirement for appropriate containment and/or treatment systems such as bunds, temporary sumps and oil/water separator systems will be included within the drainage design to prevent pollution to soils, groundwater and/or surface water from potentially contaminated drainage.

Fill and backfill materials will be sourced from either on-site excavation or imported to site. Excess excavated material (i.e. spoil), including materials unsuitable for fill, will be temporarily stockpiled onsite or will be placed in a designated spoil area. The intent is to re-use excavated materials as far as possible for fill and backfill with excess to be managed in accordance with further detailed construction planning.

Erection of Permanent Structures and Mechanical and Electrical Works

Above surface construction will include the installation of permanent building structures for operational storage, maintenance, control and instrumentation, electrical plant, administration and welfare purposes on site. This phase of construction will include cleaning, painting and welding activities. Desalination Plant equipment and system packages will also be mechanically installed and connected followed by completion of electrical works on site and substation connections prior to testing and commissioning.

Construction Plant, Equipment and Traffic

On-site plant and equipment will be used throughout the construction period and is expected to include trucks, excavators, cranes, graders, rollers, dozers, concrete pumps, scrapers and welding machines. Road traffic associated with the desalination site construction will move to and from the site via the existing public highway and access roads. Access to the site is expected to be from the main Ports Highway to the west of the site, subject to relevant permitting approval and traffic management planning.

It is anticipated that above ground fuel diesel tanks will be required to supply equipment on site during construction. In addition, other fuels, oils and chemicals will be supplied and stored on site in containers.

5.4.2 Conveyance System

The key Conveyance System construction and installation activities will comprise:

- Conveyance Pipeline Construction Works
  - Pre-construction surveys and mobilisation activities (including access works and compounds)
  - Conveyance pipeline installation using trenching methods
- Pipeline Crossing Installation Methods
- Construction of Conveyance System AGIs

5.4.2.1 Conveyance Pipeline Construction Works

Pre-construction and Mobilisation

Prior to construction of the Conveyance System commencing, it will be necessary to establish temporary compounds and facilities to support the construction work as well as undertake a number of road upgrades and establish new access roads to allow construction traffic to access the compounds and work areas along the route. It is expected that the activities to upgrade roads and construction new access routes will be undertaken ahead of the main pipeline installation works moving along the conveyance pipeline route with the main compounds established in key strategic locations before the commencement of works and retained for the whole construction period. Plant, equipment, supplies and construction materials will be stored at the compounds which will be securely fenced. The compounds will be provided with appropriate drainage, surfacing and containment measures to mitigate for potential spills from any fuels or chemicals stored on site. The location of the compounds will be carefully selected e.g. outside of communities and in areas away from surface water features (e.g. wadis) and not at risk of flooding. Construction camps for the workforce will also be established during the mobilisation phase (see Section 5.4.7 below). Construction traffic will utilise the existing local road network and the new and upgraded roads to access points along the pipeline construction corridor (Refer to 5.4.7.3 below).

Conveyance Pipeline Installation Using Trenching Methods

Pipeline construction will follow a sequential process and include a number of distinct operations which can be broadly categorised as follows:

- Route surveying, preparation of the working strip, surface stripping and grading
- Trenching
- Pipe stringing
- Pipe laying, welding, installation and backfilling

The works to construct the 438 km pipeline will be broken down into manageable lengths called “spreads”. The spreads will consist of work teams carrying out different activities operating along a rolling work front. At this stage of the Project, it is assumed that pipeline trenching and installation will be conducted across five individual spreads and associated work teams.

Route Surveying, Preparation of the Working Strip, Surface Stripping and Grading

Route survey works will include topographic and photographic records of the existing condition of the pipeline route and immediate surrounding area as defined by the boundaries of the working strip. These records will be used as the standards against which the quality of the subsequent restoration work will be judged when construction work is completed.

Ahead of the main construction works moving along the route, the exact pipeline route will be marked out and the associated width of the working strip on both sides of the route will be defined. The limits of the working width will be clearly signed. Safety and security measures such as temporary fencing will be provided around active working sections to prevent public or animal ingress. Existing physical features such as walls, poles, pavements and property fences will be disturbed by the minimum amount necessary for safe working. Records of buried facilities such as drains will be prepared and verified with the landowner/user to prevent accidental damage during pipeline construction. Existing third-party services will be located, marked, and either safeguarded or diverted. Warning posts will be erected for overhead cables, and temporary crossing points clearly identified.

The working width for pipeline installation is determined by the space allocations required to access and safely install the pipeline, specifically based on the following requirements:

- Trench Zone: Trench width and slope allowances according to geotechnical conditions)
- Working Zone: Space for lowering-in, welding, and jointing
- Equipment Zone: Crane swing radius (and excavator/other machinery footprint
- Materials Zone: Pipe stringing, topsoil/ spoil/ backfill material storage
- Safety & Access Zone: Safe pedestrian/vehicle access routes around the site

The working width will therefore necessarily vary taking these constraints into consideration with the narrowest working strips within constrained urban areas and wider working strips in areas not constrained by existing above ground or underground features. Typically, the working strips for the conveyance pipeline construction will range between approximately 35m and 60m with wider working strips in the range of 50-100m in some unconstrained areas to allow for access, materials storage and handling. In urban areas the minimum working width is limited to 18.5m, which is sufficient to safely accommodate a 100 ton crawler crane and the pipe trench, assuming construction plant use public roads to access the working area.

Any obstacles or existing infrastructure that intersects the route that cannot be avoided through routing refinements will be removed in consultation with the owner, where relevant, or disturbed as little as possible. Section 5.4.2.2 provides more detail on the specification of crossings for existing utilities, transport networks and sensitive natural features.

Surfacing will be removed from the working strip where existing surfacing along the pipeline route will comprise a variety of hard engineered surfacing (e.g. road surfacing and asphalt where the route aligns with existing roads), as well as earth and rock. Removal of topsoil and vegetation will be undertaken using earth moving equipment, from the working strip, with the topsoil stockpiled along the edge of the strip. Consideration will be given to the value of vegetation for local grazing or other community use before clearance to assess whether any areas of high value can be left in-situ. Topsoil stockpile heights will be minimised to prevent soil disturbance and limit dust generation. Topsoil will be stored in designated areas such that it avoids being crossed by construction vehicles or mixed with other materials excavated during trenching to support the eventual re-instatement and restoration of the construction corridor. In locations where hard surfacing is present, equipment such as peckers or circular saws will be used to prepare the surface with removed materials stored separately from topsoil. The working strip will then be levelled using plant including graders and dozers.

