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2019 CANADIAN CONSULTING ENGINEERING AWARDS

Saskatoon Southeast Water Supply System Zelma East Project


Zelma Pump Station

Project Summary

AECOM engineered and administered construction for SaskWater on a non-potable water supply system from the Zelma Reservoir to the proposed BHP Billiton potash mine near Jansen, SK. AECOM used innovative design and construction procurement methods to deliver a complex project on schedule that reliably delivers water to a multi-billion dollar mine development project, while helping SaskWater enhance the delivery of water to communities along the 93 km transmission main route.

Winner of the 2018 ACEC Saskatchewan Brian Eckel Pinnacle Award for overall achievement and Award of Excellence in the Municipal Infrastructure and Water Resources Category

Innovation

The SSEWSS Zelma East system delivers non-potable process water to BHP Billiton's proposed potash mine with an ultimate supply rate of 26.4 ML/d from the Zelma Reservoir located 80 km from the site. The water system services existing and future SaskWater customers and the new BHPB mine with a combined ultimate capacity of 34.6 ML/d.

The core purpose of the project was to deliver water through a 97 km long pipeline to BHPB at an initial rate of 4.7 to 9.6 ML/d up to 19.2 to 26.4 ML/d once the mine is in full production as well as five municipal customers with water requirements ranging from 0.3 to 1.2 ML/d.

The conceptual design phase of the project focused on the main elements of the water delivery system which were the pumps and pipeline. The challenge of the pumping and pipeline system was to assess the combined design inputs to determine the optimal technical and economic solution to reliably deliver water. The assessment considered the length of the pipeline; the wide range of flow rates; transient pressures caused by valve closures and power outages; the variable pipeline elevation over the entire length and a 6.5 metre drop over the final 8 km; pipe materials impact on maximum operating pressures, installation costs and corrosion protection requirements, and required bury depths for air management impacting pipeline structural design.

The pipeline options considered were high pressure steel, ductile iron (DI) and polyvinyl chloride (PVC). Pumping options included primary pumps located at the Zelma Reservoir with booster pumps located at pipeline station 62.5 km. Using engineering principles we evaluated the pipeline and pumping options hydraulically and structurally and then modelled them to assess transient conditions with steady state and extended period simulations (EPS) using WaterCAD V8 XM and Hammer V8 XM. This technical analysis, along with a life cycle cost analysis, identified a combination of 750 mm diameter and 600 mm diameter DR18 PVC as the most economical option.

Vertical turbine (VT) and split case horizontal pumps were evaluated. VT pumps were selected due to their flow variability and associated efficiency over the flow ranges anticipated during the life of the system. Tee head VT pumps were installed in double wall coated steel pump cans embedded into the floor of the Booster Pump Station. The intake and pump wells were designed in accordance with Hydraulic Institute standards and verified by Computational Fluid Dynamics (CFD) modeling.

Complexity

Zelma Pump Station

The size and complexity of this project required SaskWater and AECOM to identify how the work would be procured and executed. Factors influencing this process included capacity of suitable contractors, project timelines, ability to effectively manage contractors' and major suppliers' QA/QC procedures, safety requirements and contract coordination.

Two equipment supply and three primary construction contracts best met the needs of the project including two pipeline supply contracts, two pipeline installation contracts and one facilities contract for construction of the two pumping stations and meter building. Contractor prequalification processes were used prior to tendering each of the contracts.

The two contracts for the supply of 93,000 metres of PVC piping involved a number of coordination issues including shipping versus installation schedules, on-site storage, contractor inspection and acceptance procedures and tracking of materials. To address these issues, unique QA/QC procedures were developed including unique individual pipe markings and tracking sheets.

The second pipeline installation contract, which was tendered 12 months after the first installation contract was awarded, considered lessons learned from the first contract to develop an alternate procurement process. The alternate process included consideration of the contractors' previous performance, safety program and QA/QC procedures in addition to price for contractor selection through a formal negotiated proposal process.

