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DEFINITION & IMPLEMENTATION OF THE DEWATERING WORK METHOD STATEMENT FOR THE RED LINE NORTH UNDERGROUND PROJECT IN DOHA-QATAR

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TABLE OF CONTENTS

List of Figures

List of Tables

List of Annexes

Abstract

Qatar is planning one of the most comprehensive rail networks in the Gulf. It will include a passenger and freight railway linking Ras Laffan in the north with Mesaieed in the south via Doha, a high-speed link between the New Doha International Airport and Doha city center that will link to Bahrain by a planned causeway, a freight rail link; which will form part of the GCC rail network, a light rail network in Lusail and a metro network in Doha.

The metro network will play an intricate role in Qatar's efforts to host FIFA's World Cup in 2022. The metro will be essential in ensuring the smooth transportation of fans between the airport, hotels and the various football matches, whilst simultaneously minimizing congestion on the roads.

To this end ISG JV, a consortium led by Italian contractor Salini Impregilo S.p. A., has been appointed by Qatar Railways Company (QRAIL) to design and build the Red Line North Underground (RLNU) metro in Doha. The RLNU will stretch approximately 13km northwards from Mushaireb station. The scope of work will include the excavation of two parallel tunnels of 11.6km in length and seven new underground stations. An important and intrinsic component of RLNU is sustainability.

It is recognized that Doha Metro is an essential project and an environmentally attractive transport option that supports both the living standards and economic competitiveness and attractiveness of the city. Notwithstanding, it is also recognized that human and economic development typically competes with the protection of the environment. In Qatar this phenomenon is particularly apparent with the country now facing major environmental challenges that need to be solved like:

- Preventing water scarcity
- Protecting natural aquifer
- Reducing carbon emissions
- Increasing energy efficiency

- Safe guarding the marine environment

Due to this fact, in October 2008 the Qatar National Vision 2030 (QNV 2030) was launched. It defines long-term development outcomes for Qatar and provides a framework within which national development strategies and implementation plans can be prepared.

In essence, the QNV 2030 is based on the Guiding Principles of Qatar's Permanent Constitution and is underpinned by four interrelated pillars:

1) Human Development: Development that expands the opportunities and capabilities of all the people of Qatar to enable them to sustain a prosperous society.
2) Social Development: Development of a just and caring society based on high moral standards and supportive social policies, and where Qatar plays a significant role in the global partnership for development.
3) Economic Development: Development of a competitive and diversified economy capable of meeting the needs of, and securing a high standard of living for, all it's people both for the present and for the future.
4) Environmental Development: Management of the environment such that there is harmony between economic growth, social development and environmental protection; the three dimensions of sustainable development.

It is clear that the RLNU project encompasses each of the four pillars; therefore the project scope has to be aligned with the requirements and ambitions of QRAIL, the Qatar Sustainability Assessment System (QSAS)) and the Civil Engineering Environmental Quality Assessment (CEEQUAL).

In order to comply with these objectives several methodologies must be applied during the project life cycle. This report will be focused in one of this methodologies; the so called Work Method Statement (WMS). WMS or Safe Work

Method Statement (SWMS) is defined as a document that identifies hazards, asses the risk of those hazards occurring and identifies the risk controls that must be put in place (OFSC, 2010). Furthermore, WMS is a technique for identifying hazards with a focus on the relationship between the worker, the task, the tools and the work environment so as to either eliminate risk or reduce it to an acceptable level (OHSA, 2002).

Specifically, this report will deal with the definition of the RLNU's Dewatering Work Method Statement. At the end of this document a description regarding to what was defined in the Dewatering WMS and what actually happened during the implementation phase will be presented.

The reasons for choosing this particular topic respond to the fact that this task was one of the core objectives during my internship period, and also because it gathered several issues that exemplify the characteristics of working in a project of this kind.

1. Description and Scope of Work

The first part of this report will be focused in the definition of the Dewatering WMS which include the Dewatering System strategy for Al Diwan, Al Bidda, West Bay South, West Bay Central, Al Wahda, Cultural Village, Trough Golf Course and two Emergency Exits (West Bay Lagoon and Arch Roundabout); see Figure 1. To produce the WMS synergies were created between: Plant Department, Technical Department, Safety Department and the Subcontractor.

The second part of the report will be centered in the problems and further modifications that were carried out during the installation and control phase of the Dewatering System at Al Wahda Station. Due to the practical approach of the second part it is possible to identify my contribution from a managerial perspective; merging both technical and managerial skills.

Figure 1: RLNU Location Map

The deep well Dewatering System will be installed to lower the ground water level and relief the pore pressure during excavation in order to provide a dry, stable and safe working conditions. The system will also provide a controlled means of discharging the ground water. Figure 2 shows a transversal cut of the excavation area together with the deep wells arrangement.

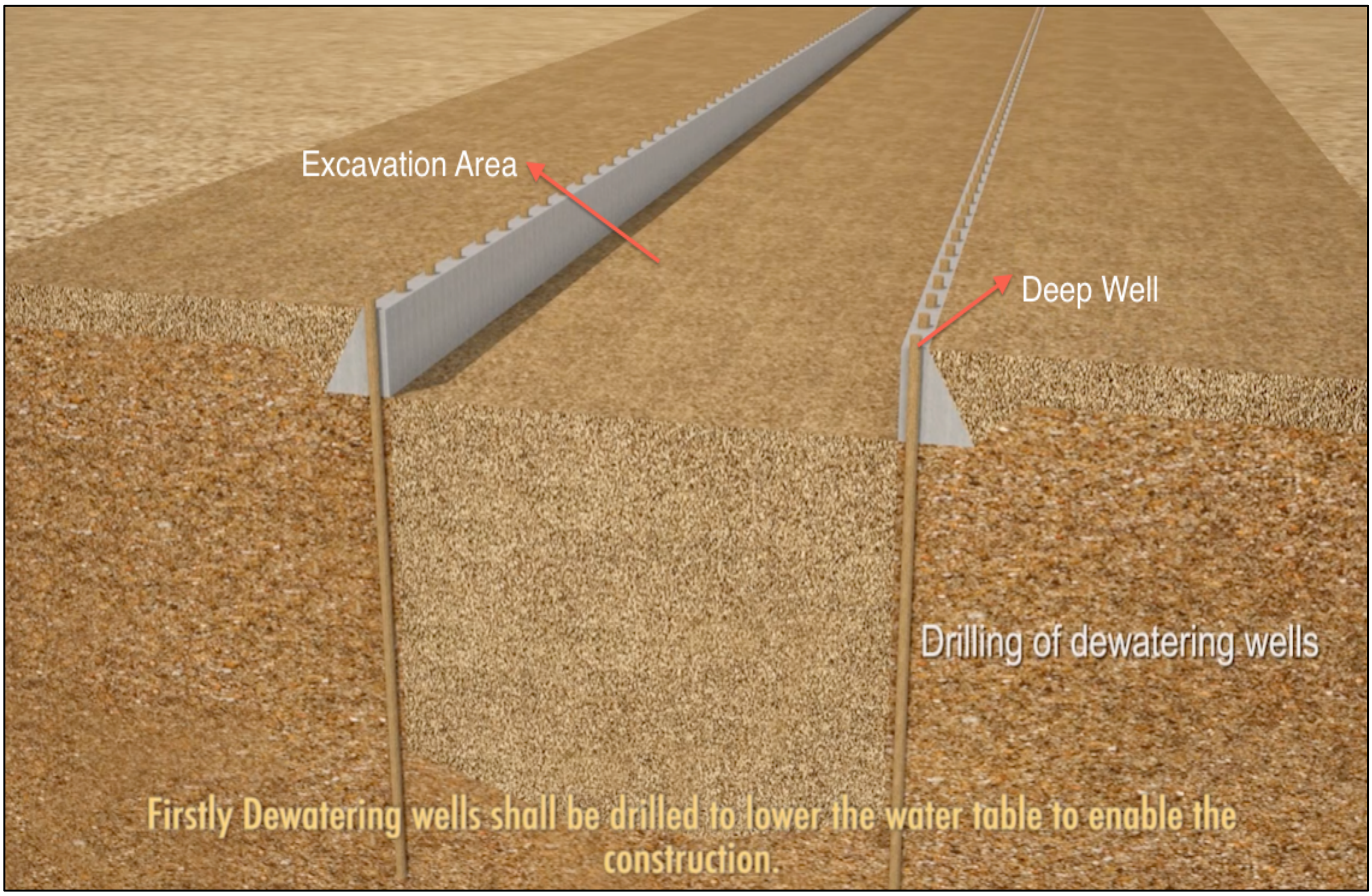

Figure 2: Transversal cut of the Excavation Area

The deep well system consists of deep well by a borehole fitted with a slotted liner and an electric submersible pump. As water is pumped from a deep well, a hydraulic gradient is formed and water inflows into the well forming a cone of depression around it in which there is little or no water remaining in the pore spaces of the surrounding soil. The water level will always be maintained at 1m below the bottom of excavation. Figure 3 shows the basic arrangement of a deep well.