Pipeline Trenching

The pipeline will be laid in a trench generally around 4m deep for standard pipelay conditions, with approximately 1.5m clearance depth between the pipeline and the top of the trench. The trench will be excavated to a sufficient depth to allow 20cm bedding material under the pipeline. The trench dimensions will vary according to soil conditions and the construction location. For trench excavation in urban areas or subject to other constraints, trench width will be limited to approximately 4.6m, with the trench sides/walls supported by driven sheet piles. For trenches excavated in loose soils, the overall trench depth will be deeper (to 6m) and wider (16m) to ensure trench stability.

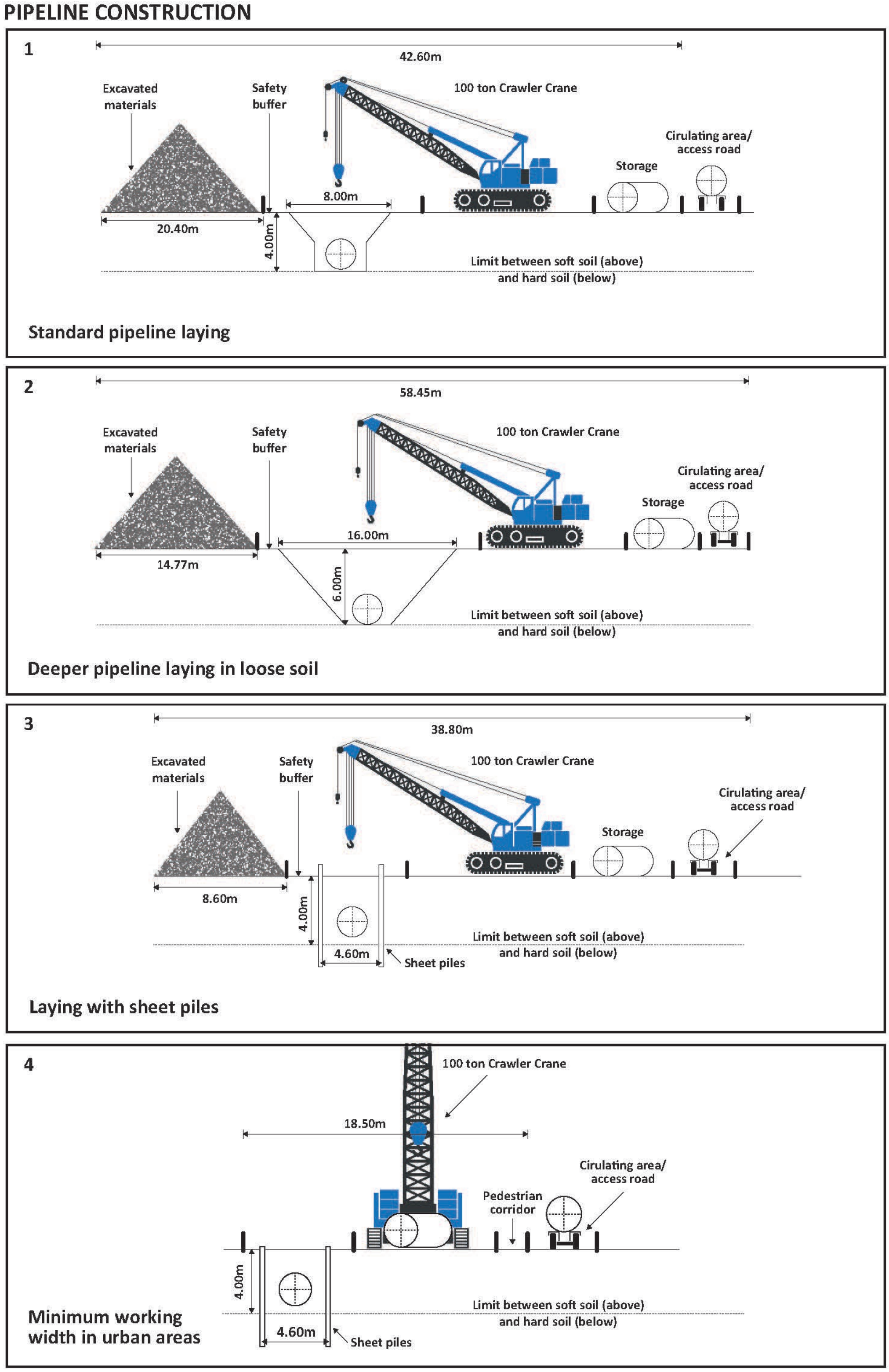
Figure 5-10 below presents the typical configuration for standard pipelaying, pipelaying with space constraints using sheet piling, pipelay in loose soils and the minimum working width within urban areas.

The trench will be excavated to the required depth using mechanical excavators/ or trenchers straddling or running alongside the pipeline trench. Any rocks encountered may first need to be broken down with a rock hammer or pecker attachment on an excavator before they can be removed from the trench. Excavated materials will typically be stored adjacent to and separately from the previously removed topsoil. When trenching in proximity to existing underground services, excavation will be conducted by hand to avoid any unnecessary damage.

In constrained areas, storage of excavated materials locally may not be feasible. In this case excavated materials will be transported to a designated area for spoil management where materials will be stored. Where the material is suitable for backfilling, it will be transported back to the route for this use (after having been sent to a crusher and screened as required).

Additional excavation will be provided to provide a workable area for the welding team after the pipe sections have been lowered into the trench. Any water encountered during the trenching will be channelled to the nearest wadi bed using collection sumps, pumps and hoses. In areas of high water table the trench depth may have to be increased to accommodate dewatering.

Figure 5-10: Indicative Pipeline Construction Configurations within Working Width



The rate of trenching within each spread will primarily be driven by the ground conditions encountered along the route and construction constraints. When installing the pipeline in urban areas or at locations with physical constraints, working practices and equipment will be used will be modified as required to minimise disruption to local residents and potential damage to infrastructure such as overhead power lines, highways and underground utilities. Trenching is forecast to progress at a rate of 300-500m per day in open/ rural areas and a slower rate of 100m per day in constrained and urban areas due to the expected conditions and need for adaptive methods.