In order to have direct control over the selection of critical electrical equipment, the prequalification and tendering of major electrical components, PLC/HMI equipment and programming services was completed independently of the facilities contract and novated into that contract once the supplier was selected.

Social and/or Economic Benefits

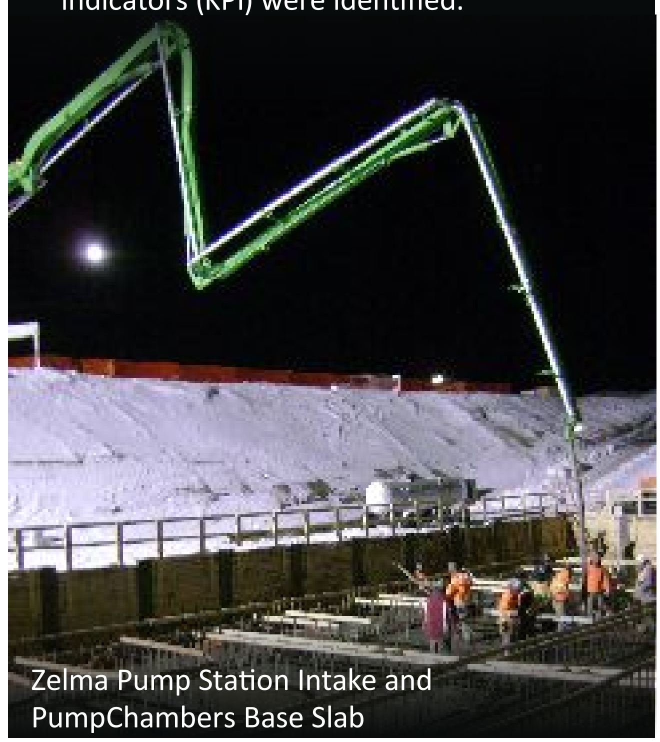
Installation of 750 mm Diameter PVC Piping

The primary objective of this project was to provide a reliable process water delivery system to BHPB's mine site to prevent interruptions in the mining process resulting in missed economic opportunity costs. The mine and water supply system are located in rural Saskatchewan where employment and business opportunities can be limited. Once the mine is operational, the mine and water supply systems will be sources of well-paid jobs and will require ongoing supplies and services from local companies to support mine operation. The additional direct economic benefits of this project were the local suppliers and contractors involved in the construction of the water delivery system.

In addition to supplying water to BHPB's mine site, the water supply system provides a source of water to one of SaskWater's existing municipal clients as well as four future municipalities . This water will be used by these municipalities as source water for their potable water treatment systems for treatment and distribution to their residents. The options for good quality water supplies for this purpose are limited in this part of the province and the water supplied by the SSEWSS Zelma East system is considered to be very good quality for this purpose. Therefore, the project is also providing a reliable high quality water source to help these communities provide safe drinking water to their residents.

Safety Culture

BHPB has a very strong safety culture and this focus on safety was an important consideration throughout the project. It impacted the planning and execution of our duties on the project as well as being a constant consideration for end users in the design. AECOM's role included safety monitoring and reporting for all contractors and consultants on the project. This provided an opportunity for an AECOM staff member to take on a new responsibility, under direction and mentorship from more senior and experienced safety staff, and to grow her knowledge regarding safety programs on construction sites. The safety monitoring and reporting involved working with all construction firms, as well as SaskWater and BHPB, to assess safety concerns and improve safety performance on the project. As the project progressed, improvements in safety key performance indicators (KPI) were identified.



Zelma Pump Station Intake and PumpChambers Base Slab

Environmental Benefits

Winter Intake Moving to Intallation Position

The design of the intake system was under the jurisdiction of the Department of Fisheries and Oceans (DFO) and their Freshwater Intake End of Pipe Fish Screen Guideline (1995). The intake design also required special consideration due to limited dissolved oxygen (DO) levels in the Zelma Reservoir during the winter as a result of surface ice cover which negatively impacts fish habitat. In consultation with SaskWater and their environmental consultant we decided that two intakes would be constructed for redundancy with one primarily for summer use and one for winter.

