Abu Dhabi’s super sewer

Deep tunnelling will commence in the Middle Eastern emirate of Abu Dhabi for the first time later this year in a new 40km sewer project reports Bernadette Redfern

When the government of Abu Dhabi first installed a sewage collection system back in the 1970s it could not have predicted the stratospheric growth that was to characterise the next four decades. From a population of around 156,000 in 1975, it is today approaching 1 million and the network of 50 pumping stations and mains that collect sewage and transport it to Mafraq treatment works is severely under strain. The result has been some surcharging of the gravity mains that feed the pumping stations and not surprisingly this had led to complaints from the public.

The organisation charged with managing and upgrading the sewer network is the Abu Dhabi Sewerage Services Company (ADSSC), formed in 2005, and until last year, a subsidiary of the Abu Dhabi Water and Electricity Authority (ADWEA).

Back in 2006 it undertook a masterplan which explored the potential issues that the emirate would face, along with proposing solutions for the network. “The original masterplan consultant GTZ Dornier called it a sewage time bomb,” explains ADSSC managing director Alan Thomson. “It predicted that by 2008 Abu Dhabi would face mass sewer flooding. I am delighted to say we have managed to prevent this so far and we will continue to do so until the final solution is in place,” he says.

Right: The 40km deep tunnel system has been divided into three contracts, one of which has been awarded

Below: A network of about 50 km of connecting sewers will feed into the main sewer tunnel

Masterplan

In 2007 the completed masterplan was revisited following the release of the emirate wide growth strategy, “Plan 2030.” This high level planning document set the strategic objectives for all government departments and, among other things, outlined expectations for a population of 3.1 million by 2030. A further separate independent check found the masterplan to meet all requirements for the new plan.

ADSSC’s masterplan envisaged that to meet such growth the best solution would be a deep sewer tunnel that would collect effluent and transfer it all to a single pumping station by gravitation. This would then move flows to a new sewage treatment works at Al Wathba. As implementing something on this scale was
were large enough to attract international tunnelling contractors but not too large that you put all your eggs in one basket," says Marshall.

Design and build

As with many tunnelling schemes, the client opted for a design and build approach, and estimates that this saved 12 months on the construction programme as it allowed TBM orders to be placed at contract award, enabling detailed design and shaft sinking to be done in parallel with procurement of the boring machines. Designs were produced to approximately 30 per cent complete for the tender documents to be issued. There are three other contracts, two for connecting sewers and one for a pumping station, and to date all six contracts have been tendered and bid.

So far only one contract has been awarded. Italy’s Impregilo picked up the AED 891 million (USD 246M), contact for the middle section of the sewer in September 2009. "This section has a 5m internal diameter and the three EPBMs will be 6.3m diameter. Testing of the first TBM will take place at the end of July," says Marshall.

The EPBMs are new machines coming from Herrenknecht’s main facility at Schwandorf in Germany. The first is scheduled to be installed in the launch shaft in mid-October with boring getting underway in December. The other two EPBMs are on a one month lag with testing taking place in August. Construction of this section is set for completion by June 2013.

Originally it was envisaged that the entire STEP programme would be completed by the end of 2012, however the Abu Dhabi government is carefully reviewing all of its growth forecasts in the light of the global financial crisis. The emirate has a reputation for conservative planning, a move that has served it well as neighbouring states have seen their growth plans plummet - along with bank lending.

As a result, although the remaining five contracts have been evaluated by ADSSC and a preferred bidder has been chosen, they are still awaiting approval from various government departments. "The more advanced contracts, which are the other two tunnel contracts, are relying with the highest Abu Dhabi authority the Executive Council," says ADSSC’s Thomson. "The other contracts have been evaluated by our own team and are currently being considered by our chairman."

Given the current situation Thomson expects that 2014 is now a more realistic deadline for the project. "The other..."
elements will be approved in due course. It is really just going through the bureaucratic procedures which are part and parcel of government controls,” says Thomson.

Next expected to be awarded are the remaining two tunnel contracts. The first section is the 17km length from Abu Dhabi Island to Mussafah on the mainland and will have a 4m internal diameter. The final 10.5km section will run from Mafraq to the sewage treatment works at Al Wathba and has a 5.5m internal diameter. Access shafts will be constructed at 2.5m spacings and the winning contractors are expected to bore through the sandstone, mudstone and gypsum at rates of 100m per week.

Coping with the ground
The presence of gypsum presents a potential risk for the tunnellers. Its propensity to dissolve in the presence of groundwater has led to a series of underground voids and caverns on the mainland, which the team refers to as “solution features”.

This risk led the contract team to specify pressurised face tunnelling for the bore to prevent any uncontrolled ground loss, and although ADSSC did not specify whether EPBMs or slurry, all contractors bid using EPBMs. “We also require the EPBMs to have the ability to forward probe and we have asked the contractors to provide forward looking radars to pick up any cavities. And we have compressed air so we can get into the cutterhead if there is a need to change tools,” says Marshall.