Pipe Laying, Welding, Installation and Backfilling

Pipe sections will be transported from a central storage facility to a secondary facility along the pipeline route before being delivered to site for installation. Each section will be lowered into the trench, onto a pre-prepared bedding layer, using mobile cranes. The trench will be inspected for any debris that could damage the pipe coating before the pipe sections being installed.

Once in the trench, the pipe sections will be aligned and connected using an internal line up clamp (ILUC) and pipe facing machine (PFM) to form a string before being welded together using either manual welding equipment or automatic welding machines that travel along the pipeline string. The bulk of the pipeline, i.e. from BPS2 to PSADC, will be welded using automatic machinery. Manual welding equipment will be used on the initial and latter sections of the pipeline. The completed welded section will be visually inspected and then tested by radiographic Non-Disturbed Testing (NDT) methods before it can be approved and field joint coating applied over the welded joint. Any defective welds will be remedied by repair or replacement before being re-tested. Compressed air is provided to power air driven tools, remove dust from welding areas and support weld inspections.

Fibre optic cable conduits will also be installed alongside the pipeline as part of the SCADA and leak detection system.

The pipeline trench will then be backfilled initially with fine-grained granular padding/ bedding material, mechanically sieved and well graded with no sharp edges that could damage the pipeline coating. The backfill material will be obtained, as far as practicable, using the same trench spoil that was taken from the trench originally. Crushing and screening equipment will be used to prepare the padding/ bedding materials from the excavated trench material. This equipment will be either located within the spread or in designated areas, appropriately located away from communities. Additional backfill material may be procured from local quarries if there are insufficient source materials available from trench excavation.

After the initial layer of screened material is placed into the trench, the previously excavated material from the initial trenching will be replaced to complete the backfill. Trucks will be used to transport excavated materials removed and stored in the designated spoil management area back to the route for backfill.

Hydrostatic Testing

Hydrostatic testing (or pressure testing) will be carried out after backfilling of the pipes, with the welded joints left exposed to check for any potential leaks (e.g. from faulty welds or cracked pipe) before commissioning. Alternatively, welded joints may be checked individually within a backfilled trench following pressure testing using above ground assessment methods. Sections of the pipeline will be filled with fresh water, from wells or the local water distribution network, pressurised to 1.25 times the maximum design pressure of the system and then assessed for any leaks or damage. Once the pressure test is complete, the pipe section will be dewatered and the water collected for re-use in the next section of pipe for pressure testing. Contaminated test water will be sent to a temporary tank, filtered before re-use (assuming applicable quality standards are met). Hydrostatic test water that can no longer be used, will be discharged to wadis or made available for re-use locally in agreement with the municipality and in compliance with the relevant discharge standards.

5.4.2.2 Pipeline Crossing Installation Methods

The majority of the conveyance pipeline route (over 99%) will be constructed using the standard trenched pipeline installation methods described above. The pipeline route, however, crosses a number of linear features including roads, highways and highway intersections, ephemeral water courses or channels (wadis) and railways. Estimated number of crossings at the time of writing are as follows:

- 308 minor road, access track, major highway and highway intersection crossings
- 209 wadi crossings
- 7 railway crossings

Crossings of these features will either be carried out using trench “open cut” methods, where the pipeline trench would be excavated directly across the crossing feature, or as a trenchless crossing which minimises ground disturbance at the surface to cross beneath a feature. Trenchless crossings methods include jack and bore, thrust-boring, auger boring, micro-tunnelling and horizontal directional drilling (HDD). These methods are employed where ground conditions permit, and where disruption to third parties will be unacceptable or where there will be significant damage to the environment by the use of open cut methods. The design of crossings along the pipeline route is part of ongoing design activities, however it is currently assumed that trenchless crossing methods will be used for wadi crossings and for major highways and highway interchanges. An estimated 2km of auger boring at 53 separate locations is currently assumed.

For minor roads and access tracks associated with agricultural activities or smaller settlements crossed by the pipeline, open-cut construction methods will be used. Landowners will be consulted to inform them of temporary road closures. Measures, such as creating detours or phasing road closures, will be implemented to minimise nuisance to local traffic. When the open cut method is used, traffic will be diverted around the crossing via detours or temporary roads. To minimise the duration of traffic disruption, the pipe will be prepared prior to commencement of roadway excavation. Once the pipeline has been installed, the trench will be backfilled and compacted in layers in accordance with relevant specifications. The roadway will then be resurfaced over the compacted trench. Final selection of crossing methods will be coordinated with the appropriate road management authority.

The railway crossings are currently also planned to be undertaken by open cut methods subject to further detailed design.

5.4.2.3 Construction of Conveyance System Above Ground Installations (AGIs)

The construction of the Conveyance System AGIs at the locations for the four pumping stations, two regulating tanks and break pressure tank (BPT) will involve the same type of activities as described for the Desalination Plant construction, namely:

- Pre-construction surveys and mobilisation activities
- Groundworks, excavations and subsurface works
- Erection of permanent structures and mechanical and electrical works

At each AGI location, mobilisation activities will include fencing and security arrangements prior to works commencing and establishing access routes and temporary site facilities e.g. temporary offices, workshops, storage areas and temporary welfare facilities.

Following clearance and levelling of each site (including the areas where substations will be constructed at BPS2, BPS3 and PSADC), structural excavations will be undertaken as required to provide foundations for buildings, process plant and equipment and tanks. Excavations will also be undertaken for the proposed evaporation ponds for overflow at BPS3 and PS ADC. Trenching to enable installation of underground pipework and cabling as well as drainage ditches and channels will be completed followed by backfilling activities as required with materials re-used where possible. The permanent process plant and buildings will be installed with on-site electrical works completed and substation connections made prior to testing and commissioning.

On-site plant and equipment used throughout the construction period is expected to include trucks, excavators, cranes, graders, rollers, dozers, concrete pumps, scrapers and welding machines. It is anticipated that above ground fuel diesel tanks will be required to supply equipment on site during construction. In addition, other fuels, oils and chemicals will be supplied and stored on site in containers.