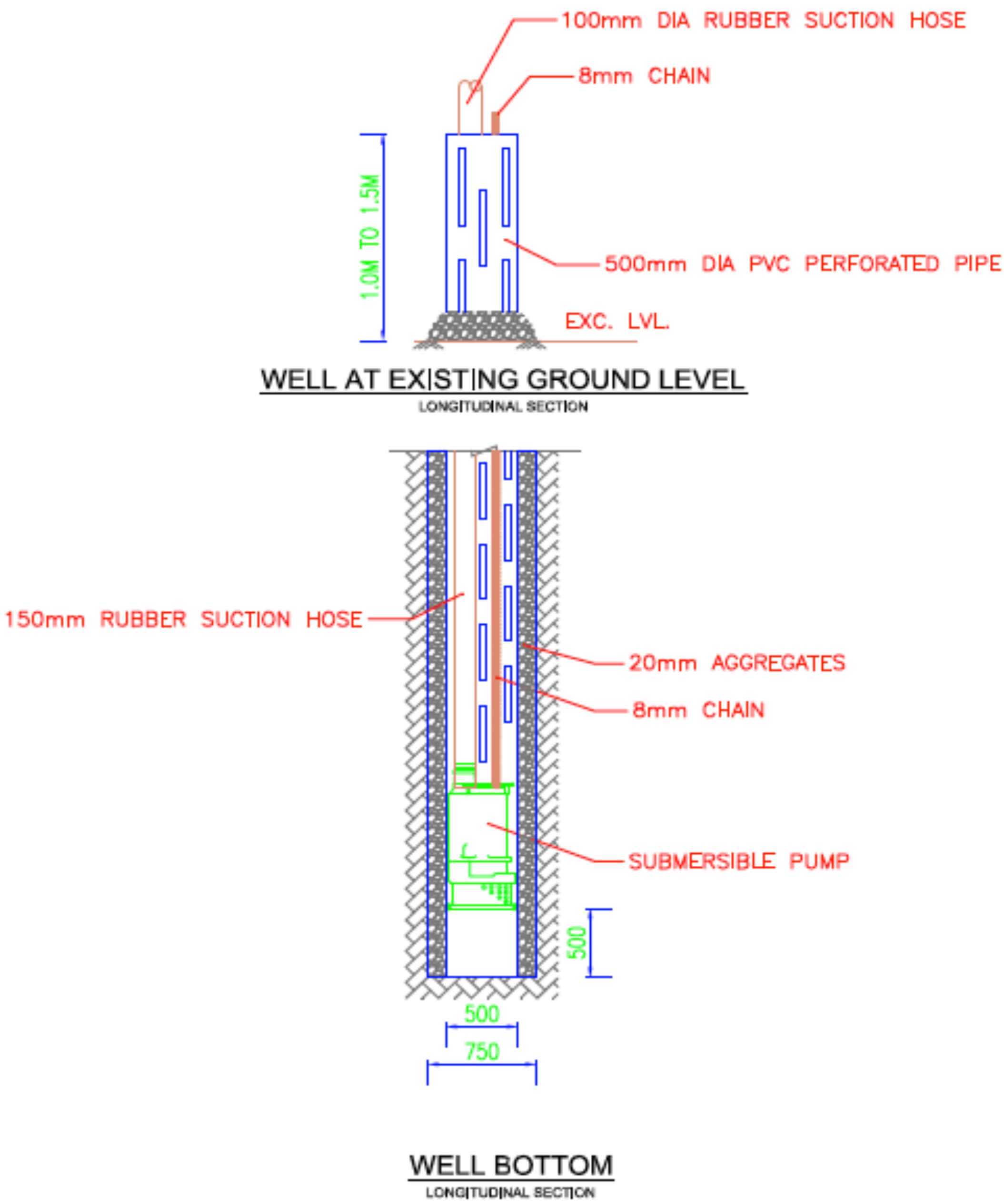

Figure 3: Deep Well Configuration

The wells casing shall be positioned approximately 50cm above the bottom of the borehole with the submersible pump placed inside the well casing. The pump will discharge groundwater through 150mm diameter rubber reinforced hose. An armored rubber flexible hose will then connect the head works to the discharge lines. The discharge lines run along the ground surface to a sedimentation tank. The pump will then be powered by a steel wire armored electric cable that runs from the pump, up the well, along the flexible pipe and alongside the discharge lines; the cable shall terminate at a pump control board.

The collected flow, after flowing through the sedimentation tank, will be discharged to the approved discharge point. The Dewatering System will be operational 24 hours and appropriate maintenance and monitoring arrangements will be made to achieve satisfactory groundwater level during excavation.

The main specifications of the system design are shown below:

		Al Diwan	Al Bidda	West Bay South	West Bay Central	EE-Arch-RD	Al Wahda	Cultural Village	EE-Lusail	Golf Course
	Dewatering work duration (days)	904	951	641	820	713	1006	743	684	682
WELLS	Number of Wells	28	25	15	28	3	26	15	4	26
	Diameter of Wells (mm)	750	750	750	750	750	750	750	750	750
	Depth of Wells (m)	39.9	32.3	38.6	41.4	36.5	29.5	29.4	45.2	22
PUMPS	Capacity (m3/h per pump)	36	66	72	90	50	66	66	54	60
	Total Capacity (m3/h)	1008	1650	1080	2520	150	1716	990	216	1560
	Head (m)	42	34	41	44	39	32	32	47	24
	Power (Kw)	11	11	15	15	11	11	11	15	7.5

Table 1: Dewatering System Specifications

2. Definition of the Dewatering WMS

2.1 Prior Activities to be Completed

Prior to commencing the dewatering works it is essential that some prerequisite works are complete as below:

1. All personnel must complete a Safety and Environmental induction together with any training required to safely and competently perform their work tasks.
2. Briefing and alert will be enforced to all personnel involved in the relevant site activity before starting the work.
3. Ensure that there are no obstructions in the locations of the dewatering wells. For this purpose a series of trial pits will be excavated to identify any utility that may interfere with the works.
4. Relocate / divert any utility which is interfering with the excavation or pre-excavation works.
5. Installation of all necessary ground monitoring instrumentation.

6. Preparation and check of all the necessary materials, plant and equipment to be used for the specified works.
7. Statement of No Objection for the following:
   - DD2 Design Drawings and Report for Excavation Support and Dewatering Wells
   - Design Report for Outline and Station Monitoring
   - Preconstruction Survey Report
8. All deep well locations shall be identified and marked out by the surveyor
9. All the required permits will be available:
   - Installation of dewatering line (i.e. Road Opening Permit by Ashghal; Private Authority/Owner Permit)
   - Water Discharge Point (i.e. Ashghal Permit; MoE (Ministry of Environment)

Upon completion of the above activities the dewatering works will commence. It is proposed to install deep wells along the excavation area. Deep wells involve the installation of perforated casing into which submersible pumps can be lowered and operated to reduce the ground water level. Pumps will be connected to a common discharge header from which water can be pumped to a sedimentation tank for treatment and from there to the approved discharge point.

2.2 Phases of Execution

The dewatering works include the installation of a deep well system, sedimentation control and discharge of ground water to the proposed discharge points as approved and permitted by the authorities. The construction sequence for the installation of the Dewatering System is:

- Drilling and installation of Deep Well Casing and gravel filling
- Well Development
- Installation of submersible pump inside the wells
- Sedimentation control
- Water Testing and Treatment (if required)
- Discharge of flow
- Maintenance of the Dewatering System

- System decommissioning

2.3 Method of Execution

2.3.1 Drilling and Installation of Deep Well Casing

The construction of the temporary deep well system will be carried out using a rotary piling rig to install 500mm diameter slotted PVC casing inside the 750mm diameter drilled holes. The annulus between the temporary and the PVC casing will be filled with 3/4” filter aggregate in order to allow drainage into the pipe slots and prevent excessive fine material passing through into the future pumping area.

2.3.2 Well Development

Prior to install the pumping system it is necessary to develop the deep well to ensure its safe and efficient performance. Well development will provide a means to improve the natural permeability of the ground around it.

2.3.3 Installation of Submersible Pumps

After installing the slotted PVC casing inside the wells, electrical submersible pumps will be installed within each one of them. See Figure 4.

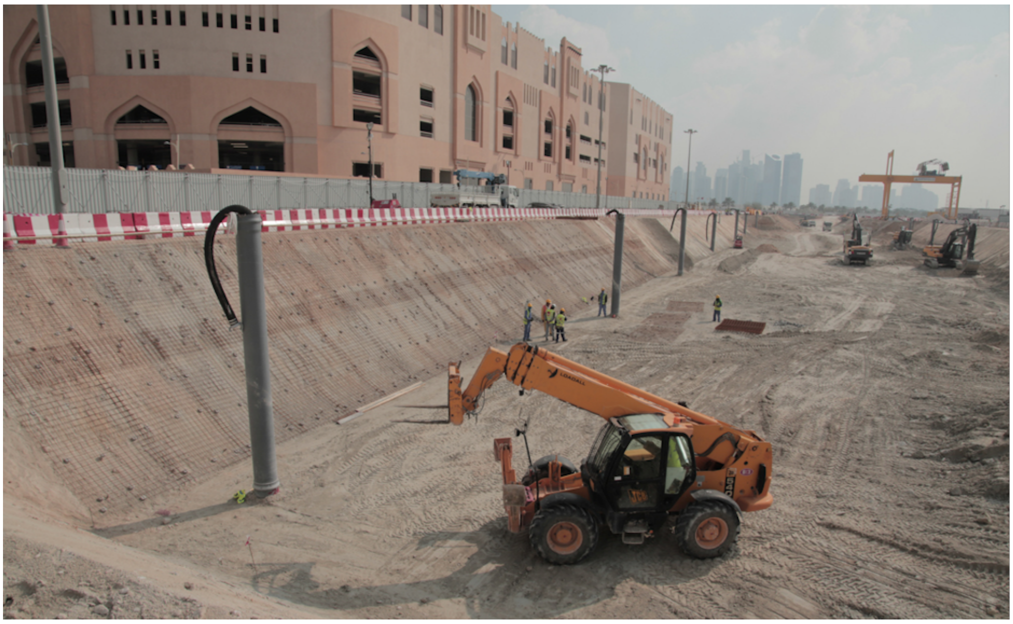

Figure 4: PVC Pipes with Submersible Pumps

Prior to lifting any unit a lifting permit and a lifting plan needs to be filled by a competent person performing this activity. The electrical submersible pumps will be connected to discharge pipes, cables and removal rope prior to the lifting procedure. A test will be carried out on the pump's electrical operation before installation inside the well. A lifting handle provided with the pump will be used for the lifting/lowering process. The pumps will be lifted up using a mobile crane of adequate capacity. Wells location will be indicated by warning tape.

The piping arrangement from the pump will consist of rubber suction hose to top of the well fitted to lay flat discharge hoses lying on the ground level. This will allow the discharge to follow the profile of the excavation.

While crossing the site haul road the discharge pipelines will be located inside a concrete casing laid throughout the length of a trench having minimum 300mm cover from the finished ground level. However, the pipelines paths will be studied in order to minimize the number of crossings. The trench backfilling will be done with the same excavated soil which will be compacted up to the finished ground level.

Spare discharge hoses will be available at site in case of rupture of joints and heavy vehicle/plant movement will be limited in the areas with discharge lines crossing the roads.

Quick release couplings will be utilized to minimize the interruption of excavation works. A Non Return Valve will be connected between the discharge hoses and the rising pipe (rubber suction hose) to prevent the discharge water to flow back into the well in case of a breakdown of the pump.

The pumps will be connected to the control panels fitted with both audio and visual warning alarms in the event of failure. The alarm will be audible and visible to the personnel working in the power station area. In case of failure of a pump, standby submersible pumps will be available for replacement. The damaged pump will be isolated and the standby pump will be started.

The control panels will be connected to a distribution board, which in turn connected to the main generator. A 50% standby power source (1 standby generator for 2 running generators) will be available, which will be started in case of power failure. This will be a manual switchover done by the dedicated electrician working in the power station area.

All generators, distribution boards and control panels will be situated in the power station area (designated area on each site) on the ground surface outside the station box. A dedicated team of mechanics and electricians will be on site full time to handle any failure.

To control any surface water or seepage of water between the voids of hard impermeable strata, French Drain System (Figure 5) proves to be very efficient. The extraction of groundwater will take place by gravity. In case of formations with low permeability the drain trench will be refilled with drainage sand or gravel. As a result the flow of groundwater to the drains will be improved.