Extensive site investigations have also been carried out with more investigation to be done prior to boring. “If a cavern was detected we would try and grout it up either from the tunnel or from the surface in advance of the TBM arriving. So far there is no real evidence of any solution features in the depths we are tunnelling in,” he says.

From a tunnelling perspective ADSSC and CH2MHL are optimistic about the ground conditions as despite large pressures at the deepest point of the tunnel – 8bars, permeability of the ground is very low. “The biggest risk is encountering a very large cavern. The probability of this is low but the impact is high,” says Marshall.

The EPBMs will place a 200mm thick concrete structural lining and once this is complete contractors will enter the tunnel with steel shuttering to place the internal lining that also acts as a dual corrosion protection system. This comprises HDPE that is in contact with the flows and a concrete backing cast in situ that is at least 200mm thick. “The structural lining is gasketed so it should be a dry tunnel. Any leakage that comes in from groundwater would find its way through the concrete and run down the back of the HDPE and run onto the tunnel invert as the bottom 30 degrees is not lined in HDPE,” explains Marshall. “If it was fully lined then any water coming in would not be able to penetrate and so would bubble it until it burst, but ingress is expected to be very minimal,” he says.

The HDPE itself will be supplied in 2.5m roles that will be welded together on the surface before running it into the tunnel and wrapping it around the steel shutters. The concrete liner will then be poured. This is a similar method to that used on Singapore’s DT8. “In Singapore for example we had some shutters that were 37m long,” says Marshall.

Above and next page: Preparatory works underway at the launch shaft (WS3)
flows in to the new sewer tunnel. Part of the rationale behind structuring the main tunnel and connection sewers in separate contracts is to enable both local and international firms to participate in the scheme and it is envisaged that local firms will be involved in link sewer construction. Between the two link sewer contracts a network of 50km of connection pipes will be created. Marshall says these are not expected to be at risk of encountering solution features as the majority of them are on the island where such caverns have not been a problem.

Connection sewers range from 400mm to 3m diameter lying anywhere between 10m and 25m deep. These will be pipejacked in place from manholes at 3m centres and the biggest challenge for the team will be getting authority approvals for the detailed designs of the jacking pit locations and receiving pit locations.

The sixth contract to be awarded is for the new deep pumping station at Al Wathba sewage treatment works. “A single pumping station design was a major consideration in cutting down odour problems in the future as wherever you have a pumping station you effectively have sewage coming to the surface in one way or another and more likelihood of an odour problem,” says Thomson.

ADSSC has reserved a 4.7ha plot of land from the Abu Dhabi Municipality for the pumping station and ground conditions are expected to consist of overburden soils followed by a weak sedimentary rock formation. Contractors will be expected to take into account expected artesian ground water conditions. According to ADSSC the construction of the pit could involve reinforced concrete diaphragm walls, secant pile wall, shotcrete and rock bolts, followed by inner structural concrete ring walls, intermediate slabs, and a base slab. However the most appropriate form of excavation support system will be left up to the contractor.

Although government is taking its time over awarding the contracts, the consensus seems to be that this piece of infrastructure is badly needed, and it is part of wider investment in the emirate’s water network. “We are building another four waste water treatment plants, two in Abu Dhabi itself and two to cover Al Ain the second city. These are well in advance and will add an extra 800,000m3 per day to our treatment capabilities across the emirate,” says Thomson.

**Short-term measures**

The current capacity at Mafrag is 360,000m3 per day but Abu Dhabi is currently averaging 500,000m3 per day. Fortunately for ADSSC the heat accelerates the bacterial activity that kills pathogens so although the wastewater is not being treated for as long as it was designed to be, the effluent leaving Mafrag is still high enough quality to be used for irrigation. As an interim arrangement ADSSC has placed connection pipes between the existing Mafrag sewage treatment works and the new treatment plants which will convey some waste water down to the new plants to relieve Mafrag. “Flows have increased 8 per cent per year. We are making temporary arrangements with overland pumping, tankering where that is practical, and a refurbishment of some of our pumping stations if only for a few years to improve efficiency to keep the wolves from the door,” says Thomson.

Another advantage of the project is that it is also training local engineers to manage multi-billion UAE Dirham capital projects – experience that is difficult to obtain in the region. “We have got people from ADSSC who are working on the project management and are from this part of the world that we hope that by the end of the project will have gained some valuable experience,” says Marshall.

“This was very much a consideration at the start of the contract,” says Thomson. “We discussed it before CH2M Hill were appointed and decided that in conjunction with the ADWEA chair and board that is would be a valuable opportunity. At present we have five trainees. Once construction rolls out we would like to bring more in to the programme.”

Much work remains to be done before Abu Dhabi’s sewage problems are a thing of the past but major steps have been taken and a solution is on its way. The government is taking its time making the awards but at the same time is ensuring that Abu Dhabi gets the best infrastructure available. As a result the experience gained herein terms of both expertise and knowledge about local ground conditions, will be important information for other local and regional projects in the future.