5.4.3 Renewable Energy Facilities

Construction of the Renewable Energy facilities will include the following activities:

- Site preparation and Solar PV Plant installation
- Transformer station and building installation
- Access and internal road works

5.4.3.1 Site Preparation and Solar PV Plant Installation

Prior to construction commencing, pre-survey activities, e.g. geotechnical surveys, will be carried out and the site will be securely fenced. Grading and levelling will be undertaken using excavators and bulldozers to minimise the cut and fill requirements and amount of excavated spoil. Excavations will be carried out for the electrical equipment (e.g. inverters) concrete foundations. The foundations for the Solar PV modules and trackers will be installed as rammed piles using a pile driver or hydraulic hammer. Based on the site area and number of modules and trackers, it is estimated that up to 100,000 piles will be required.

Cabling works to connect the main electrical equipment across the site will require trench excavations for laying of the following cables and cable conduits:

- Direct Current (DC Power Cables)
- HDPE conduits
- DC Solar cables
- Earthing conductor

Once the cables have been laid, the trenches will be backfilled ahead of installation of the remaining electrical equipment and final cable connections.

5.4.3.2 Transformer Station and Building Installation

The installation of the principal power and auxiliary transformers and Neutral Grounding Transformers (NGT), will require excavation and compaction for the concrete foundation and steel reinforced structure, including firewall that will separately house each transformer type.

Each transformer type is stored in a protective tank which will be installed on the concrete foundation. Associated piping and electrical connection works including oil filling of the transformer will then be completed.

Various site building will be constructed to support the day-to-day operations of the Solar PV plant including the:

- Gas Insulated Switchgear (GIS) Building (for substation protection)
- Main Control Room (MCR)
- Firewater Pumphouse and underground tanks
- Administration and accommodation buildings
- Pre-fabricated storage warehouses

Building construction will comprise civil works to install building foundations (laying concrete slabs) and complete structural works and building fit out. The fire water pump house equipment installation will include the placement of the fire water pumps followed by the installation of extensive fire water piping and valve network. The fire water spray and fire alarm system will finally be installed to ensure the facility is fully operational and secure.

5.4.3.3 Access and Internal Road Works

Site periphery and internal roads will be constructed to facilitate inspection and maintenance of the PV Solar Plant. An access road will run between the main highway to the Administration Building. The internal and site periphery roads will be constructed of 3m wide compacted gravel with 0.5m shoulder on each side. The access road will be 4m wide with 0.5m shoulder on each side and constructed from asphalt. Road construction will require earthworks to grade and level the surface before laying and compacting of basic and finishing layers for the road surface type.

5.4.3.4 Construction Plant, Equipment, Access and Utilities

On-site plant and equipment will be used throughout the construction period and is expected to include trucks, excavators, cranes, concrete pumps and welding machines. Road traffic associated with the Renewable Energy site construction will move to and from the site via the existing public highway and the new access road to be constructed as part of the construction works. A temporary access route may be established initially until the new access road has been constructed. Access to the site will be from the Desert Highway to the south-west of the site via the Wadi Rum Road.

It is anticipated that above ground fuel diesel tanks will be required to supply equipment on site during construction. In addition, other fuels, oils and chemicals will be supplied and stored on site in containers.

Temporary utilities will be provided on site through construction including temporary welfare and sanitary facilities and potable water supply.

5.4.4 Overhead Transmission Lines and Substations

5.4.4.1 Overhead Transmission Lines Construction

Construction of the OHTLs including the OHTL between the RE Facility and the new NEPCO substation in Aqaba will commence with completion of detailed topographical and geotechnical surveys of the OHTL route followed by establishing a construction Right-of-Way (RoW) along the route. All necessary vegetation and obstructions will be cleared to provide construction access to the tower locations, equipment laydown and assembly areas and to ensure permanent safe clearances for the future transmission lines.

At each tower site ground excavations and levelling will be undertaken to prepare the area for installation of the reinforced concrete foundations.

The lattice-steel tower sections and associated fittings will be delivered to each site for assembly on the ground before being lifted into position using cranes or derricks. The towers will then be bolted onto the pre-installed foundations.

Insulators will initially be attached to the tower arms, along with suspension clamps. A pilot rope will then be hoisted along the sections between each Tower to pull the conductors and the overhead earth wire into place. The conductors will be tensioned to the required sag before the dampers, spacers and arcing horns are installed. Finally, the earthing system connecting the tower and earth wire to grounding rods will be fixed in place.

The completed line will undergo electrical testing, such as insulation resistance and continuity checks, to ensure there are no faults before a final detailed inspection to verify that all clearances are met, and the RoW is fully clear. Upon certification by NEPCO, Overhead Transmission Lines will then be energised.

5.4.4.2 Substation Construction

Substations will be constructed at the IPS, BPS2, BPS3, PSADC and RE Facility locations and within a designated plot near to Desalination plant in Aqaba (see Figure 5-9). In each location the area for the substation will be levelled and graded and foundations installed ahead of installation of buildings, structures and electrical equipment and cabling. Equipment will be tested and commissioned prior to commencement of operations.

5.4.5 Commissioning, Start-Up and Construction Completion

The AAWDC Project commissioning, start up and construction completion phase is intended to bring the plant to a safe, fully operational state that meets all design and performance criteria as well as any regulatory requirements.