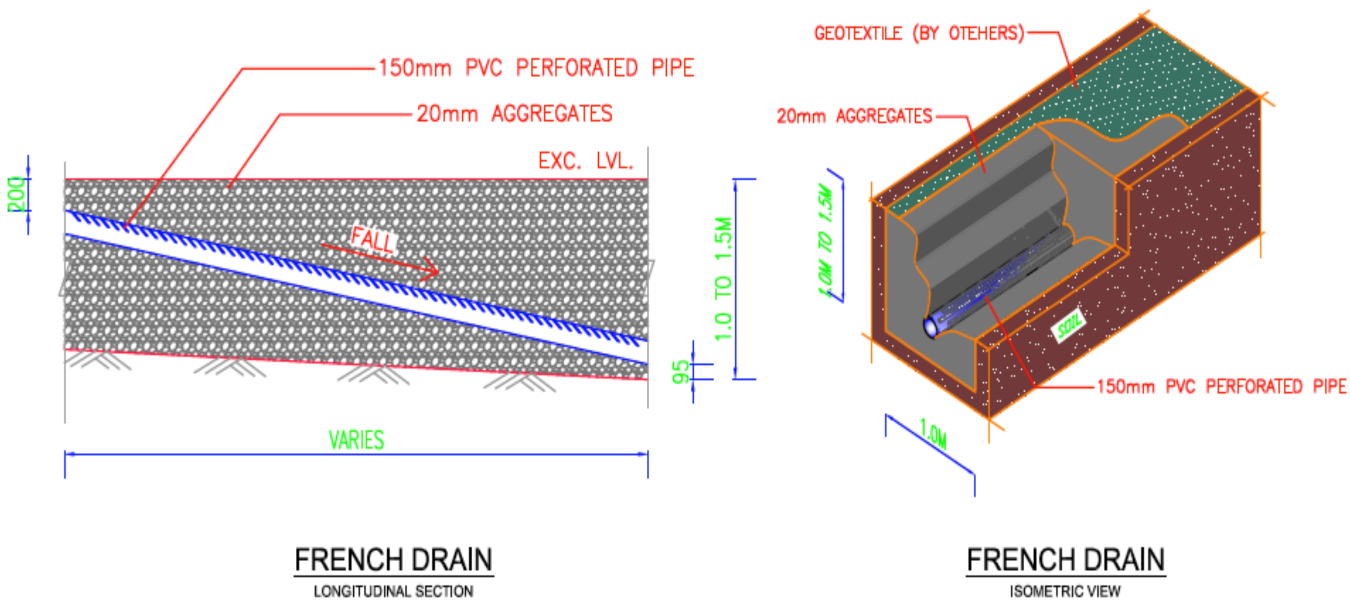

Figure 5: French Drain

The French drains may be required in the excavation after reaching the final excavation level, allowing the surface water if any, and possible seepage from the side of the excavation to be diverted to the dewatering wells. The drain system consists of excavated trenches and does not include the provision of any foreign piping into the excavation. The drains, if needed, can be backfilled with single size angular gravel such as 15 or 20 mm diameter that will be left in place under the structural blinding. See Figure 6.

Figure 6: Excavation Drain

2.3.4 Sedimentation Control, Water Testing & Treatment and Discharge

To prevent sediment-release related impacts the dewatering activities will be controlled by routing the discharge water into sedimentation tanks before its release to the storm water system. The samples of the pumped water will be taken and the quality of water will be tested against the acceptance criteria

If the testing report shows the quality of water as per the acceptance criteria, the water from the sedimentation tank will be discharged to the approved discharge point. If the test result is unacceptable, a special settling basin, filter, or other appropriate best management practice to trap sediment and/or for contamination treatment will be installed. After treatment, quality of water will again be tested against the acceptance criteria and if found acceptable will be discharged to the approved discharge point.

All the discharge lines will be fitted into the sedimentation tanks installed as per design locations. Sedimentation tanks will be sufficient in dimension and numbers to reach the target of flow expected without overtopping. The tanks will be prefabricated steel or metal type and a clean out of the tank will be required once one-fourth of the original capacity is depleted due to sediment accumulation.

All sediment tanks will have a V Notch to calculate the actual discharge flow. A daily check on discharge from the sedimentation tank to the approved discharge point will be carried out by the subcontractor so that it does not exceed the allowable limits in accordance with MoE/Ashghal. Diesel powered booster pump will be fixed with the sedimentation tank to discharge the water to the approved location. The refilling of the fuel will be carried out by opening bleeding screws of the pump and refueling it as and when necessary.

The groundwater discharge options will be either to discharge the flow to the manhole (storm water or foul sewer system) or to sea (via an outfall). The discharge approach will be aligned to minimize the impact on the existing baseline condition and/or the environment.

The testing permit procedure for discharging water either to sea or manhole is represented in the flowchart of Figure 7.

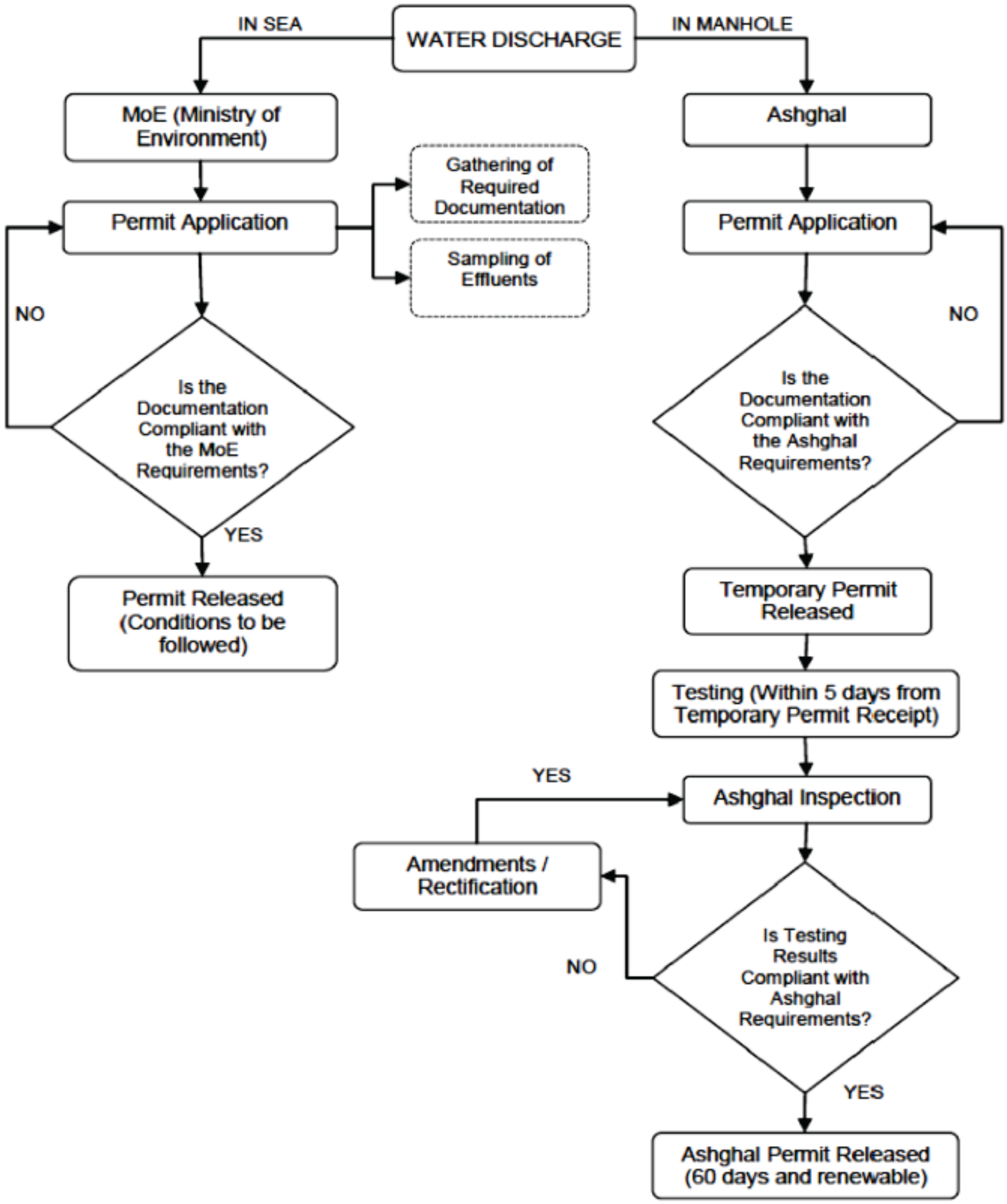

Figure 7: Water Discharge Permit Procedure

All drainage facilities will be regularly inspected and maintained. Sampling prior to and during disposal to sewer or storm water line will be undertaken frequently to determine the characteristics of wastewater according to the Construction Environmental Management Plan.

2.3.5 Maintenance and Decommissioning of Dewatering System

After installation of the system and start-up of dewatering activities a daily check will be carried out on the generators, control panels, pumps and discharge hoses up to the discharge tank. Daily check will include the stand down time & maintenance of pumps and generators. A daily maintenance schedule of pumps and generators will be developed by the subcontractor. The subcontractor’s staff will be on site 24 hours, even during holidays and non-working days, as the system cannot be stopped due to the possibility of rise in groundwater level.

When the construction works have been completed the Dewatering System will be decommissioned. A brief description of this process is pointed out below:

- Pumps and associated hoses will be removed from all pumping wells
- Pumping wells will be backfilled with a cement grout that is trimmed into place (the grout will need to flow into gravel surround as well as filling the PVC casing). The grout will be used to fill the casing to approximately 1m below ground surface
- PVC casing will be cut off below ground surface
- Remaining space between the casing backfill and the finished ground level will be backfilled with engineered fill in accordance with Qatar Construction Specifications 2010 (QCS) section 6, part 3.3.2 (Roadworks – Earthworks – Fill Material)

2.3.6 Monitoring and Countermeasures

The observation wells/piezometers will be installed to monitor and observe the groundwater level outside the pit. For the monitoring of the ground water level the following principle will apply:

- Records will be maintained containing elevation readings and groundwater levels in the observation wells and piezometers
- Observation wells and piezometers that become inactive, damaged or destroyed, will be repaired or replaced within 24 hours

Groundwater monitoring shall be performed for a period of minimum 4 weeks before any dewatering takes place at a given site and until any influence of the dewatering has ended. Piezometers will be used to verify assumption of the hydraulic design and control the groundwater drawdown. Piezometers shall be removed and/or backfilled when no longer required.

The minimum measurement frequencies of the leveling sections will follow the schedule in Table 2.

Description	Normal Frequency	Attention Frequency	Alarm Frequency
Before excavation works	1/week	-	-
During excavation works	6/week	7/week	14/week
After completion of the excavation	2 /week	7/week	14/week
After completion of final lining	1/week for 3 months	Will be defined by design according to conditions	Will be defined by design according to conditions
Termination/Handover	3 months after completion of final lining	Will be defined by design according to conditions	Will be defined by design according to conditions

Table 2: Minimum Measurement Frequencies

2.3.7 System Risk Assessment & Protection Measures

To ensure dry conditions for the excavation it is essential that the Dewatering System operate reliably to maintain the drawdown at least 1m below excavation level. The use of combined drain and deep pumping system limits risk to the project in case of breakdown of a pumping well as described previously. Additionally, the pumping capacity of each pump is more than required to allow groundwater drawdown to the required levels. The conclusion from this is that the system is relatively unaffected by a single well stoppage, although local drawdown may give cause for concern if this condition lasts for more than a few days.

