



## CANADIAN CONSULTING ENGINEERING AWARDS 2020

# DAWSON CITY WATER TREATMENT PLANT

LOCATION: DAWSON CITY, YUKON  
CLIENT/OWNER: YUKON GOVERNMENT  
CONSULTANT: ASSOCIATED ENGINEERING  
SUBCONSULTANTS: KOBAYASHI + ZEDDA ARCHITECTS, TETRA TECH &  
WILDSTONE CONSTRUCTION GROUP



## ADVANCED WATER TREATMENT IN HERITAGE-STYLE BUILDING



“THE BETTER WE PLAN IT, THE BETTER THE END RESULT WILL BE, SO WE WANT TO MAKE SURE WE PLAN SOMETHING THAT WILL BE APPLICABLE TO DAWSON AND THAT ALSO WILL NOT COST A FORTUNE TO OPERATE”

- NORM CARLSON, DAWSON CITY SUPERINTENDENT OF PUBLIC WORKS



## DAWSON CITY WATER TREATMENT PLANT

### EXECUTIVE SUMMARY

Dawson City, the Yukon Territory's second largest town, provides residents with drinking water from four wells situated near the confluence of the Yukon and Klondike Rivers. The town's aging water treatment plant did not meet the Guidelines for Canadian Drinking Water Quality and needed to be replaced. The Yukon Government retained Associated Engineering to provide design and construction services for a new water treatment plant for Dawson City.

Associated Engineering's design team developed an ingenious treatment process utilizing cartridge filtration, a treatment technology typically used for smaller water systems, followed by ultraviolet and chlorine disinfection. The treatment process requires little specialist training, is easy-to-operate, minimizes chemical use, and is environmentally friendly, as filter cartridges can be washed and reused.

Cold climate engineering was employed throughout the project, including freeze protection for pipes, to safeguard the water supply during Dawson City's harsh winters when

temperatures can drop well below  $-40^{\circ}\text{C}$ . Water within the plant is heated by an energy efficient heating system that draws heat from the local biomass plant. Building power is supplemented by a solar photovoltaic system in the summer. Climate change mitigation was also addressed in the design that featured concrete construction below the flood elevation and sensitive electrical and controls equipment above it.

Through consultation with the town's Heritage Advisory Committee, the building façade was designed to replicate an early 1900's cold storage building, reflecting the town's character and rich history. The design ensured that local materials and trades could be employed for construction to benefit the local economy.

Sustainable and resilient by design, the new Dawson City Water Treatment Plant provides reliable and safe drinking water for many years to come and is a landmark in the community.

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DAWSON CITY'S NEW WATER  
TREATMENT PLANT IS A MODEL FOR  
ENERGY EFFICIENCY AND RESILIENCE.

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## BACKGROUND

Home of the Yukon Gold Rush, Dawson City is a popular stop along the Alaska Highway where tourists enjoy the town's history, sights of the Aurora Borealis, and the surrounding natural beauty. The town's unique architecture preserves its Klondike-era character, and offers a glimpse into its past. As a result, the community of about 1400 swells to nearly 5000 during the summer tourist season.

Dawson City provides residents with drinking water from four wells located near the confluence of the Yukon and Klondike Rivers. The town's 40-year-old drinking water treatment plant struggled to treat the well water to meet the Canadian Drinking Water Quality guidelines.

The Yukon Government sought to replace Dawson City's aging water treatment plant with a modern facility. The new plant needed to treat water from the four wells. The proximity of the wells to the rivers placed the groundwater supply at risk to contamination should any pathogens in the river water infiltrate the aquifer, known as GUDI or Groundwater Under the Direct Influence.

The plant's design also had to accommodate

the large changes in water demand during the tourist season. In addition, the plant needed to be energy efficient, reliable, and simple-to-operate. The Yukon Government also wanted a facility that minimizes life-cycle operation and maintenance costs.

The Yukon Government retained Associated Engineering with Yukon-based architect, Kobayashi + Zedda Architects, to provide design and construction services for a new water treatment plant. The new plant would be situated along 5th Avenue in the town's historic core.





## INNOVATION

After evaluating various processes, the design team recommended cartridge filtration for treatment. While cartridge filtration had never been used for a system this size in Western Canada, the technology is appropriate for this groundwater source, which is low in turbidity and colour; is simple to operate; and eliminates the need for the chemicals typically required in traditional water treatment systems to remove small particles in raw water supplies.

Since they are washable and reusable, cartridges only need to be replaced about twice a year, a benefit considering Dawson City's remote location and limited access to supplies. The design could also adapt to varying demand.

The 6 million litre per day plant employs a two-stage cartridge filtration system using 5-micron sized filters, followed by a 1-micron filter to protect against protozoa pathogens. The treatment process also includes ultraviolet and chlorine disinfection.

Cold climate engineering was essential to ensure that pipes and water would not freeze, thus safeguarding the water supply during winters when temperatures can drop below -40°C.