5.4.5.1 Commissioning Processes

The commissioning process is an integrated sequence of activities to facilitate the transition from the end of the construction phase to operational handover. Key activities will include:

- **Factory Acceptance Testing (FAT):** Equipment, electrical systems, and control software (PLC/SCADA) are tested at the manufacturer's facility to verify they meet specifications before delivery

- **Supply Verification:** Confirms that all equipment received on-site is correct, undamaged, and has passed all required factory tests
- **Construction Verification:** A series of systematic checks and inspections (e.g., pressure tests, alignment, electrical continuity) to ensure installation complies with design and contractual specifications
- **Electrical Energisation:** Following successful pre-energisation checks, equipment is powered up. This stage is formalised by the issuance of Notices of Energisation (NOEs)
- **Pre-Commissioning Testing:** This is divided into two stages:
    - **Dry:** Functional testing of components without process fluids (e.g., electric motor rotation tests, instrumentation checks, Site Acceptance Testing (SAT))
    - **Wet:** Operation of facility components using fluids (e.g. seawater, potable water) to verify performance against design specifications, including mechanical, electrical, and control system checks under load
- **Process Commissioning:** Once pre-commissioning is complete, the systems are tested as a single integrated whole under process conditions. This phase involves final adjustments to instrumentation, process stream sampling, and operator training. The goal is to demonstrate plant can operate across its full design range

5.4.5.2 Commissioning Sequencing

The Intake and Outfall Facilities (comprising the seawater intake, IPS and outfall system) will be commissioned first to establish a seawater source and a discharge route for Desalination Plant effluents. With the intake and outfall systems operational, the Desalination Plant and Conveyance System will be activated sequentially as their construction is completed. Initial activities for the Desalination Plant's chemical and cleaning systems will require a temporary supply of service or potable water, as the plant will not yet be self-sufficient. Permanent electrical power supply will be established at the IPS and Desalination Plant ahead of their respective commissioning.

The Desalination Plant will utilise available seawater from the IPS to undertake process testing with all resulting water discharged to the sea. The discharge will consist of water treated to Project drinking water standards and RO brine. No chemical additives other than those required normally in water production will be used during commissioning of the Desalination Plant. In contrast, the Conveyance System pumping stations are planned to be commissioned using limited volumes of water that are recirculated locally within the pipework, allowing the pumps to be tested without needing to fill the entire pipeline network from the outset. Detailed commissioning plans will be developed as part of detailed engineering activities. These plans will include the testing procedures for individual process units and system tests, including performance test protocols and the Project approach to wet and dry pre-commissioning including sources of water, approach to water efficiency and re-use, potential chemical use and disposal/discharge.

Once the Desalination Plant has achieved its first production of potable water and the Conveyance System is ready, a final phase of integrated testing and validation will consist of a two-month observation period followed by a one-month final performance test. These tests will validate the entire system's performance, whether operating with a partial flow to Aqaba or the full design flow to Amman, leading to the project's completion of the transition from the EPC phase to Operations and Maintenance (O&M) phase, otherwise referred to as the Project Commercial Operation Date (PCOD).

5.4.6 Reinstatement of Construction Sites

In all Project locations, following the completion of construction activities all construction and temporary equipment will be removed and hose areas in temporary use will be reinstated to their pre-construction condition or better. Particular care will be taken to ensure that land drainage infrastructure, access roads, other networks and facilities, and vegetation, which were disturbed/ moved during construction, will be reinstated to their former state. Photographic records will be made of the pipeline route and Project sites, where relevant, before and after the works. If required, the final step will be the establishment of access barriers to prevent trespassing on the conveyance pipeline ROW at appropriate points. All posts and markers will be located to minimise interference with agricultural activities. Cathodic protection system test posts will be installed. The final stage in the construction process, once reinstatement is established, is the removal of the temporary fencing where it has been installed.

Detailed reinstatement plans and associated management and monitoring activities will be developed where required as part of construction environmental management plans to ensure appropriate measures are undertaken to confirm pre-construction conditions are achieved with corrective actions taken where necessary.

5.4.7 Construction Workforce, Camps and Logistics

5.4.7.1 Construction Camps

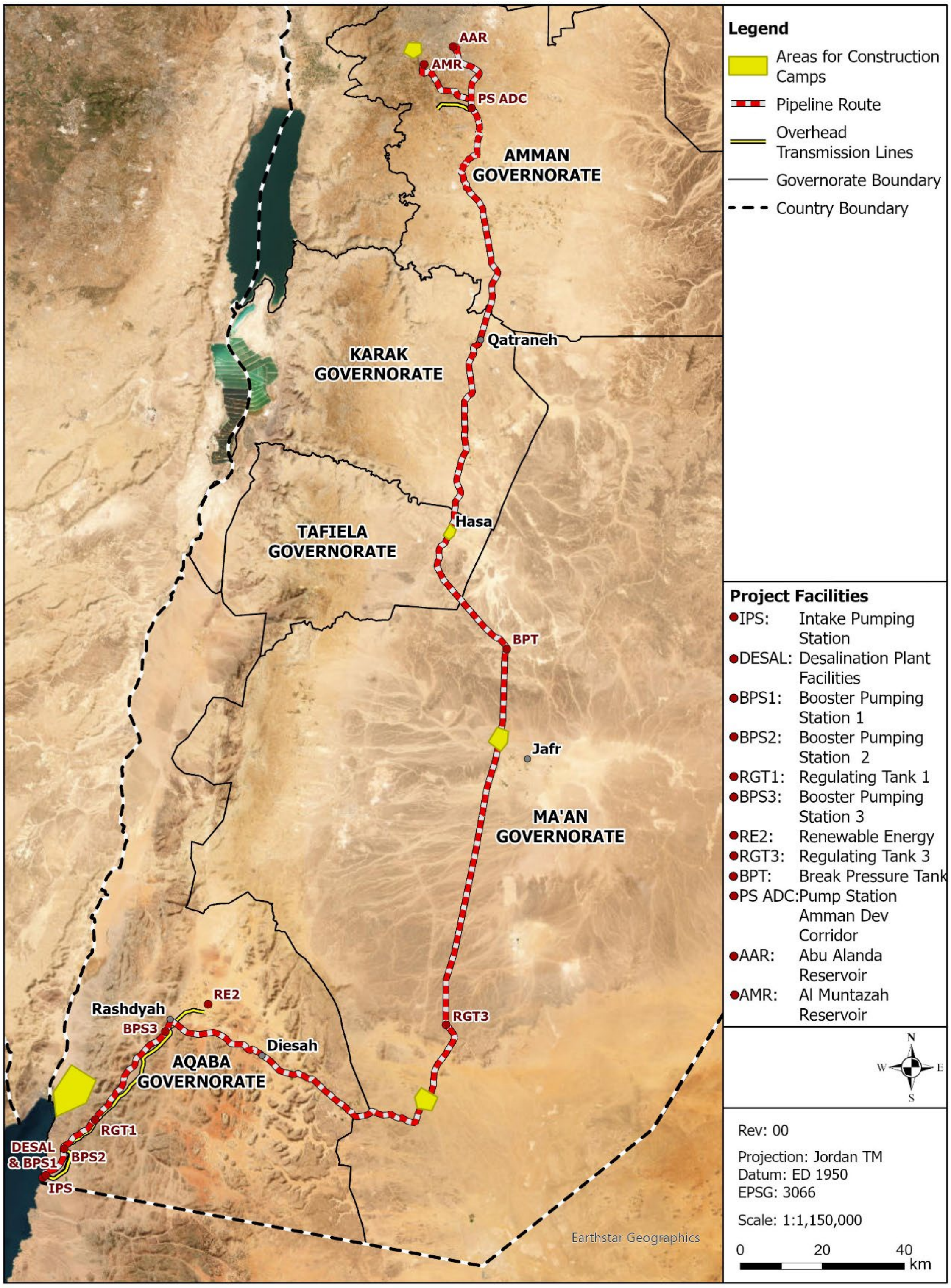
The Project will establish and utilise self-sufficient, autonomous construction camps to accommodate the workforce and support the construction logistics effort for approximately 36 months. It is expected that up to five main camps will be established to support the Project construction works (refer to Figure 5-11). The Project is currently considering camps located along the Conveyance Pipeline route (areas to the south of the RGT3 location, near to Jafr and near to Hasa are being evaluated in the Governorates of Aqaba, Ma'an and Tafiela) to support the Conveyance system construction. Additionally, a camp including a logistics base and pre-casting yard in or near Aqaba will be established to support the construction of both the IPS, Desalination plant, and southern sections of the Conveyance System, and another camp will also be established in Amman. The main Project offices will be established in Amman and Aqaba.

