Mid Halton Wastewater Treatment Plant, Micro-Hydro Facility

2020 Canadian Consulting Engineering Awards

HATCH

Installed turbine and generator

Project highlights

An effluent outfall tunnel was constructed at the Mid-Halton Wastewater Treatment Plant (WWTP) to accommodate increased flows due to growth. The WWTP is located four kilometers from the Lake Ontario shoreline and is consequently at an elevation of 40 meters above the lake level. Utilizing this difference in elevation, a micro-hydro system was installed in the effluent outfall to provide a source of sustainable power generation, reducing the carbon footprint and energy costs of the WWTP.

Aerial view of the drop structure shaft construction at the WWTP

Innovation

The Region of Halton (the Region) engaged the services of Hatch to provide engineering services for the Mid Halton WWTP Phase IV-V Expansion Project (the Project) in the Town of Oakville, Ontario. As part of this project, a new dedicated Effluent Outfall tunnel (outfall) needed to be constructed to convey treated effluent from the Mid Halton WWTP to a diffuser field located offshore on the bed of Lake Ontario.

A key innovation on this project was the incorporation of a micro-hydro facility at the WWTP, specifically within the drop structure constructed to transfer effluent from the WWTP to the deep, tunneled outfall. Flows entering the drop structure are either directed to the micro-hydro facility or can alternatively be bypassed to a set of energy-dissipating baffles, on their way to the Effluent Outfall. Due to the elevation head available at the drop structure and expected flows at the facility, a 700kW hydro turbine was selected to generate electricity “behind the meter” (i.e., for use within the WWTP). By generating electricity in this manner, the micro-hydro facility reduces the amount of electricity the Region needs to purchase thus reducing plant operating costs.

The amount of energy generated by the micro-hydro facility depends on the amount of flow directed to it. The facility was designed to accommodate a wide variety of flow conditions, ranging from the current relatively low effluent flow levels, up to the high flow levels anticipated under the WWTP’s future build-out capacity. When flows exceed the capacity of the generating facility, the excess flows are discharged via the baffle side of the drop structure. Based on recent, post-commissioning results, which represent the lower end of the anticipated future energy production, the micro-hydro facility was reliably producing over 3,000 kWh of energy each day – a significant portion of the WWTP’s total energy needs.

This type of micro-hydro application has been under investigation at a variety of wastewater treatment plants around the world to take advantage of the potential energy available from effluent discharges; however, very few have been installed. The key benefits to the Region were reduced operating costs of their facility, as well as a lower carbon footprint and community recognition as being an environmentally conscious organization.

Complexity

While the overall WWTP expansion and outfall projects were incredibly complex undertakings, the micro-hydro system too had its share of complexities and challenges to be overcome, including:

- **Accommodating large flow variations.** The present expansion increased the capacity of the WWTP in terms of average daily flow from 75 million liters/day (MLD) to 125 MLD, with the build-out capacity of the WWTP estimated to be 400 MLD. Operating head conditions will also change as the volume of flows passing into the effluent outfall increases. Both factors made sourcing a suitable turbine unit very challenging. A comprehensive review of a potential turbine types determined that there was only one manufacturer (OSSBERGER®) which could provide a unit that could handle the ranges anticipated for both flow and operating head.

  For typical hydropower installations, a reservoir is constructed to store water to ensure a relatively constant supply of water. Unfortunately there was no space on the WWTP site to construct a reservoir and wastewater treatment plants tend to have large fluctuations in effluent flow throughout the day. Additionally, routine operations and maintenance activities at the WWTP may cause large fluctuations in flow. These factors meant that the micro-hydro facility had to have the ability to adjust to sudden changes in flow that could occur without warning. Accordingly, the supervisory control and data acquisition control system for the micro-hydro facility had to be very robust, have multiple fail-safes, monitor key data continuously to adjust to flow variations, and, if necessary, safely (and quickly) shut down in the event of sudden reductions of flow.

- **Squeezing all necessary equipment inside a small space, approximately 30 meters below the ground surface.** The micro-hydro facility and the separate flow baffle system were constructed inside a single shaft with an interior diameter of 10 meters. Half of this space was required for the baffle drop system, leaving only the remaining half available to accommodate the micro-hydro facility. To maximize available operating head, and therefore the amount of power generated, the micro-hydro equipment had to be located approximately 30 meters below the ground surface. The limited space made the layout of the vertical penstock supplying water to the micro-hydro turbine, the micro-hydro turbine and generator, and auxiliary equipment very challenging and necessitated that certain equipment (electrical controls, hydraulic power units, etc.) be housed above the turbine platform. The depth of the installation also made personnel access difficult, requiring the installation of an elevator for routine access and ladderways for emergency egress. Access hatches at the top of the shaft and jib cranes at the turbine level also had to be provided to facilitate future maintenance of the micro-hydro facility. Detailed 3D modeling of the entire installation was carried out to ensure that all components of the facility could be installed and operated without critical clashes.