In case of stoppage of any wells prompt review of the situation and repairs will be started. Stoppage of several adjacent wells will be responded and addressed promptly to prevent the groundwater to rise up. The principal concern requiring rapid response would be a significant rupture of the header main. Rapid response will be needed partly to re-establish drawdown but possibly more importantly to prevent excessive water leakage around the excavation.

The main protection measures involve locating the system away from obstructions and ensuring that only planned crossing routes for haul roads and lifting operations are used.

Good quality material will be used to prevent the rupture of header main. Sufficient valves will be provided in the header to permit addition or removal of portions of the system without interrupting operations in the remainder wells. Valves will also be located to permit isolation of a portion of the system in case of rupture.

2.4 Tools and Equipment Required

The following equipment will be deployed on site to carry out the activities explained before:

- Mobile Crane
- 15 Kw Electrical Submersible Pumps
- Sedimentation Tank with 3 stage weir and “V” notch (4.0m x 2.1m x 2.1 m)
- Generator
- Control Panel
- Distribution Board
- Hand Tools

2.5 Materials Required

The following materials will be used for the execution of the works:

- 6” PVC Lay Flat Discharge Hose
- 6” Fittings including connectors
- 6” Heavy duty rubber suction hose
- Valves
- Electrical cables

2.6 Personnel Required and Designated Responsibilities

The dewatering activities will be carried out by ISG JV and a selected subcontractor. The responsibilities of ISG JV are to supervise, to provide drawings and required documents for the execution of works and to coordinate the works. The subcontractor will handle the installation process and the maintenance of the system according to ISG JV requirements.

The key personnel are shown below:

JOB STATUS	QUANTITY
Construction Manager	1
Production Manager	1
Plant Manager	1
Site Engineer	As required
Site Foreman/Supervisor	As required
Health and Safety Manager / team	As required
Environmental Manager / team	As required
QA / QC Manager / Team	As required
Chief Surveyors / Survey Team	As required

Table 3: ISG JV Key Personnel

JOB STATUS	QUANTITY
Operations Manager	1
Superintendent	1
Foreman/Supervisor	As required
Mechanics	As required
Electricians	As required
Operators	As required
Riggers	As required
Banksman	As required
Workers	As required

Table 4: Subcontractor Key Personnel

ISG JV will assure that all personnel involve in carrying out the works will:

- Be given a safety induction prior to starting the site activities
- Operate safely the equipment. Machine operators will be qualified and experienced

2.7 Risk Management

Risk management is a necessary part to be tackled in any given activity within any given project. The main stages that described this process are shown below in Figure 8:

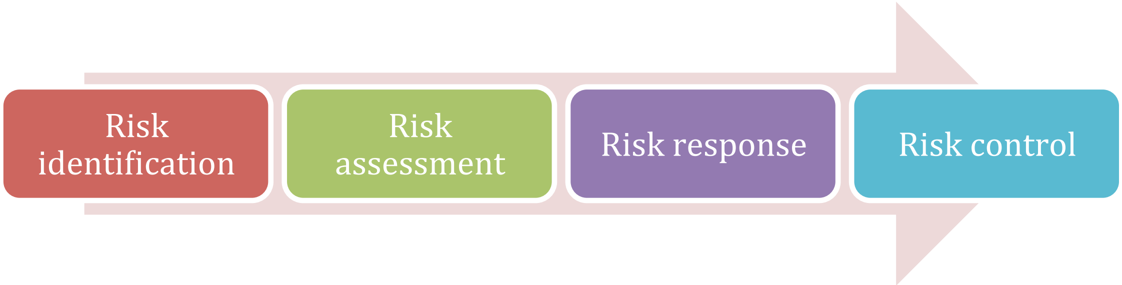

Figure 8: Risk Sequence

The first step to ensure an efficient Risk Management is to identify correctly the potential risks. To find out the relevant risks within this work several technics were used: Brainstorming, Risk Breakdown Structure and Analysis of Previous Experiences.

Since the focus of this report is related to the Work Method Statement Document strategic risks regarding Subcontractors, Suppliers and other external agents were not studied; however in the conclusions some important comments regarding this particular will be pointed out.

During the elaboration of the Dewatering WMS risks related to Health & Safety and Environment were deeply studied and analyzed

2.7.1 Health & Safety and Environment

All the operations relevant to the dewatering activities must be programmed and executed in a safe manner complying with all the regulations, so as not to cause danger, inconvenience or interference to the general public or other contractors working on site.

In order to cope with the risks that might occur during the implementation phase a Risk Assessment and Hazard Analysis was performed. Previous experiences in similar projects as well as assumptions concerning the new sources of hazards were putted in place to create a rating system. The rating system is based on the probability of occurrence and degree of consequences of a given situation. See Figure 9.

Severity Wheighting (P x C)	
1 to 3	Low (L)
4 to 9	Medium (M)
10 to 25	High (H)

		DEGREE OF RISK CONSEQUENCES				
		1- Very Low	2- Low	3- Medium	4-High	5-Very High
PROBABILITY OF OCCURRENCE	1-Improbable	1	2	3	4	5
	2- Remote	2	4	6	8	10
	3- Occasional	3	6	9	12	15
	4- Probable	4	8	12	16	20
	5- Frequent	5	10	15	20	25

Figure 9: Risk Rating Matrix

Once the rating system was defined and the relevant risks identified it was possible to measure their impact and established the mitigation actions to avoid or diminished their effects; see Annex 6 and 7.

3. Installation & Control of the Dewatering System at Al Wahda Station

The main challenge during the installation and commissioning of the Dewatering System at Al Wahda was that initial calculations regarding needed capacity were highly underestimated. Consequently, my task was to coordinate and manage the required modifications in order to comply with the real capacity needed. At the beginning Al Wahda Station was supposed to have 26 deep wells and 26 submersible pumps of 11Kw respectively, after the new calculations Al Wahda ended up requiring 41 deep wells and 41 submersible pumps of 22 Kw respectively. Total capacity increase from 1716 m3/h to 4510 m3/h.

The new system configuration required urgent actions in 4 main areas:

1. Dewatering Pipes
2. Sedimentation Tanks & Discharge
3. Water Measurements
4. Cost Control

3.1 Dewatering Pipes

In the Dewatering WMS was stated that flexible rubber hoses of 150 mm of diameter would integrate the pipes system. The increase in the overall capacity showed that the hoses were not adequate. After several meetings with the dewatering responsible the solution that we adopted was to acquire and install HDPE pipes of 355 mm of diameter. In Figure 10 is possible to observe the difference between the old blue flexible hoses and the new HDPE pipes.

In order to start with the installation of the HDPE pipes I made a drawing with the schematic position of the dewatering lines and the pumps that had to be connected in each one of them; see Annex 1. The system will be integrated by 5 principal dewatering lines and three emergency pipes.

Figure 10: Replacement of Dewatering Hoses

To carry out this job the following methodology was defined:

1. A trench of 1m x 1m must be excavated to keep the pipes underground. The purpose of this was to maintain a good mobility around the excavation area and keep protected the dewatering lines.
2. Once the trench was opened the pieces of pipe (12m long each one) were positioned and the welding process started.
3. After the welding was completed the line was checked to detect any failure joint and then the pumps were connected to the system.

Due to the urgency of the work and the lack of equipment and skilled labor force a contract agreement for the welding process was signed with a subcontractor. Figure 11 shows the installation process.

Figure 11: Installation of HDPE pipes

With this arrangement of pipes the system was capable of reaching the new required capacity and furthermore, in case of need, a higher flow could be managed without doing any other modification.

3.2 Sedimentation Tanks & Discharge

Originally, the subcontractor, proposed the installation of four sedimentation tanks with the dimensions specified in Annex 2. Due to the increase in the water flow tanks capacity were insufficient. To solve the problem two approaches were adopted:

1. Increase the flexibility of the system by developing an anti-overflow mechanism.
2. Install an additional tank to increase the capacity of the system.

One of the main characteristics of the dewatering process is that the flow is not constant since it depends on the accumulation of underground water. Due to this fact during peaks some tanks were constantly in overflow. The fastest and most economic solution was to connect the four tanks in order to create a waterfall effect. Annex 3 shows the design that I proposed.

Tanks were located at a distance of 0.5m from each other. Between the first tank and the last one a difference in high of 0.950m was created to ease the flow of water. The highest tank was receiving the highest amount of water while the lower one, which was not connected to any dewatering line, worked like a buffer. Is important to notice that each of the four tanks were connected to booster pumps in order to send the incoming water to the final discharge area. This system proves to be very efficient and no overflow took place after its implementation; see Figure 12 below.

Figure 12: Anti-overflow Mechanism

The second action taken was to install an additional tank with a superior capacity. The most convenient solution was to modify one of the warehouse shipping containers. The 40 feet cargo container was reinforced to withstand seawater. Figure 13 shows the final arrangement.

Figure 13: Final Dewatering Tanks Arrangement

Last but not least, the types of booster pumps used for the final discharge had to be modified. Initially, the subcontractor supplied mechanical booster pumps that worked with diesel. The fact that the pumps were refilled within a short gap of time became a problem for the workers, especially during the night shift. In order to solve this situation it was decided to acquire new electric pumps. Electric pumps helped not only to increase the reliability of the system but also helped to decrease the level of noise contamination within the tanks area.

3.3 Water Measurements

One of the key activities of the monitoring process was the water level and water flow measurements. The water level was effectively measure with the piezometer procedure described previously in the WMS. Water flow measurements were extremely important because it showed detail information regarding the behavior of each pump, however the measurement procedure was not effective.

During the first phase of the Dewatering System installation each rubber hose was provided with a flow measurement point. A flow measurement point was composed by a metal joint in which a flowmeter was connected (rubber surfaces were not appropriate for this purpose). The instrument used was a Dwyer PUF-1001 Flow Meter, see Figure 14.

Figure 14: Dwyer PUF Flowmeter

The main problems with the previous procedure were:

1. Measurements were not accurate due to the irregularity of hose's arrangement (i.e. lack of long straight sections).
2. The connection of the flowmeter in each measurement point lasted on average 10 minutes. This time multiplied by the 41 dewatering pumps made the process extremely long.
3. Measurement points were not reachable any more due to the fact that rubber hoses were replaced by underground HDPE pipes.

The easiest solution for the above problem would have been to install flowmeters in each well, however due to the disposition of the wells it was difficult to make the installation. At the same time, this option was not attractive from an economic point of view.