Key facilities are expected to include temporary accommodation for up to 1500 workers per camp, canteen and welfare facilities such as toilets, showers, and rest areas. Camp utilities will be provided through temporary supply e.g. tankered potable water supply, power generation from diesel generators, with temporary drainage and containment systems provided and lighting installed for safety and night operations. The camps may also be used to support Project logistics, providing storage areas for construction materials, pipe sections and equipment; designated zones for the temporary storage of waste, chemicals, and fuel; and maintenance and workshop areas. Additional satellite camps or mobile units may be deployed along the conveyance pipeline route as needed.

5.4.7.2 Construction Workforce

The Desalination Plant and IPS construction is estimated to require a peak workforce of between 2,000 - 2,500 staff and labourers. Most of the accommodation for this workforce is expected to be provided at the construction camp established at or near to Aqaba. The Conveyance System workforce is projected to average around 2,600 personnel with a maximum of approximately 5,400 personnel during peak construction periods.

Figure 5-11: Areas for Project Construction Camps



5.4.7.3 Pipeline Construction Logistics

The Project is actively evaluating materials procurement options for the Conveyance Pipeline and plans to engage up to three separate suppliers, including national and international companies. Temporary facilities for handling and storing pipe sections before delivery along the Pipeline RoW will be established and certified over ~18 months or more, before pipeline construction commences.

From a worst-case schedule perspective, assuming all pipe sections were imported from overseas, e.g. via shipping through the GoA, delivery vessels would be expected every 15 days at Aqaba Port. Ships would deliver approximately 600 pipeline sections per voyage, which would then be transferred by trailer trucks to the temporary storage facility located approximately 10km from Aqaba Port, working 24 hours per day. The temporary storage facility will be located to avoid residential areas and minimise nuisance to residents.

It is expected that between 20 and 30 trailer trucks operating continuously will unload the pipe delivery vessel to the temporary storage facility over three days. The same trucks will then transfer the pipe sections from the temporary storage facility to the active pipelaying destination (or, if necessary, an interim storage location along the pipeline ROW) within the next 12 days before the next international pipe delivery. Temporary marshalling areas along the RoW will be established to manage delivery vehicle movements, and convoys of pipe-section deliveries along public roads and highways will be avoided. Approximately 20% of Project traffic is expected to use the main public roads and highways. Most truck movements, principally those responsible for the transfer and delivery of excavation and backfill materials, will avoid passing through towns and villages or utilising main roads and highways.

5.5 Operations

5.5.1 Overview

The operational phase of the AAWDC Project will involve the production and delivery of potable water from the intake facilities at Aqaba to the Abu Alanda Reservoir 2 and Al Muntazah Reservoir in Amman. The control of the overall desalination and conveyance system is consistent with the MWI agreement to deliver a fixed daily quantity of freshwater to the Project delivery points, with the design intent being the production of 300 MCM/yr of freshwater.

Routine operations procedures will be applied to all activities that have an operational effect on the water intake, desalination, and conveyance process, personnel or the surrounding environment. A common SCADA system will be used to monitor and control the entire water desalination and conveyance system.

Operational power loads of the Project facilities (in normal operation regime) are shown in Table 5-9.

Table 5-9: Operational Electrical Power Loads of the AADCWP Facilities

Project Facility	Electrical Power Load (MW)
Marine Works and Desalination Plant	126.4
BPS1	43.9
BPS2	51.5
BPS3	51.5
PSADC	26.8

Project Facility	Electrical Power Load (MW)
Total	300.1

The annual consumption of the Project Facilities (in kWh) is proportional to the loads indicated above. The electricity consumption at the three main tank facilities (RGT1, RGT3, BPT) will be negligible.

The operations and maintenance of the AADWC Project facilities is expected to require approximately 100 staff.

5.5.2 Intake and Outfall Facilities and Desalination Plant

5.5.2.1 Intake System

During operations, routine maintenance of the intake pumps and other mechanical equipment at the IPS will be undertaken to ensure performance remains in accordance with Project operational requirements.

The seawater intake system is equipped with screens and a self-cleaning system that will generate waste during operation. The coarse 50mm mesh screen and associated fish-recovery device installed at the intake mouth are designed to prevent large particles or fish from entering the intake. They will require cleaning to remove debris. Waste will be collected and disposed of at the approved waste management facilities, along with other waste generated during routine maintenance activities at the IPS.