- **Designing the WWTP drop structure to have two completely independent sides.** As discussed above, the WWTP structure needed to be designed with a flow drop baffle system on one side and the micro-hydro facility on the other. As the baffle side of the structure could surcharge with effluent under surge or high flow conditions, the two sides of the structure had to be designed to be completely separate. While this complicated the structural design, the greater challenge was accommodating proper air circulation to and from the baffle side of the structure. Due to space constraints, the only practical way to provide this ventilation was to provide openings, via hard piping under each baffle shelf, connected to a closed manifold system on the micro-hydro side of the shaft. This is the first known use of piped venting for a baffle drop system in the world and required independent analysis by the Iowa Institute for Hydraulic Research to validate the approach and confirm sizing of the vent pipes.

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Looking up from the drop structure shaft prior to lining

Social and/or economic benefits

The key social and economic benefits of the Project are the reduced operating costs and reduced carbon footprint for the facility, while also assisting the Region's movement towards being more sustainable and environmentally conscious.

The success of the Mid-Halton WWTP micro-hydro facility in generating renewable energy allows it to be used as an example of how wastewater treatment plants can be reenvisaged as resource-recovery plants. Nutrients can be recovered in the form of biosolids or phosphorus. Digester gas can be used to produce energy. The Mid-Halton facility proves that energy can also be recovered from effluent flows.

Renewable energy applications have been under investigation at a variety of wastewater treatment plants around the world. However, when it comes to generating electricity from effluent flows, very few installations have been completed. The successful demonstration of this application on the Project validates the concept and allows this type of this application to be more readily considered at other wastewater treatment plants and water system facilities.

Throughout the design process, Hatch assisted the Region in negotiating with the local utility (Oakville Hydro) to identify the necessary system safeguards and obtain the necessary permits for the behind-the-meter system. Hatch also assisted the Region in securing a grant for the installation, through Ontario's "Save on Energy" program, lowering the overall cost of the installation and increasing its return on investment.

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Environmental considerations

By providing a source of renewable energy for the Mid-Halton WWTP, the micro-hydro facility not only reduces the amount of electricity the Region needs to purchase, but also reduces the amount of electricity the local electrical utility needs to produce, thereby contributing to the reduction of global carbon emissions and helping mitigate climate change. From this perspective, the Project clearly represents a net benefit to the environment. In addition, the construction of the Project also had to address several key environmental issues including protection of environmentally sensitive areas, natural habitats, and endangered species.

The WWTP drop structure is located adjacent to Sixteen Mile Creek which is a potential habitat for the endangered Redside dace. The project team used their extensive experience in computer modeling to create accurate, defensible estimates of infiltration into the shaft and tunnel which confirmed that there would be no impact to the creek or surrounding environmentally sensitive areas. They coordinated closely with the Ontario Ministry of Natural Resources and Forestry and the local conservation authority to satisfy them that potential impacts of the proposed construction would be negligible, protecting Lake Ontario and the surrounding environment.

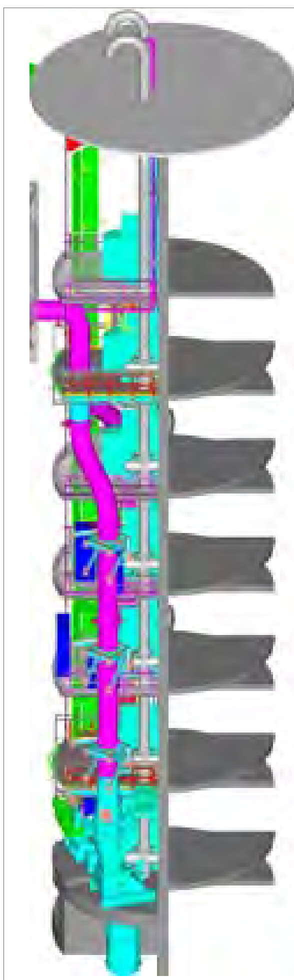
The first-of-its-kind piped venting system for the baffle drop was independently reviewed

Meeting the client's needs

Hatch's project team successfully delivered a dedicated effluent outfall that carries treated effluent from Mid Halton WWTP to a diffuser field in Lake Ontario. This project was completed and operational as of June 2019. Hatch also identified to the Region the potential to generate renewable energy from the effluent flows. This value-added feature has significantly reduced the operating costs and carbon footprint of the WWTP.

Detailed 3D modelling was required to fit the micro-hydro facility and the separate flow baffle system inside the same shaft

While the value of the opportunity was clear to the Region, the WWTP operations staff needed to be confident that they would be comfortable operating and maintaining this asset on project turnover. The key concerns were that they had no prior experience operating a hydropower system and that the addition of this system must not cause any impacts to the essential functions of the WWTP. The micro-hydro facility was engineered with extensive technical and operational reviews throughout design, construction, and commissioning, and will operate automatically with operator intervention only required to re-start the facility after a shut down. Fail-safes were engineered into the design to ensure that the micro-hydro facility would promptly and automatically shut down in the event of an issue at the WWTP. Stringent testing of all fail-safes and redundant fail-safes was required during the commissioning phase. Hatch worked closely with the Region's commissioning team and the contractor/subcontractor to ensure the testing and commissioning process met or exceeded the goals and expectations of the Region.



3D model view of the Micro-Hydro and Baffle Drop sides of the WWTP shaft

First of their kind baffle vent pipes at the top of the WWTP drop shaft