The summer intake screen is a conventional stainless steel wire dual tee screen. In order to provide uniform removal of water from the lower elevations of the reservoir, where the DO levels are the lowest, the winter intake screen was designed with a 1,000 metre long x 800 mm diameter fused high density polyethylene (HDPE) pipe and 200 single 75 mm diameter stainless steel screens spaced at 5.0 metres along the pipe.

The winter intake was designed using hydraulic calculations based on Bernoulli's principle then hydraulically modeled using MIKE 3D and EPANET 2 software to check for uniform flow over the entire length of the intake pipe which would maximize the withdrawal of water from the lower levels of the reservoir. Due to the complexity of the system it could not be modeled with a single software package so the results of the MIKE 3D and EPANET

Final Assembly of Reservoir Winter Intake Section

Construction of Intake Lines in Coffer Dam

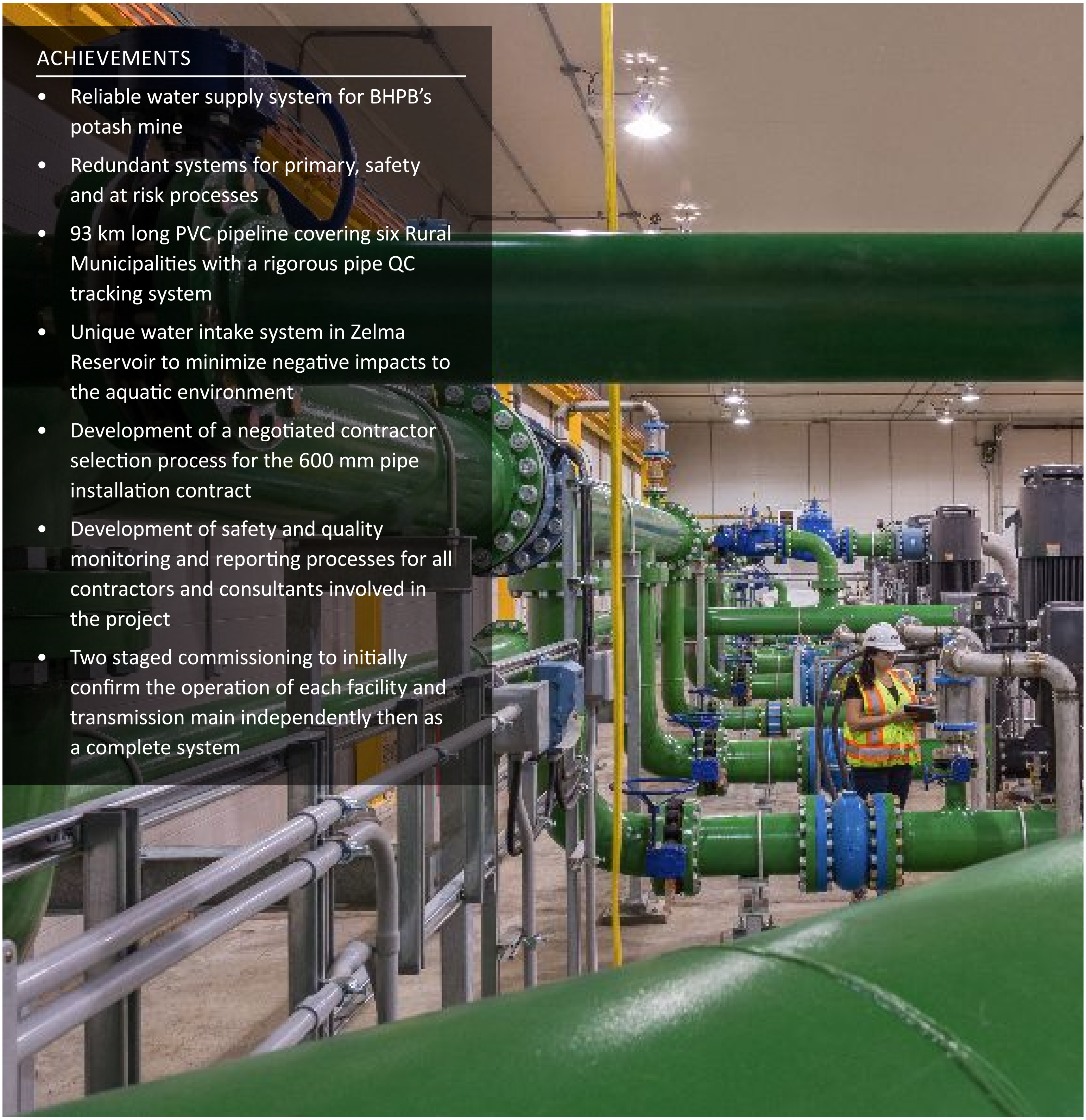
Pump Station Intake Pipes Construction

Meeting Client's Needs

The primary objective of the project was to provide a reliable water supply to the mine site for BHPB's potash processing facility along with the proposed new municipal users. Any water supply system shut downs lasting more than seven days would interrupt the operation of the mine's processing facility with significant economic implications.

The design and construction processes were guided by this need for reliability and the completed system includes:

- Failure modes and effects analysis (FMEA) workshops during the design and construction phases of the project. The design phase workshop focused on system operation to identify what could fail, what are the consequences and how the design could be changed to prevent or mitigate negative consequences.
- All of the electrical switchgear in the Zelma Pump Station was initially located in a single electrical room with a common busbar, which made the entire system vulnerable to fires or collateral damage from failures of other switchgear components. Three changes were made to address this vulnerability. Firstly, separate electrical rooms were designed with pump variable frequency drives (VFDs) strategically located in these