5.5.2.2 Desalination Plant

The Desalination Plant is designed to operate within the design parameters specified in the Project Design Envelope (refer to Table 5-1) which covers a range of intake conditions to account for natural variations in the seawater extracted from the Gulf of Aqaba. Routine operations and maintenance will be supported by monitoring of plant performance on a regular basis to recognise when RO membrane elements are becoming fouled. During normal operations RO membrane cleaning will be conducted when the RO system shows evidence of fouling that exceeds tolerable levels. Common foulants of RO membranes are wide ranging and can include:

- Mineral scales (e.g. calcium carbonate or sulphate scales)
- Metal oxides (e.g. iron, manganese, copper, nickel etc.)
- Silica scales
- Inorganic colloidal deposits
- Natural organic matter
- Man-made organic materials (e.g. cationic polyelectrolytes)
- Biological (e.g. bacterial biofilm, algae or fungi)

The combination of the flushing, backwash and chemical cleaning-in-place (CIP) approach specified within the design is designed to address the potential fouling along with a maintenance programme to monitor the condition and effectiveness of the Desalination Plant filters and membranes

Solid process wastes from water treatment will be generated in the Solids Treatment System. Once dewatered these wastes will be transported via a typical containerised skip system to appropriate approved waste management facilities for disposal. Other wastes generated in the Desalination Plant will include spent cartridges from CIP cartridge filters, replaced RO membranes as well as miscellaneous office wastes and domestic wastewater.

Safeguards will be put in place to avoid overdosing of production chemicals and overfilling of process vessels and storage tanks. In the event of an overflow, liquids will be collected within secondary containment features such as kerbed areas connected to dedicated drainage sumps. Overflows will not be directed to the outfall.

5.5.3 Conveyance System

The Conveyance System operates by pumping and regulating freshwater flow rates to meet the demand at the end user reservoirs and turnout points. The system will be capable of following a daily or seasonal demand profile such that it can transport water between approximately 10% and 100% of the maximum design capacity.

The entire system will be monitored and controlled from the main Control Centre (CC) located at the Desalination Plant with a back-up CC at the PSADC. Fully automatic operation of the Pumping Stations will also be available at each Pumping Station in the event that both CCs are unavailable e.g. due to loss of communications.

A key operational requirement will be pressure management within the water network to maintain the integrity and lifespan of the steel conveyance pipelines and subsequently reduce the risk of leaks. High frequency pressure sensors will form part of the SCADA system to detect and reduce the effects of pressure transients (high speed variations in pressure). A vent system along the pipeline allows release of air during filling of the pipeline and entry of air during drainage of the system. Drain stations that allow drainage of the pipeline are described in more detail in Section 5.3.3.2. The maintenance philosophy adopted will ensure that losses to the drain stations are kept to a minimum in the event of a pipeline inspection or repair work.

The chlorination system, required to maintain freshwater residual chlorine levels within specified limits, will be automatic based on measured existing residual chlorine levels and pumping station flow rates.

There are no specific routine process related waste streams or discharges anticipated from the Conveyance System AGIs. Staffing levels at Pumping Stations will be minimal and routine inspections along the pipeline RoW are expected to generate small quantities of domestic waste.

5.5.4 Renewable Energy Facilities

Routine operations at the Solar PV Plant will be highly automated via the Main Control Room (MCR). Maintenance activities will include periodic panel cleaning, the frequency of which will be influenced by the prevailing weather conditions and any associated dust levels. The cleaning method is expected to be a water based (wet) washing system, whilst the Project is also considering a ‘dry’ cleaning system, using brushes or compressed air systems, to remove deposit build-ups on solar panels. The preference for the cleaning method is to avoid the requirement for using freshwater, however this will be confirmed during detailed design.

There are no specific routine process-related waste streams or discharges anticipated from the RE Facilities. Staffing levels at the Solar PV farm will be minimal expected to generate only small quantities of domestic waste.

5.6 Decommissioning

At the end of the Project's operational lifetime a decommissioning strategy will be developed and implemented in accordance with the applicable legislative requirements and with consideration of best practicable environmental options. The main civil works, including the buildings and tanks, and the hydraulic structures of the Project, including pipelines, will have a design life of 50 years.

At the time of writing no information is available with regard to decommissioning activities or decommissioning methodology.

5.7 Summary of Estimated Project Emissions (including GHG), Materials and Waste

5.7.1 Summary of Estimated Emissions

5.7.1.1 Construction

A summary of expected annual AAWDC Project construction phase greenhouse gas (GHG) emissions for the following Project components is provided within Table 5-10 below:

- Marine Works (including construction of intake lagoon and outfall system)
- IPS and Desalination Plant
- Conveyance System AGIs
- Conveyance System Pipeline (including bulk materials transportation)
- RE Facility and OHTL
- Construction camps and personnel transportation

Table 5-10: AAWDC Project Construction Phase GHG Emissions

-	Marine Works	IPS and Desalination Plant	Conveyance AGIs	Conveyance Pipeline	RE Facility and OHTLs	Construction Camps and Transport
-	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)	(tonnes)
Year 1	2,724.3	397.5	452.6	802.7	219.1	18,484.9
Year 2	7,264.8	622.1	1,206.8	11,639.8	472.0	36,969.8
Year 3	6,356.7	501.2	980.5	9,633.0	404.6	36,969.8
Year 4	0.0	51.8	75.4	2,408.2	0.0	18,484.9
GHG total	16,345.8	1,572.6	2,715.3	24,483.8	1,095.7	110,909.4

Basis of estimate:

1. Vessel types and associated fuel consumption rates provided within Appendix 5-2
2. Onshore Construction Plant types and associated engine sizes provided within Appendix 5-2.
3. Construction Camp and personnel transportation fuel consumption rates provided within Appendix 5-2
4. Duration of Vessel/onshore Construction Plant and Construction Camp usage based on the indicative Project Schedule (Figure 5-2)
5. Emissions Factors used to calculate emissions provided within Appendix 5-3
6. Global Warming Potentials (GWPs) that are used to express the tonnes of CH_4 and N_2O in terms of CO_2 are the standard GWP factors of IPCC Assessment Report 6 (2021)

5.7.1.2 Operations

During Operations, direct emissions from the Project facilities will be minimal and limited to occasional use of diesel generators during emergencies and upsets, and the use of maintenance vehicles. Power will be routinely provided to the Project Facilities from the Project RE Facility and from Jordan's electricity grid. The Project is designed to produce and deliver 300MCM/year of desalinated water and to operate to ensure that an emissions cap of 3.2 kg CO_{2e}/m^3 water is not exceeded. Annual GHG emissions associated with the Project Operations phase are shown in Table 5-11 below. The emissions are calculated using the International Finance Institutions (IFI) default grid emissions factor for Jordan (382 gCO_2e/kWh), as it reflects the long-term projected decarbonization of Jordan's electricity grid, based on national energy transition plans and alignment with IFI harmonized GHG accounting methodologies. This factor incorporates anticipated increases in the share of renewable energy generation and corresponding reductions in average grid carbon intensity over the Project's operational lifetime.

