ON A GRAND SCALE

Atlanta's water supply program will transform a quarry into one of the largest reservoirs in North America, **Desiree Willis,** technical writer for Robbins, reports

Above: The Bellwood Quarry is a massive, 400ft (122m) deep site that will ultimately become Atlanta's reservoir of emergency water

Desiree Willis
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THE AVERAGE NORTH AMERICAN public utility has only a three-day back-up supply of clean drinking water. The City of Atlanta, was, until recently, no exception to that rule. In fact, just three cast-iron water mains built in 1893, 1908, and 1924 conveyed raw water to treatment facilities for ultimate use by 1.2 million customers in the city and surrounding areas. The overtaxed system, paired with the increasing risk of drought, prompted the city's Department of Watershed Management into action. In 2006, the Department took steps to purchase the Bellwood Quarry from Vulcan Materials Co.—a 300ft (91.4m) deep, vertical-sided behemoth of a quarry where granitic gneiss was mined for a century to become structural blocks for Atlanta's buildings as well as crushed stone aggregate for roads.

The USD 300M project would turn the inactive quarry into a 2.4bn gallon (9bn L) raw water storage facility connected up with the Chattahoochee River and various water treatment facilities, bolstering the city's emergency water supply to 30 days at full use and to 90 days with emergency conservation measures. The price is a small one to pay by many estimates: if the city were to lose its water supply, the estimated economic impact could be at least USD 100M for just one day.

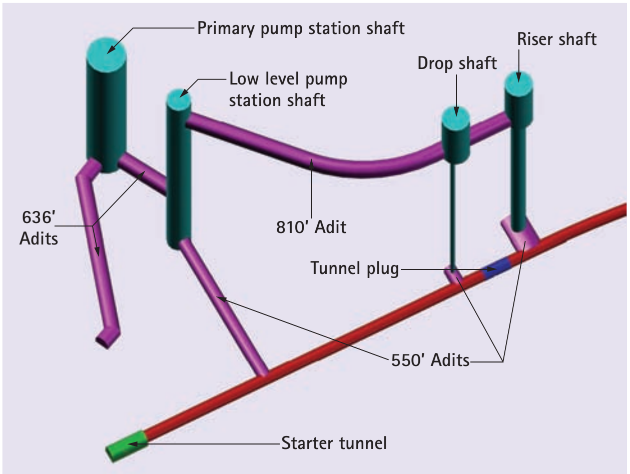
To make the program a reality would require excavation of Georgia's deepest tunnel (more than 400ft [122m]), starting at the quarry and running under two treatment facilities for 5 miles (8km) to an intake at the Chattahoochee River. It would also require construction of two pump stations at the Quarry and Hemphill Reservoir, five blind-bored pump station shafts at the Hemphill site up to 420ft (128m) deep, as well as two more pump station shafts, one riser shaft, and one drop shaft. The quarry would ultimately store raw water before it is withdrawn for treatment at the Hemphill and or Chattahoochee water treatment plants, connecting the Quarry to the Hemphill Water Treatment Plant (HWTP), the Chattahoochee Water Treatment Plant (CWTP) and the Chattahoochee River. After construction, the area around the Quarry would then be turned into Atlanta's largest park totalling 300 acres (1.2km2) complete with hiking and biking trails, baseball fields, and an amphitheatre.

A TALL ORDER

The project schedule, primarily driven by the condition of the city's existing water infrastructure, compelled the city to consider Alternative Project Delivery (APD) instead of traditional design-bid-build. The project schedule required a start date for construction of January 2016 and a substantial completion date of September 2018. The method selected was construction manager at risk (CMAR), where the contractor acts as a consultant to the owner during the development and design phase and as a general contractor during the construction phase. The setup resulted in a unique process to start TBM manufacturing, in particular, before the tunnelling subcontractor was mobilised at the site. The decision to use a new TBM by the City of Atlanta was primarily risk-based.

The PC Construction/HJ Russell (PCR) JV was selected as the CMAR for the project, who then purchased a 12.5ft (3.8m) diameter Robbins Main Beam TBM for the tunnel. The designer for the construction works including tunnel and shafts, JP2–consisting of Stantec, PRAD Group, Inc., and River 2 Tap–specified the hard rock TBM. "This is certainly a unique project arrangement," says Don Del Nero, vice president of Stantec. "The CMAR purchasing the machine and the engineer-of-record specifying the machine may represent the longest such tunnel to be delivered under this setup in North America."

Above: Tunnel alignment and treatment plants



Right: A schematic showing the network of shafts and connections that will make up the reservoir where the quarry is now located

Bottom: The TBM was specified by designer joint venture JP2 and purchased by the Construction Manager at Risk, the PC/Russell JV in an alternative contract setup

DESIGNING FOR ROCK

Specifications for the robust hard rock machine were made following detailed geotechnical and hydrogeological field investigations comprising 25 deep borings along the tunnel alignment and 30 shallow borings in the areas for shaft construction. The borings revealed granitic gneiss rock averaging 25,000 psi (172MPa) UCS along with five transition zones between soil and bedrock where groundwater was expected. These zones had the potential for high-yield, fracture flows, as local wells in the area had been reported to yield up to 500 gallons (1,893L) per minute.