After discussing and brainstorming with the technical department we came up with a quicker and less expensive alternative. The new water flow measurement procedure was based on electric current readings from each pump. Once the current readings were taken, the results were extrapolated using pump's performance curve to get a water flow value. Annex 4 shows a table that summarizes the previous process.

The advantages of this new approach were:

1. Decrease of the overall flow measurement time due to the fact that current readings were done in few seconds.
2. Flow measurements were performed even though HDPE pipes were located underground.
3. Extra costs were negligible.

Although most of the outcomes of the solution were positive there was a 10 to 15 percent inaccuracy in the final flow measurements. Nevertheless, this level of inaccuracy was acceptable because the idea of this control was to have an overall picture of the system in a short period of time. If the obtained data was too inconsistent further analysis were performed in the required pump.

3.4 Cost Control

Due to the fact that the Dewatering System was redesigned cost control became a key issue. The initial contract price was adjusted according to the new requirements. Moreover, the subcontractor agreed to provide all the extra material needed.

In the practice subcontractor's performance was really poor. The quality of the jobs done were not aligned with ISG JV standards so extra supervision and manpower had to be supplied. Furthermore, the subcontractor failed on supplying the needed material on time.

To cope with this problem ISG JV decided to provide all the extra material to finish the works in the due date. The costs related to this particular were deducted from the contract price since this was supposed to be subcontractor's responsibility. To identify these costs I worked together with the Procurement and Warehouse Departments. In a monthly basis I grouped and divided, according to the type of material and location, all the relevant costs to be deducted. Annex 5 shows a table with cumulated costs until the month of May.

Conclusions

The experience acquired during the installation and commissioning of the Dewatering System proved that the Work Method Statement is an efficient tool to coordinate works and reach the highest Health & Safety and Environment levels. Notwithstanding, as it was explained in this report, several modifications were done in order to cope with unforeseen situations.

Due to the initial miscalculations the installation and commissioning of the Dewatering System were characterized by day-to-day uncertainties and problems. Therefore, managerial skills were extremely important to comply with the due date. My contribution was focused in: Technical support (i.e. WMS definition, CAD drawings, flow calculations and system capacity estimations), definition of work methodology, managing of personnel and monitoring of subcontractors.

Every big construction project deals with uncertainty, delays and conflicts within stakeholders. RLNU project was not exempt of this, in fact, according to my observations some of the Qatar working conditions made these problems even more risky:

1. Supplier's reliability is very low. Often delivery times are not respected and variety of products is poor compared to other markets. Most of the time products have to be acquired outside of the country.
2. Subcontractor´s performances are never as good as expected. Bargaining power is normally on subcontractor´s side so the enforcement power from the client is low. It is very difficult to end a contract agreement even if there are proves of non-compliance.
3. On average the quality of the labor force is very low.

At the moment RLNU project is at the end of its initial phase. The first Tunnel Boring Machine (TBM), named "Lebretha", was satisfactory launched at Al Wahda Station in July 2014 and therefore the excavation of the first tunnel has begun.

To conclude I would like to add that this experience was extremely enriching and challenging. I was able to apply several concepts and methodologies studied during the Master in Management Engineering directly into the work field. The scope of knowledge acquired was not only related to the Dewatering System, but also I had the opportunity to follow up closely the assembly of a Tunnel Boring Machine. Moreover, during these 6 moths I was capable to understand the dynamics within a civil construction project.

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OFSC, 2010. ***"Guidance for producing Safe Work Method Statements (SWMS)"***. Department of Education, Employment and Workplace Relations, Canberra.

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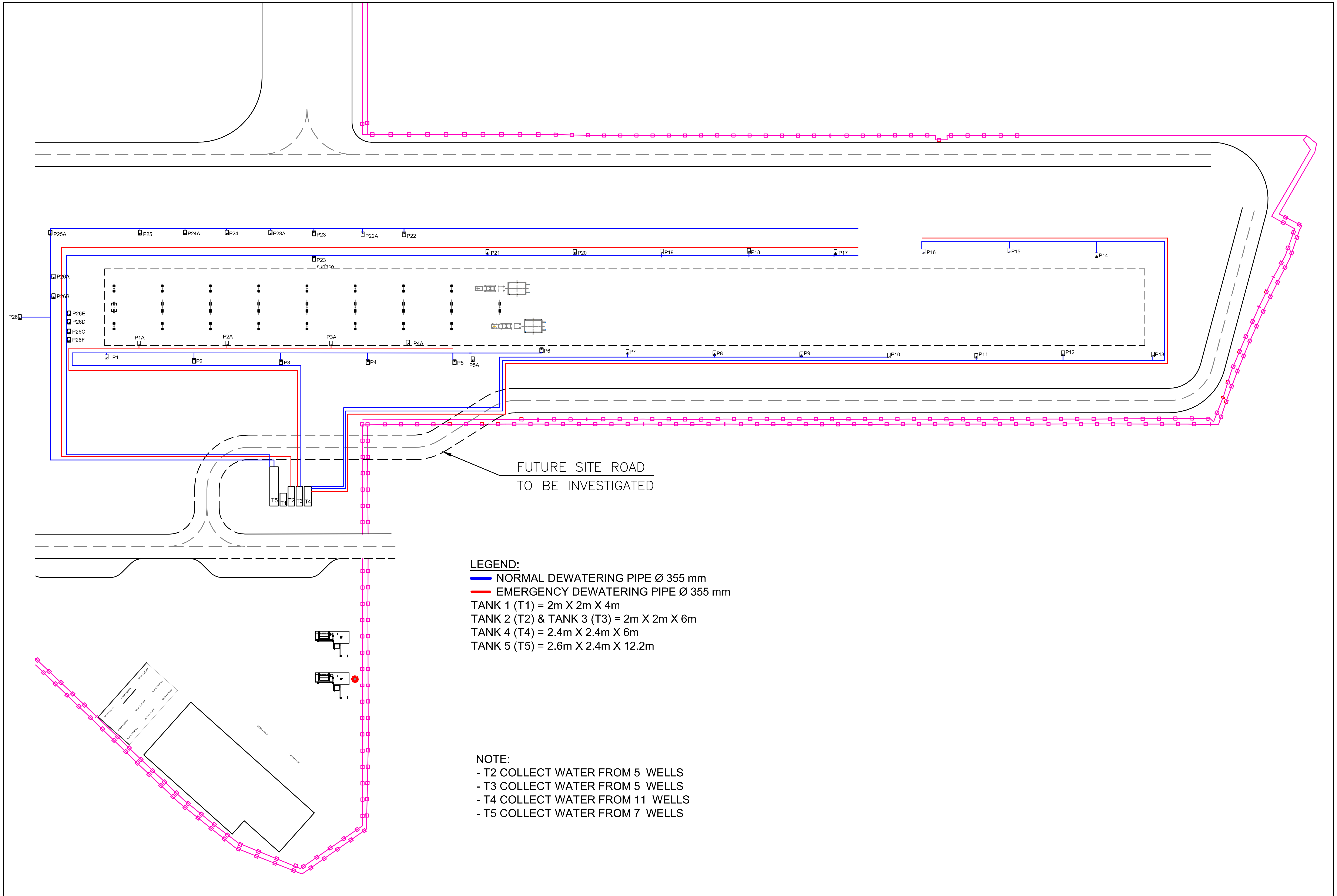
Annexes

Dewatering Lines Al Wahda



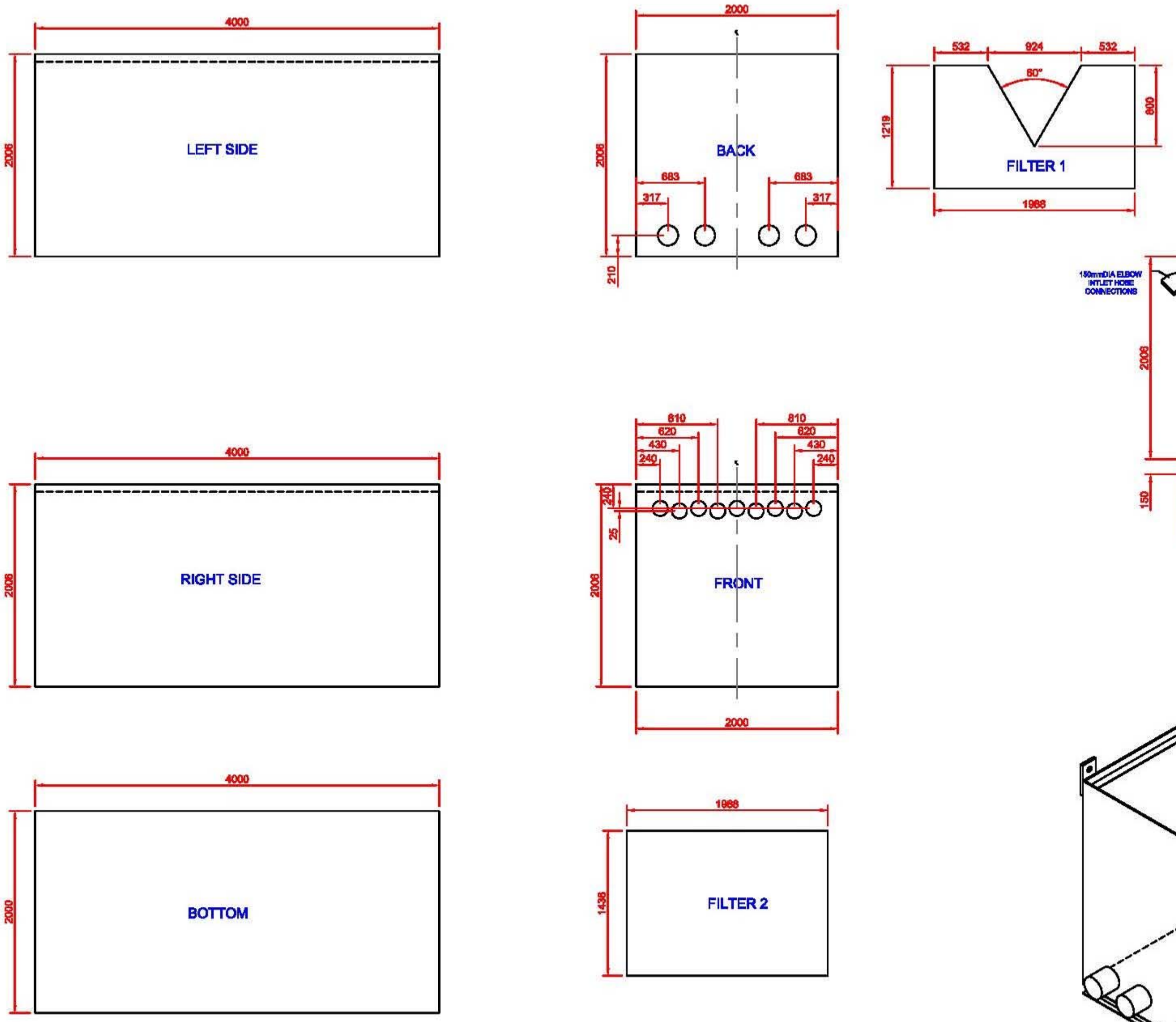
LEGEND:

- NORMAL DEWATERING PIPE Ø 355 mm
- EMERGENCY DEWATERING PIPE Ø 355 mm

TANK 1 (T1) = 2m X 2m X 4m
TANK 2 (T2) & TANK 3 (T3) = 2m X 2m X 6m
TANK 4 (T4) = 2.4m X 2.4m X 6m
TANK 5 (T5) = 2.6m X 2.4m X 12.2m

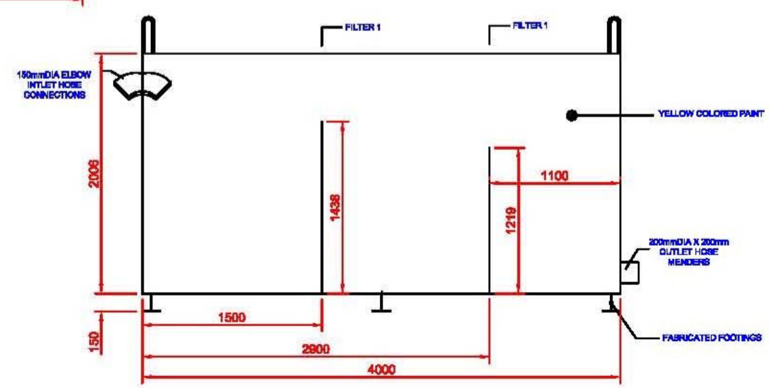
NOTE:
- T2 COLLECT WATER FROM 5 WELLS
- T3 COLLECT WATER FROM 5 WELLS
- T4 COLLECT WATER FROM 11 WELLS
- T5 COLLECT WATER FROM 7 WELLS

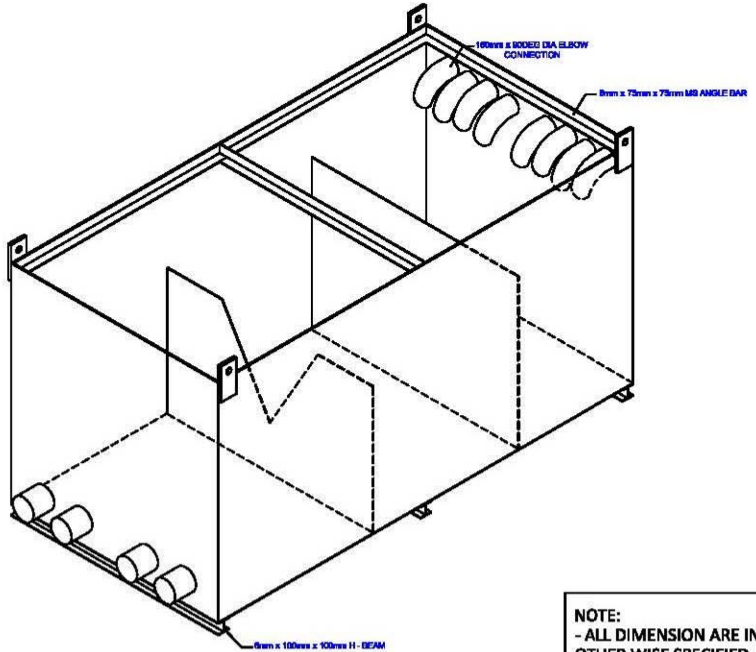
Sedimentation Tank Dimensions



ESTIMATED MATERIALS:

1. 3.0 SHT - 6mm x 6000mm x 2000mm MS PLATE
2. 1.0 SHT - 6mm X 2438MM X 1219MM MS PLAT
3. 3.0 LENGTH - 6mm X 75mm X 75mm X 6m MS ANGLE BAR
4. 9.0 PCS. - 150mm DIA ELBOW
5. 2.0 PCS. - 200mm HOSE MENDER



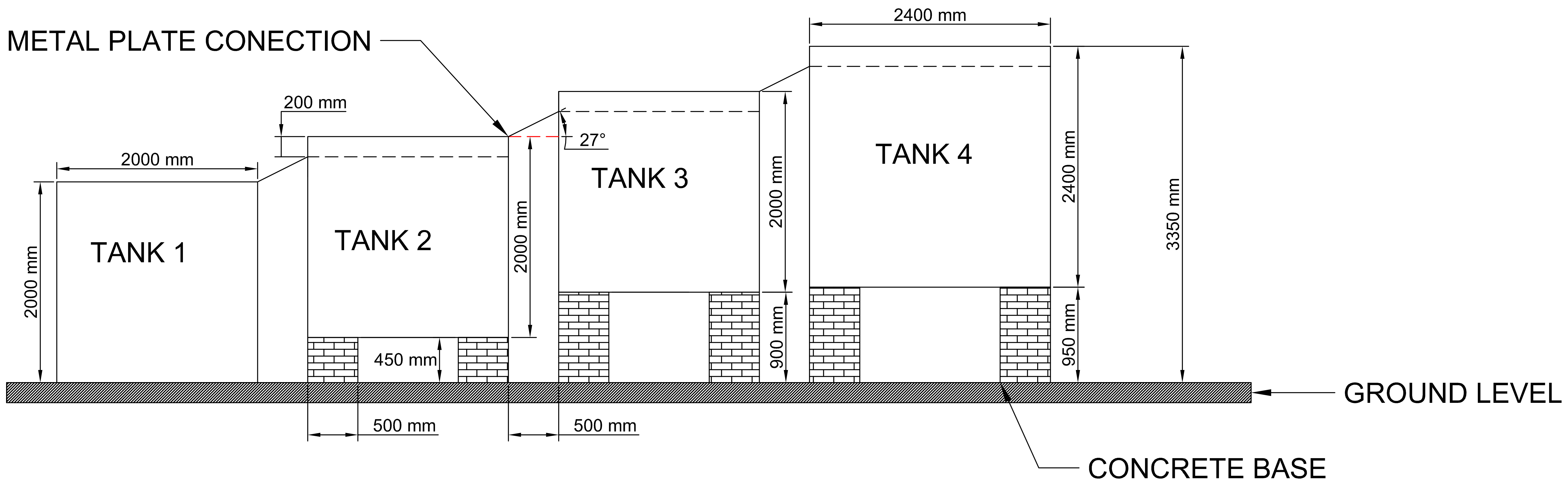


NOTE:
- ALL DIMENSION ARE IN MILLIMETER OTHER WISE SPECIFIED

UNITED EQUIPMENT GROUP INDUSTRIAL AREA, STREET 39 GATE 39 PO.BOX 5673 DOHA QATAR TEL: NO. 4606413 FAX: NO. 4602395 EMAIL: UNIQUIP @QATAR.NET .QA	DRAWN:	NEIL BASINANG	NOVEMEBR 10, 2011	PROJECT TITLE:	CUSTOMER:		
	CHECKED:	RAMI ABUMAALI	NOVEMEBR 10, 2011	SEDIMENTATION TANK (4.0m X 2.0m X 2.0m)	----		
	DIVISION:				FILE NO.:	REV.	SHEET NO.
	DEWATERING				UEW---	0	1/1

Sedimentation Tanks Arrangement

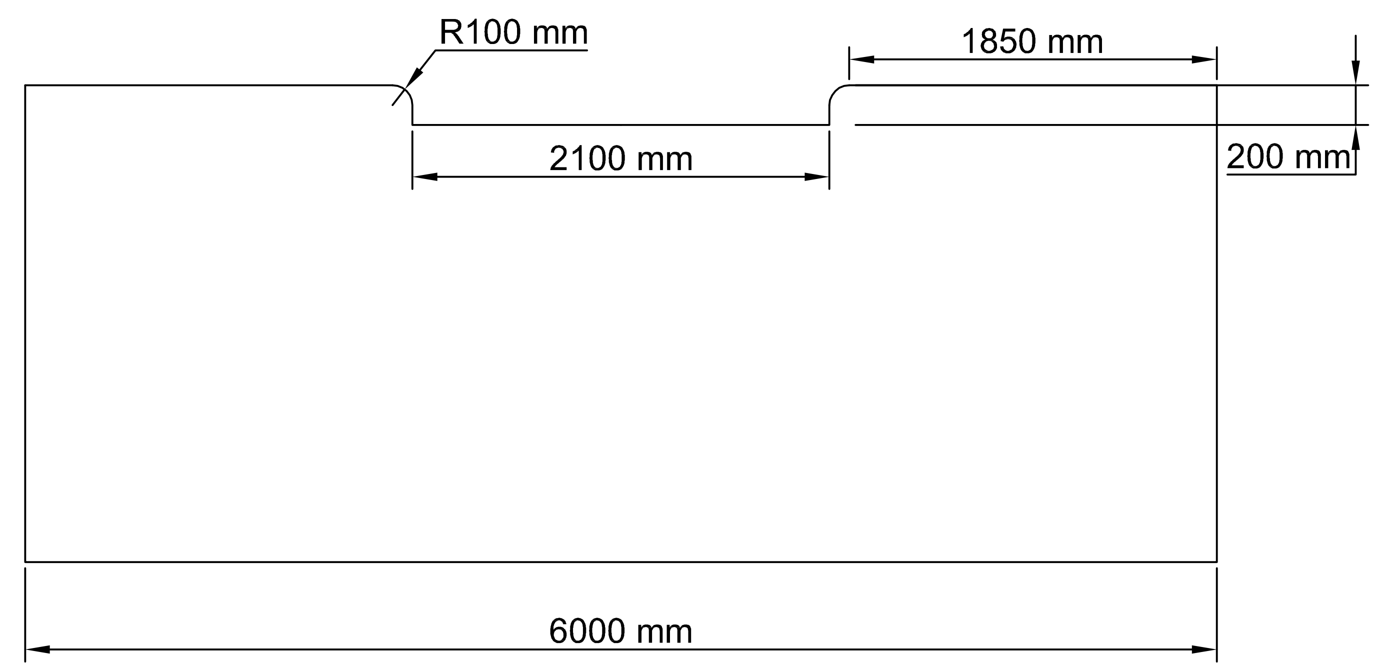
FRONT VIEW



DIMENSIONS

TANK 1 (2000 X 2000 X 4000)
TANK 2 (2000 X 2000 X 6000)
TANK 3 (2000 X 2000 X 6000)
TANK 4 (2400 X 2400 X 6000)

DETAIL "A" LATERAL VIEW (LEFT SIDE OF TANKS 4,3 & 2)