rooms to maximize operational flexibility in the event of damage in a single electrical room. Secondly, the switchgear in each electrical room could be independently disconnected from the main service switchgear, without affecting other switchgear line-ups. The third change included modifications to the heating and cooling system design to isolate the rooms in the event of a fire.
- There was no backup to the controls system for the primary pumping systems in the Zelma Pump Station. The solution was for two identical PLC/HMI panels to be installed in separate Zelma Pump Station electrical rooms. One PLC is the primary controller and the second can be brought on-line in the event of a failure with the primary controller.
- The on-site standby generator was sized to support building electrical loads and the two jockey pumps in order to keep the transmission mains pressurized and to supply demands for municipal customers, but not to operate the duty pumps. It was decided that the generator need not have capacity to operate the larger duty pumps since a utility power outage lasting longer than seven days is unlikely, so there would be little risk to BHPB's operation. In order to mitigate the remaining small risk, the design was revised to accommodate an external portable generator that would be interlocked to the electrical service through a Kirk Key system.
- Reliable communication for the process controls system is needed for the three facilities which are spaced over a 93 km distance and radio modems were selected based on reliability and life cycle costs. Although radios are a relatively reliable communication system, failures can occur and there was a significant potential for equipment damage if communication is lost between facilities. As a result the process narrative was modified for each facility so it can operate as independently as possible. However, there were still a number of process functions that relied on information from other facilities. Where process functions relied on information from other facilities, these processes would go to a "safe mode" when inter-facility communication is lost to allow limited operational capabilities with a significantly reduced potential for catastrophic damage.