It was decided that the TBM would feature 19-inch cutters to excavate the hard rock with greater penetration while offering longer cutter life. The machine design included four Variable Frequency Drives giving an installed power of 1,770 HP and

Top: ***TBM components being trucked to the jobsite***

Centre: ***The TBM was launched in October 2016***

Bottom: ***Atlanta Mayor Kasim Reed (left) and Atlanta City Councilman Andre Dickens (right) attend the TBM's launch ceremony to kick off the tunnel excavation***

operational cutterhead thrust of 1.82 million lb (83 million kg).

Tunnel support along the alignment was classified into three types: A, B, and C. The TBM would erect ground support consisting of two rows of double corrosion protection dowels as both excavation support and permanent support in Type A ground. Type B ground support would consist of four friction dowels with welded wire mesh, and Type C support would consist of steel ribs with welded wire mesh as lagging. Both Type B and Type C ground would be concrete lined after excavation. The tunnel lining would have a 100-year design life, making the finished internal diameter 10ft (3m). Ultimately the tunnel is expected to be lined along approximately 40 to 50 per cent of its length.

DELIVERY ON LOCATION

TBM components were shipped in truckloads to the jobsite in summer 2016 to be assembled using Onsite First Time Assembly—a method developed by Robbins to build machines on location rather than in a manufacturing facility. The method has the potential to shave months off of the delivery schedule and millions in USD.

The PCR JV sub-contracted the Atkinson/Technique JV (ATJV) to work on the assembly and launch of the machine, and to operate the TBM during tunnel construction. This was done in concert with a small contingent of Robbins assembly staff as required in the TBM specifications.

"Simply getting the components to the bottom of the massive quarry on the steep roads was challenging," says Jeremy Pinkham, Robbins field service manager-the Americas.

Crews worked in the blazing heat of summer at the bottom of the quarry, which was below sea level, on days where highs hit 110 degrees Fahrenheit (43.3°C) at 100 per cent humidity. The challenges of working under these difficult site conditions, paired with the new contract relationship, caused some delays over the originally planned schedule. However, the TBM's start of boring still commenced months ahead of what would have been possible with full shop assembly followed by reassembly at the quarry portal.

The machine was launched in the second week of October 2016 following a large ceremony in which Atlanta's mayor Kasim Reed and local and national media were in attendance. During this ceremony the TBM was christened "Driller Mike", after local rapper and activist "Killer Mike".

CONSTRUCTION PROGRESS

A substantial scaling program of the quarry walls was undertaken to provide safe egress and ingress to the quarry bottom and TBM location throughout assembly and machine launch. Scaling

Right: ***The Robbins Field Service crew endures hot summer days of 110 degrees Fahrenheit at 100 per cent humidity during the TBM assembly***

around the quarry rim took place from April through August 2016. To secure the approximately 300ft tall rock face above the tunnel portal at the base of the quarry, a stabilisation system was designed. The system covers the full depth of the quarry and a width of approximately 400ft centred over the portal. Three millimetre mesh and rock dowels have been installed in the locations identified to have potential rock wedge failures. Canopies were installed as additional protection to workers at the portal. At the tunnel "eye", where the tunnel breaks into the ground from the portal, 20ft- (6m-) long spiles were installed along the tunnel crown to stabilise the transition area. While scaling of the Quarry could last indefinitely in such a large drill and blast excavation, following initial inspection, ATJV implemented a scaling protocol that requires visits quarterly to inspect the rock mass and Quarry rim.

Since the October launch, the machine has advanced at rates up to 15ft per hour (4.5m) and 50ft (15.2m) per day in two eight-hour mining shifts with a daily maintenance period. "The machine is generally in favourable geology, but like other Atlanta area tunnels, it's in very hard and very abrasive rock. Cutter wear has been good; well within estimates," says Del Nero of the progress. He added that the crew typically performed three to four cutter changes per day. Muck removal is being accomplished with five-car muck trains. One train covers 6 linear ft of tunnel. While much of the excavation has been uneventful the crew did come across an old abandoned well directly in the tunnel alignment, which was promptly sealed off.

***Top:* Robbins 19-inch diameter disc cutters were chosen**

***Above:* An abandoned well was found intersecting the tunnel crown**

***Right:* Aerial view of primary and lower level pump station shafts**

COMING UP

Construction of the shafts and pump station at the Hemphill site, where an existing reservoir is located, requires extensive planning. The construction of the five blind-bore shafts at the site poses a significant risk to the unlined reservoir. As such, a shaft pre-excavation grouting program was designed for the soil to rock transition zone and rock zone to greatly reduce the chance of communication between the reservoir and the five pump shafts. Grouting from the surface was planned with special care taken to additionally avoid any risk to the tunnel structure.

The shafts will be constructed using blind bore techniques since surface blasting is prohibited at HWTP due to adjacent reservoirs. Upon the completion of the five, 11ft (3.35m) diameter steel casings in overburden, the 9.5ft diameter 400ft deep blind bore shafts will start drilling from the bedrock surface to tunnel depth through the steel casings in overburden. Upon completion of the blind bore drilling, a 76-inch ID steel pipe casing with 1-inch wall thickness will be lowered into the shaft and grouted in place. Ultimately the shafts will be directly connected to the tunnel via five, 2.4m diameter adits with lengths ranging from 6m to 9m.

As for tunnel construction, several zones requiring systematic probe drilling still lie ahead at various locations along the alignment including under the Hemphill Reservoir. However ground conditions are expected to remain favourable overall. "This is a good, robust machine," emphasises Pinkham. "It is more than capable of excavating this tunnel without issue"

References

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