GOING DIGITAL FOR WASTEWATER PLANS

Toronto’s Ashbridges Bay Treatment Plant outfall project uses 3-D modelling to deliver results on time and within budget.

BY DENISE DEVEAU

Toronto’s Ashbridges Bay Treatment Plant is one of Canada’s largest and oldest wastewater treatment plants, servicing approximately 1.6 million residents. The century-old facility discharges treated effluent into Lake Ontario through an existing one-kilometre-long outfall that dates back to 1947. With that tunnel reaching the end of its service life and having limited hydraulic capacity, work on a replacement is underway.

The city turned to Hatch, an engineering and construction consultancy firm with a global team members, to design the new tunnelized outfall. The design process started in 2015; construction began in 2019; and the target is a completion date in 2024. Throughout the process Hatch has relied on a suite of Bentley’s 3-D modelling applications to ensure deliverables would be on time and within budget.

DESIGNING FOR SUCCESS

Hatch and the city of Toronto evaluated numerous alternative outfall design concepts for the shaft, tunnel(s) and risers, including various construction methods such as tunnelling and in-lake dredging. The decision was made to proceed with a single large-diameter tunnel.

“The preferred outfall alternative was assessed to have the lowest life cycle costs with the least environmental impact during construction,” says Kevin Waer, senior project manager, tunnels at Hatch. “It also allows treated effluent to flow by gravity from the plant, through the effluent conduits, into the shaft, along the tunnel, and be dispersed into the lake via risers from tunnel crown to the lakebed along the last 1,000 metres. Ports are installed on the top of each riser to enhance treated effluent dispersion into Lake Ontario.”

The design involved, among other elements, sinking a shaft adjacent to the shoreline and then mining a tunnel through rock beneath the lakebed below Lake Ontario.

“To be clear, this is not any typical tunnel,” says Waer. “We’re effectively building a shaft, which is a football-field deep into the ground, a tunnel that is approximately three times the length of the Golden Gate Bridge, and a tunnel diameter [that is] the size of an average two-storey house.”

The most challenging construction
sequencing constraint was to have all risers installed, grouted, and tested for leaks before tunnelling, below with a tunnel boring machine (TBM), explains Wafer.

"Without this constraint, the risk of over-drilling a riser into a completed tunnel would result in significant worker safety, property damage, schedule, and financial impacts to the outfall project."

Another constraint involved probing ahead of the TBM to assess the potential for water inflows and to implement pre-excavation grouting to improve rock quality and limit water ingress into the tunnel, as required.

LEVERAGING THE POWER OF DIGITIZATION

The location, complexity and scale of the project required an integrated approach leveraging computer-aided design with engineering analysis, while considering the underwater soil and environmental features. The team used Bentley's 3-D modelling software during the project's design phase for all major design elements, including the effluent conduits, shaft support of excavation and final lining, tunnel liner, riser-to-tunnel connections, risers, ports, and port protection.

The software allowed engineers to create surfaces from borehole logs, including the lake's water level and the anticipated tunnel invert. This enabled the prediction of geological boundary conditions below the lake to make significant design decisions.

"This is an important design approach to mitigate potential risks of tunnel inundation from the above lake," says Wafer. "Generating the lakebed surface profile using 3-D tools also enabled us to locate the diffuser risers as far as possible from the shoreline, to improve dispersion and minimize environmental impacts within Lake Ontario, and prior to the local underwater feature called the "Toronto Scarp.""

3-D modelling also assisted in the development of each segment of the precast concrete tunnel lining (PCTL), he adds. "It allowed us to design a complete tunnel PCTL ring and then determine the 'clocking' or rotation of each ring, as well as predict possible tunnel-to-riser connection issues and generate bid design drawings."

The software was key in expediting delivery, reducing costs and delivering the detailed design on time and within budget. Hatch estimates that the digital tools saved roughly 2,000 hours of staff labour, with digital collaboration and the use of 3-D models for technical peer and constructability review workshops adding to the savings as well.

"The outfall project design phase was completed to the City's satisfaction, on time and under budget, which is commendable," says Justyna Teper, senior engineer with the City of Toronto, and the outfall project manager.

THE ROAD TO COMPLETION

Construction commenced in 2019 and is expected to be completed in 2024.

"With the risers installed and the tunnel now complete, we're approximately two-thirds of the way there," says Wafer. "The next challenge involves placement of grout within the rock above the tunnel crown to mitigate potential groundwater inflows, install rock bolts to support the precast concrete tunnel lining segments, and then strategically remove specific segments to excavate and support the final one to two metres of rock between the tunnel crown and each riser."

Subsequent work will include final lining installation in the shaft, effluent conduit construction, tunnel flooding, and then the final ports and port protection installation over the next few years, adds Wafer.

"When all 50 riser-to-tunnel connections are complete, we will demobilize from the tunnel and place concrete within the starter tunnel and shaft final lining up to the ground surface before making the final connection between the shaft and the effluent conduits. The tunnel will then be flooded before ports are installed on the top of each riser."

When completed, the Ashbridges Bay Treatment Plant outfall will be the largest in Canada and one of the largest outfalls in North America. "We believe this project will act as a blueprint for future outfall and intake projects locally and across the world," says Wafer.

"This is a mega project in the water industry," confirms Sandra DiMatteo, Bentley's director of industry marketing for water. "It compares to the prominent Tuas deep tunnel sewerage system in Singapore where digitalization and technological advancements play a key role in the development project. That's the way progress is made, one project at a time, advancing digitalization, advancing engineering, and advancing infrastructure together towards quality of life for our communities."

Adds Wafer, "Our exceptional and diverse team continues to successfully collaborate and innovate to solve construction challenges on this project. We are all looking forward to the day we can celebrate the outfall as commissioned and ready to receive flows from the Ashbridges Bay Treatment Plant."