ACHIEVEMENTS

- Reliable water supply system for BHPB's potash mine
- Redundant systems for primary, safety and at risk processes
- 93 km long PVC pipeline covering six Rural Municipalities with a rigorous pipe QC tracking system
- Unique water intake system in Zelma Reservoir to minimize negative impacts to the aquatic environment
- Development of a negotiated contractor selection process for the 600 mm pipe installation contract
- Development of safety and quality monitoring and reporting processes for all contractors and consultants involved in the project
- Two staged commissioning to initially confirm the operation of each facility and transmission main independently then as a complete system

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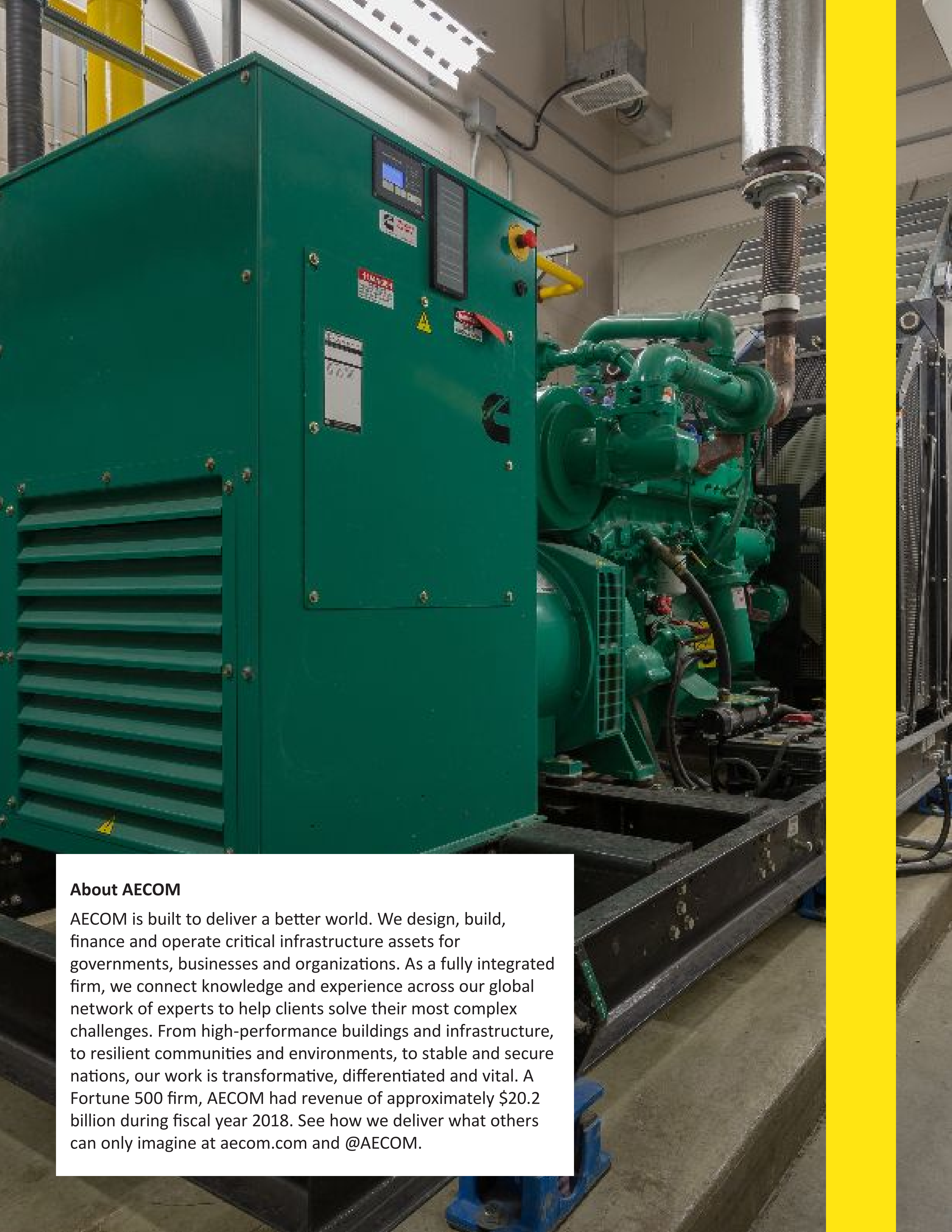

About AECOM

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