Water Flow Measurements

PUMP 22kw AL WAHDA	RED (A)	YELLOW (A)	BLUE (A)	Average A	KW output	Q estimate m³/h
1	39.3	39.2	39.8	**39**	**23**	**128**
2	38.2	38.2	38.2	**38**	**23**	**115**
2A	31.9	32	31.8	**32**	**19**	**61**
3	37.5	37.4	37.4	**37**	**22**	**108**
3A	36.5	36.4	36.4	**36**	**22**	**99**
4A	36.1	36.5	36.3	**36**	**22**	**97**
EXTR.	37.1	37.2	37.2	**37**	**22**	**105**
5	36.5	36.4	36.5	**36**	**22**	**99**
6	36.1	36	36.2	**36**	**22**	**96**
7	26.1	25.8	25.9	**26**	**15**	**24**
8	38	37.9	37.8	**38**	**23**	**112**
9	38.3	38.3	38.2	**38**	**23**	**116**
10	35.6	35.6	35.5	**36**	**21**	**91**
11	43.2	43.1	43.5	**43**	**26**	**170**
12	40.1	40	40.2	**40**	**24**	**134**
13	37.2	37.3	37.2	**37**	**22**	**106**
14	33.5	33.4	33.1	**33**	**20**	**72**
15	37.4	37.3	37.5	**37**	**22**	**108**
15A	38.1	37.9	37.8	**38**	**23**	**113**
16	35.9	35.2	35.2	**35**	**21**	**90**
17	36.1	36	36.1	**36**	**21**	**95**
18	28.2	27.3	27.7	**28**	**17**	**34**
19	33	33.3	33.1	**33**	**20**	**71**
19A	35.2	35.2	35.3	**35**	**21**	**88**
20	38.1	38.2	38.1	**38**	**23**	**115**
EXTR.	26.2	26.2	26.1	**26**	**16**	**25**
EXTR.	38.2	38.1	38	**38**	**23**	**114**
EXTR.	33.4	33.3	33.1	**33**	**20**	**72**

Total 22 KW	**2654**	m³/h
Average pump	**95**	m³/h

Total 22KW + 11 KW	**2858**	**m³/h**

Total EXTR	**339**	**m³/h**

PUMP 11 KW AL WAHDA	RED (A)	YELLOW (A)	BLUE (A)	Max A	KW output	Q estimate m³/h
25	11.3	11.2	11.2	**11.3**	**6**	**7**
26	12.8	12.7	12.5	**12.8**	**7**	**14**
27	12.2	12.2	12.3	**12.3**	**7**	**12**
28	13.1	13.2	13.1	**13.2**	**7**	**17**
29	12.8	12.9	13.1	**13.1**	**7**	**16**
30	14.7	14.5	14.8	**14.8**	**8**	**27**
31	11.5	11.4	11.4	**11.5**	**6**	**8**
32	11.3	11.2	11.4	**11.4**	**6**	**7**
33	12.8	12.7	12.6	**12.8**	**7**	**14**
34	10.9	11.1	11	**11.1**	**6**	**6**
35	12.1	12.3	12.4	**12.4**	**7**	**12**
36	11	11.2	11.1	**11.2**	**6**	**6**
37	12	12.1	12.3	**12.3**	**7**	**12**
38	12.1	12	12.2	**12.2**	**7**	**11**
39	12.3	12.3	12.4	**12.4**	**7**	**12**
EXTR.	14.1	14.2	14.2	**14.2**	**8**	**23**

Total 11 KW	**203**	m³/h
Average pump	**13**	m³/h

Cost Control Table

ISG

List of materials provided by ISG JV to United Equipment Group

Red Line North Underground

20/5/2014

Item	PR No	P/O No	Type of Material	QTY	Welding Cost (QAR)	Material Cost (QAR)	Sub-Total (QAR)
AL WAHDA WELDING HDPE							
1	3100227895	4100540389	Pipe HDPE Dia. 315 mm (external)	1000 m	12,420.00	122,401.14	134,821.14
2	3100227895	4100540389	Pipe HDPE Dia. 355 mm (external)	5000 m	86,163.75	772,800.00	858,963.75
3	3100228776	4100542286	Pipe HDPE Dia. 355 mm	2750 m	39,675.00	409,750.00	449,425.00
4	3100228776	4100542286	Pipe HDPE Dia. 355 mm	1000 m	N/A	149,000.00	149,000.00
MANIFOLDS							
5	3100228777	4100542582	Manifold Dia. 355	8	N/A	11,280.75	90,246.00
6	3100228777	4100542582	Manifold Dia. 315	6	N/A		26,880.00
AL DIWAN PVC PIPE							
7	3100228180	4100540736	PVC Pipe Dia. 500 mm	588 m	N/A	132,300.00	132,300.00
AL BIDDA PVC PIPE							
8	3100229683	4100544081	PVC Pipe Dia. 500 mm (internal wells)	156 m	N/A	35,100.00	35,100.00
9	3100229683	4100544081	PVC Pipe Dia. 500 mm (pump test)	70 m	N/A	15,750.00	15,750.00
10	3100229683	4100544081	PVC Pipe Dia. 500 mm (external wells)	104 m	N/A	23,400.00	23,400.00
AL WAHDA FLAT PVC WITH REFORCE							
11	3100229263	4100543223 4100542887 4100542880	Flat PVC with reforce 8 bar, 8" hose	14 rolls of 100 m	N/A	86,982.00	86,982.00
CENTRIFUGAL PUMPS AL WAHDA							
12	3100232954		Centrifugal Pumps	2		78,700.00	157,400.00
SEDIMENTATION TANK							
13	N/A	N/A	Sedimentation Tank 40'	1	N/A	15,000.00	15,000.00
CABLES							
14	3100222037	4100531247	Cu Cable 5X10 sq.mm	600 m	N/A	3,036.00	3,036.00
15	3100222037	4100531247	Cu Cable 1X70 sq.mm	960 m	N/A	5,760.00	5,760.00
16	3100222037	4100531247	Cu Cable 1X120 sq.mm	80 m	N/A	808.00	808.00
17	3100222037	4100531247	Cu Cable 1X185 sq.mm	390 m	N/A	5,935.80	5,935.80
SOCKETS + PLUGS							
18	3100230762	4100545577	Socket + Plug 63A	26	N/A	3,042.00	3,042.00
CONTROL PANEL AL WAHDA							
19	3100226642	4100543315	Control Panels	4	N/A	21,020.87	84,083.48
CONTROL PANEL AL BIDDA							
20	3100226642	4100543315	Control Panels	4	N/A	21,020.87	84,083.48
AL WAHDA BOOSTERS							
21	3100230375	4100544584	Booster pump 22 Kw	5	N/A	220,625.00	220,625.00
TOTAL (QAR)							**2,582,641.65**

Health & Safety Risk Assessment

Item	Activity	Hazards	Initial Risk	Precautions	Final Risk	Responsibility	Monitoring Responsibility
1.	General Education and Training	The operator or the worker itself is considered as a hazard if not inducted with the H&S standards.	High	Safety induction prior to commencing the works. Ensure everyone should attend the training and is competent to perform the job	Low	ISG Site Supervisor/Safety Officer	ISG Plant/Production/Construction Manager
2.	General Site Activities	Incorrect selection of the equipment (overall dimensions and operating performances) causing difficulties/ impossibility in performing the job or interference with activities /operating machinery.	Medium	Check / Verify that the equipment to be used is suitable to perform the job in relation to the workplace conditions. All activities will be coordinated in advance	Low	ISG Site Supervisor	ISG Production / Construction Manager
2a.	General Site Activities	Presence of simultaneous activities causing interference between equipment	Medium	Activities to be planned in advanced with regards to the area of intervention and equipment to be used.	Low	ISG Site Supervisor	ISG Production / Construction Manager
2b.	General Site Activities	Working in hot environment causing dehydration of site personnel. Contact with dust. Presence of other activities. Working in partial or full absence of light.	High	Allow for appropriate lighting facility when natural light is not available. Provide adequate site water and isotonic drinks supplies. Work as per Health Agency recommendations. Carry out regular health checks on site personnel . Allow for a site emergency vehicle. Maintain emergency contact. Safety training to personnel. Workers to wear appropriate PPE at all times. Work program will be submitted to the site responsible. All activities will be coordinated in order to avoid interferences.	Low	ISG Site Supervisor	ISG Production / Construction Manager
2c.	General Site Activities	Hot works (welding, gas cutting, etc.) causing fire, explosion or burns	High	Hot works to be carried out only under a hot works permit system. Experienced personnel to perform hot works on site. All hot works and electrical equipment to conform to ISG safety plan. Additional PPE to be worn according to work being carried out. Protection (fire blankets, etc.) to vulnerable equipment to be provided as	Low	ISG Site Supervisor	ISG Production / Construction Manager

				required. No smoking near any hot work activity, sites to have designated smoking areas. Regular inspection of the equipment/tools. Cylinders for welding & cutting should be stored properly in the designated areas on site. All cylinders must have proper safety devices such as flashback arrestors, safety gauge, etc.			
3.	Working at Night	Personnel /Plant may get hit by vehicular traffic due to poor visibility.	High	Ensure sufficient lighting in and around working areas. High visibility vest should be worn by workers at all times.	Low	ISG Site Supervisor	ISG Construction Manager
4a.	Mobilization / Demobilization of plant and equipment to/from site	Proximity to public roads causing accidents and injury to site personnel and third parties. Objects falling from lifting equipment. Sudden failure of wire rope / chain & hydraulics / mechanical system. Injury to the personnel & property damage by manual handling. Material falling from vehicles run over/stacked/crushed by a vehicle Injury by vehicle door opening / closing. Poor lighting. Poor ground / road condition.	High	Study route and site features before mobilization to assess potential hazards. Prepare plan for delivery of plant and equipment on site. Assess impacts on local traffic. Induction to machine operator and mobilization team. Follow road safe procedures when occupying public roads. Workers to wear appropriate PPE at all times. Ensure that lifting equipment and gears are in good working conditions and lifting operation is managed safely (3rd party certification). Valid 3rd party certificate for operators, riggers. Experienced personnel to be employed for the activity. Personnel to wear appropriate PPE (Safety Helmet, Shoes, High Visibility vest, Hand Gloves) at all times. Ensure all loose items are removed or secured and all materials should be properly stacked. Appropriate number of banksman to be present during the activity. Personnel movement to be controlled by	Low	ISG Site Supervisor	ISG Plant/ Production / Construction Manager

				banksman and proper access / egress route. Ensure all doors are locked properly and no persons behind when opening / closing the door. Ensure adequate lighting facility. Ensure proper access/egress and barricade in work location.			
4b.	Movement of Plant / vehicles	Simultaneous activity causing mutual interferences. Hit by moving machinery. Collision between moving equipment. Loose clothing becoming entangled in moving parts. Operation of mobile cranes, and drilling machine in narrow space causing vehicle collisions and injury/fatality to personnel.	High	Simultaneous work activities and site logistics to be planned in advance. Only qualified plant operators to be deployed. Set layout to minimize the reversing activities. Equipment on site to reverse under the control of a trained and designated banksman. Ensure the reverse alarm properly working on all plant/vehicle Plant operators to have 360 degree visibility around the machine. Signal / Eye contact with the operator while passing near the mobile plant. Personnel to wear high visible vest at all times when working on site. Enforce speed limit on site. Provide safety path/access. Loose clothing to be kept clear of moving parts of power tools.	Low	ISG Site Supervisor	ISG Plant/ Production / Construction Manager
4c.	Use & Maintenance of Plant and Equipment	Blockages, breakdown and/or damages of equipment and plants. Malfunctioning of plants and equipment. Loose connections causing injury to operative and other personnel.	High	Maintenance to be ensured on a regular basis. Check the equipment prior to starting works. Only competent person to operate the equipment. Only competent person to repair and/or maintain the equipment.	Low	ISG Site Supervisor	ISG Plant/ Production / Construction Manager
	Lifting of	Failure of lifting gears or equipment and/or tilting. Load colliding with existing		Lifting plan to be studied prior to commencing the site activities. Lifting Permit & Lifting Plan forms to be completed by a competent person. Use examined / tested / inspected lifting equipment. Ensure trained operator/rigger for lifting works.			ISG Plant/