Table 5-11: AAWDC Project Operations Phase GHG Emissions

Year	Project Emissions (t CO_2e)
2030	738,079
2031	739,462
2032	740,845
2033	742,228

Year	Project Emissions (t CO_2e)
2034	743,611
2035	744,994
2036	746,377
2037	747,760
2038	749,143
2039	750,526
2040	751,909
2041	753,292
2042	754,675
2043	756,058
2044	757,441
2045	758,824
2046	760,207
2047	761,591
2048	762,974
2049	764,357
2050	765,740
2051	767,123
2052	768,506
2053	769,889
2054	771,272
2055	772,655
GHG Total	**19,639,536**

Operation of the Project facilities is expected to indirectly generate up to 772.7 kt of CO_2 emissions per year from third-party electricity supply via the National Grid (annual average 753 kt CO_2e). The annual GHG emissions shown in Table 5-11 highlight an incremental increase in emissions year on year due to an assumed 0.5% per annum degradation rate in the RE Facility Solar PV Plants' operational efficiency. This means that the power generated by the RE Facility also declines at the same rate, and the shortfall is made up by drawing additional power from the higher carbon-intensity Grid.

With an overall annual power demand of 2,657.2 GWh, corresponding to 1,014.7 kt of CO_2 if supplied entirely from the National Grid, the contribution of the RE Facility enables the project to avoid, on average, 259.3 kt CO_2 per annum over the project lifetime.

The average CO_2 emission intensity over the project lifetime is estimated at 2.52 kg CO_2 per cubic meter of water produced.

5.7.2 Summary of Estimated Materials

A summary of the bulk material requirements for the Project is provided in Table 5-12 below. These materials are predominantly composed of:

- Concrete (including pre-cast concrete for encasement of pipeline sections or use as ballast structures)
- Steel (including structural steel and carbon steel used in pipeline manufacture)
- Aggregates (including sand, gravel and rock boulders etc)

The materials are mostly used in the construction of:

- Building foundations, frameworks and supports
- Sections of the conveyance pipeline
- Backfilling and protection of civil engineering structures
- Storage tanks
- Access roads

Table 5-12: Summary of Bulk Material Quantities used during AAWDCP Construction

Bulk Material Type	Quantity[1]	Units
Concrete[2]	340,300	m^3
Carbon Steel (pipeline)	327,250	Ton
Structural Steel	14,165	m^2
Aggregate (Fill material)	4,573,450	m^3
Aggregate (Road Base)	735,000	Ton

[1] Excluding all Renewable Energy Facility / Associated Facilities bulk materials
[2] Includes PCC, Ferro concrete and concrete for encasement, excludes potential concrete used in offshore intake towers

5.7.3 Summary of Wastes and Discharges

5.7.3.1 Construction

Solid and Liquid Wastes

The typical waste streams expected to be generated through the construction of AAWDC Project include the following:

- Non-hazardous waste: Waste from construction camps, canteens, paper, cardboard, plastics, wood and vegetation, inert wastes from construction and demolition (concrete, scrap iron, bricks, etc)
- Bulk quantities of excess earthworks or waste spoil (i.e. that is either unsuitable for re-use or surplus to requirements)

- Hazardous waste: Engine oils and used hydraulic fluids, residues of paint, solvents and resins, fluids from transformers, medical wastes, sludge from septic tanks, and various concrete additives

A waste management plan will be prepared before the start of construction works to include a detailed inventory of wastes, estimation of quantities, and identification of management solutions in alignment with national regulations and Good Industry Practice (GIP).

Liquid Discharges

The typical liquid discharges expected to be generated through the construction of AAWDC Project include the following:

- Hydrotest water (refer to 5.4.2.1 and 5.4.5.2)
- Stormwater run-off (refer to 5.4.1.4 and 5.4.2.1)
- Dewatering from shoreline/ trench excavations (refer to 5.4.1.2 and 5.4.2.1)
- Hazardous/Non-Hazardous area open drains system flushing (refer to 5.4.1.4 and 5.4.2.1)
- Vehicle refuelling/ wash-water and fuel storage area drains
- Construction camp treated sanitary wastewater
- Vessel ballast, bilge and deck drains

5.7.3.2 Operations

Solid and Liquid Wastes

During the operations phase, waste streams will be primarily associated with maintenance activities and generated by the SWRO treatment processes. The principal process waste generated at the Desalination Plant is described in Section 5.3.2.4. The Desalination Plant will also generate waste filters during changeouts and maintenance activities, cartridge filters and the end-of-life RO membranes. The Intake facilities will also generate solid wastes during maintenance from the removal of debris and biofouling from intake screens. Routine maintenance activities across all AAWDC Project facilities will generate typical domestic and operational waste streams, including sanitary waste, used oils, grease, and scrap materials. Waste management plans will be developed and implemented for operational waste streams which will include identification and quantification of anticipated wastes and approach to management.

Liquid Discharges

The principal process effluents generated at the Desalination Plant for discharge via the outfall system are described in Section 5.3.2.4. The typical liquid discharges expected to be generated during the operation of AAWDC Project include the following:

- Stormwater run-off from hardstanding areas (refer to 5.3.2.6)
- Hazardous/Non-Hazardous area open drains system flushing (refer to 5.3.2.6)
- Conveyance system pressure relief valve/ surge protection releases (refer to 5.3.3.2)
- Conveyance system washout discharges (refer to 5.3.3.2)

Appendices

Appendix 5-1 Materials Estimates

Appendix 5-2 Plant and Equipment Estimates

Appendix 5-3 Construction Phase GHG Estimates

Appendix 5-4 Operations Phase GHG Estimates