5a.	materials/tools/ equipment	structure. Overloading of the crane. Crane overturning. Spin of load. Moving lifting equipment hitting personnel during loading/unloading. Fall of material causing injury/death of personnel. Working at height	High	Use competent lift supervisor and one assistant for feedback. Monitor the SLI to avoid overloading. Area at risk should be cleared and cordoned off prior to lift. Do not allow personnel to walk/stand under suspended loads. Add number of riggers. Use tag lines to control the load to be lifted. Crane to be designed for the load to be lifted. The safe working load and maximum working radius shall never be exceeded. Test radio communication between signalman, supervisor and crane. Ensure all loose items are removed or securely fixed to the equipment to be lifted. Safety Harness / Fall arrestor to prevent falling from height.	Low	ISG Site Supervisor	Production / Construction Manager
5b.	Manual Handling	Injury, cuts, abrasions while handling lifting materials. Manual handling/lifting causing back injury.	High	Supervisor to conduct toolbox talk, restrict lifting weight by hands to max 20kg. Follow safe procedure for manual lifting of objects to prevent injuries. If the load is beyond the capacity of single person to lift, provide additional team member to lift. When lifting load with more than two people, a communication team member will be employed for controlling the movement of load. In case of heavy loads to be lifted ensure appropriate equipment is used. Workers to wear appropriate PPE (Safety helmet, gloves and safety shoes) at all times.	Low	ISG Site Supervisor	ISG Plant/ Production / Construction Manager
6a.	Dewatering	Severe loss of ground leading to excessive surface settlement.	High	Program of ground investigation drilling and assessment of water pressures under the direction of Design Consultant has resulted in implementation of appropriate dewatering system. Daily measurement of groundwater levels. Design Consultant on call during excavation	Low	ISG Geotechnical Engineer/ ISG Design Consultant	ISG Engineering Manager / Construction Manager

				& dewatering activities. Contact numbers will be posted in Foreman's office. Adequate supply of construction materials available on site (sand bags, small wire mesh, trench sheets and bleeder pipes).			
6b.	Dewatering	Inadequate design of dewatering system causing base heave and overall instability.	High	The dewatering system designed by experienced team and proof checked internal party. Adequate supply of backfill material to be always available on site.	Low	ISG Geotechnical Engineer/ ISG Design Consultant	ISG Engineering Manager / Construction Manager
6c.	Dewatering	Dewatering system power failure causing base heave or box inundation. Manual Switchover of generator in the absence of light causing tripping hazard.	High	Dewatering system installed and maintained on a daily basis. Electrical power supply maintained and inspected by qualified electricians on a daily basis. Full time electrician provided for nightshift working. Spare pump to be always available on site in the case the one used breaks down. A standby power source in the form of a generator set to be available on site in the event of power failure from the main generator. Emergency Lighting / Torches to be provided in the power station area.	Low	ISG Geotechnical Engineer/ ISG Design Consultant	ISG Engineering Manager / Construction Manager
6d.	Dewatering	Insufficient capacity of dewatering system to handle groundwater management. Flooding	High	The dewatering system designed by experienced team and proof checked internal party. Implementation of monitoring plan and trigger levels according to monitoring design note. Dewatering system installed and maintained on a daily basis. Spare pump to be always available on site in the case the one used breaks down. Surface kicker built at station area top.	Low	ISG Geotechnical Engineer/ ISG Design Consultant	ISG Engineering Manager / Construction Manager
				Good quality header mains to be installed. Sufficient valves should be provided in the header to permit addition or removal of			

6e.	Dewatering	Rupture of header main	High	portions of the system without interrupting operation of the remainder of the system. Valves should also be located to permit isolation of a portion of the system.	Low	ISG Geotechnical Engineer/ ISG Design Consultant	ISG Engineering Manager / Construction Manager
7.	Installation of generator / pumps / pipe fittings	Fall of machinery from the edge. Entanglement of body part during operation. Cuts, abrasion injury to fingers and other body parts. Rupture of joints. Trip hazards.	High	The generators must be properly secured and should be placed at a safe distance away from the excavation edge. Locate the system away from heavy plant and material movements wherever possible and ensuring that only planned crossing routes for haul roads and lifting operations, with appropriate protection measures, are used. Deploy trained operator/rigger for installation works. Avoid loose clothing and keep the body away during the installation activity. Workers to wear appropriate PPE (i.e. gloves) at all times.	Low	ISG Site Supervisor/Site Engineer	ISG Plant / Production/ Construction Manager
8.	Installation of Electrical Feedings	Electrocution, fire.	High	Ensure that all the electrical installation are installed and connected by a trained and qualified person. A safety check, using a known and reliable voltage measuring or detection device, should be made immediately before work begins and whenever work resumes. Always use insulated tools and avoid all contact with bare terminals and grounded surfaces. Fuses, circuit-breakers and other devices must be correctly rated for the circuit they protect. Isolators and fuse-box cases should be kept closed and, if possible, locked. All the main Circuits must be provided with safety switches. Calibration of all equipment before start of work. Always work on a dead circuit. Use Lock Out/Tag Out	Low	ISG Site Supervisor/Site Engineer	ISG Plant / Production/ Construction Manager

				procedure. Appropriate Fire Extinguishers to be available on site.			
9.	Use of electric powered tools/welding	Use of power tools causing electrocution, eye injury, fire, explosion, burn s. HAVS (Hand Arm Vibration Syndrome) / Vibration White Finger (VWF)	High	Hot works shall only be carried out under a hot works permit system. All hot works and electrical equipment shall conform to ISG project safety plan. Additional PPE shall be worn according to work being carried out (fireproof gloves). Protection to vulnerable equipment shall be provided as required. Fire blankets etc. Routinely check electric powered tools with Portable Appliance Testing (PAT) process. Use of battery tool / equipment wherever possible. Reduced Vibration tools / anti-vibration handles to be used to prevent HAVS/VWF condition.	Low	ISG Site Supervisor/Site Engineer	ISG Plant / Production/ Construction Manager
10.	Grouting works (cement bentonite grout)	Splash of grout into eyes. Splash of grout material to skin. Splash of cleaning water/waste grout to body during pump cleaning.	Medium	Safety Officer to give COSHH briefing to all personnel involved in the task COSHH assessment to be implemented (see Appendix G Form). Wear eye goggles Equip eye wash nearby Equip washing water nearby Release pressure of pump before cleaning	Low	ISG Site Supervisor/Site Engineer	ISG Plant / Production/ Construction Manager

Environmental Risk Assessment

Item	Activity	Hazards	Initial Risk	Precautions	Final Risk	Responsibility	Monitoring Responsibility
1.	Mobilization / Demobilization of plant and equipment to/from site	Disturbance of residents by dust.	Medium	Speed limits shall be implanted inside work area as 10km/h. Application of water for dust suppression shall be done. Care shall be taken to prevent mud/dust being transported onto the public roads by vehicle wheels (provide wash bay).	Low	ISG Site Supervisor	ISG Construction Manager
2.	Mobilization / Demobilization of plant and equipment to/from site	Disturbance of residents by noise and vibrations caused by vehicles/equipment.	Medium	Equipment shall be fitted with noise suppressors, properly and efficiently working at all times. Coordinate the activities for periods in the day when the disturbance to the public will be minimized. Regular maintenance of plant by lubrication, tightening loose parts, replacing worn-out components shall be conducted to avoid increase in noise.	Low	ISG Site Supervisor	ISG Construction Manager
3.	Movement of Plant/vehicles	Visible particulate matter. Health hazards to workers/residents due to Dust.	Medium	Application of water for dust suppression shall be done in the accesses and if required in the excavated material. Minimize handling of dusty materials. Drop heights to lorries or skips to be kept to a minimum. Activities that potentially generate high dust levels shall be curtailed, suspended or postponed in situations where the wind direction and speed is causing adverse impacts on nearby sensitive receptors. Care shall be taken to prevent mud/dust being transported onto the public roads by vehicle wheels (provide wash bay).	Low	ISG Site Supervisor	ISG Construction Manager
				Good housekeeping. Collect all relative permits before starting the work. Before leaving warehouse all equipment shall be completely checked and sent to site only if			

4.	Site Activities	Soil and groundwater contamination	Medium	all parts are regularly working. Equipment preventative maintenance shall be performed on a daily basis. Fuel hydrocarbons and any other hazardous materials shall be stored at specifically designated, taped of areas inside a spillage tray. Spillage trays shall be located under the crankcases of engines, pumps and machinery. No equipment repairing shall be done on site. Smoke and fire shall be prohibited on site. Extinguishers shall be of sufficient number, size and required type to handle any potential fire hazard. Any hoses shall be fitted with protective closer to avoid any leakages. Do not wash with groundwater. Wear appropriate PPE; wash in clean water with soap before eating or drinking.	Low	ISG Site Supervisor	ISG Construction Manager
5.	Site Activities (Dewatering)	Land, ground and surface water contamination. Erosion and sediments. Waste Generation.	Medium	Pumped groundwater will not be discharged without prior consent from the Authorities During rainy season sediment controls are to be installed where required to prevent silt laden runoff reaching the municipality storm water network No waste will be disposed-off or buried on the site. All hazardous liquids will be stored in an impervious bund area where the volume of the storage bund is not less than 110% of highest tank capacity Design and construct hazardous waste storage and re-fueling area. Appropriate spill cleanup material to be kept adjacent to storage and maintenance area / mobile re-fueling tanks and generators/pumps. Provide drip tray for generators/pumps. Install sediment controls.	Low	ISG Site Supervisor	ISG Construction Manager

				Generators should be located away from sensitive receptors near medical facility, prayer areas etc. Water Samples to be taken and tested by an approved laboratory as per the frequency described in the relevant permit. Permit to be available on site and conditions understood by the site supervisors. Results of water testing to be analyzed and if required appropriate treatment to be implemented.			