Sustainable and resilient by design, water in the plant is heated by an energy-efficient heating system that draws heat from the local biomass plant to supplement traditional oil-fired boilers. Building power is augmented by a solar

photovoltaic system in the summer. Employing renewable energy from the biomass plant and solar energy reduces the facility's long-term costs for power and heating.

### USING RENEWABLE ENERGY REDUCES THE COST FOR POWER AND HEATING.

Exterior piping is insulated and heat-traced. Notwithstanding, during commissioning in fall 2019, a plan was developed to circulate water through the underground pipes and adjacent reservoir to prevent water from freezing.

Analysis of river levels under future climate scenarios showed the facility could be flooded, as the building's lower level is below the future 200-year flood elevation. The building's foundation and walls were designed for flood resistance, and electrical and controls equipment were located above the flood level.





## COMPLEXITY

The plant fits on a small footprint of two standard residential lots. The team maximized the building footprint by designing a two-story structure and minimizing setbacks on the property, in consultation with Dawson City Council to obtain a special bylaw exemption.

Due to limited setbacks to adjacent buildings, fire-rated wall materials were used, and a fire suppression system was installed. The team created a 3D model which assisted with discipline coordination and ensured required components fit in the building footprint.

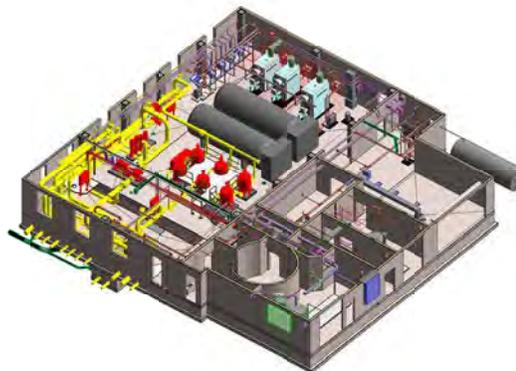
The cost of treating and distributing water is usually one of a municipality's highest cost. This is compounded in the North where water must be heated to prevent freezing. To reduce energy costs, the design of the facility harnesses energy from the town's biomass District Energy System for heating the building and potable water pipes during the winter for freeze protection. The team designed a solar photovoltaic system to augment power supply in the summer.

The new treatment plant was designed to provide the town's fire flow, as well as potable water requirements. Through a unique arrangement of piping and valves, the fire pump

supply flows are looped within the potable water distribution system. During the winter months, the potable water supply is pumped unidirectionally into the distribution system and water is directed back into the treatment plant for re-heating, thereby providing freeze protection. The system allows water to remain in constant motion throughout the winter months, while allowing fire flow supply to back-feed into the looped system when required. An innovative recessed sump area within the treatment plant provides operators with easy access to all valving and equipment at grade level.

Ultraviolet (UV) disinfection had to be added to the existing plant. The team designed a new UV system for the existing plant, and adapted this UV design for the new facility, so that the UV equipment parts could be reused when the old plant was decommissioned.

BIOMASS  
HEATING AND  
SOLAR SYSTEM  
REDUCE  
ENERGY COSTS.





## SOCIAL AND/OR ECONOMIC BENEFITS

This unique application of cartridge filtration meets water quality guidelines and the water demands of the community, while employing a technology that is easy-to-operate. Since cartridges are washable and reusable, cartridges only need to be replaced twice per year, minimizing supply issues associated with Dawson City's remote location.

Renewable energy sources augment energy supply and reduce costs. The design avoided using complex process equipment that would require specially trained personnel to travel to Dawson City for maintenance or repairs.

Chlorine gas is used for disinfection since operations staff are already familiar with this technology and the chlorine cannisters are readily available in the area.

As a cost-saving measure, a temporary sodium hypochlorite skid was placed in the old plant to provide disinfection, so that the existing chlorine gas system could be shut down and the chlorine scrubber moved for reuse in the new plant, providing cost savings.

Construction detailing, such as wood framing, considered the skills and availability of local trades, thus supporting the local economy, and reducing the need for tradespeople with specialized skills, such as structural welders, to travel to Dawson City.

USING LOCAL TRADES AND LOCALLY SOURCED MATERIALS BENEFITED THE LOCAL ECONOMY.

To reflect Dawson City's rich history linking to Yukon's Klondike Gold Rush, the team consulted with the town's Heritage Advisory Committee during design. The result is a building façade that mimics the Pacific Cold Storage Building, an early 1900's structure, including a circular staircase leading from the front entrance to the second floor to replicate the circular tank that formed part of the original building. The treatment plant's historic character fits in well with the heritage style of its surroundings.

The glass windows are triple paned and are low emissivity to increase efficiency. The large windows allow the public to view the facility and gain a better understanding of the water treatment process.





## ENVIRONMENTAL BENEFITS

To prevent freezing, water in the plant is heated by an energy efficient system that draws heat from the town's District Energy System, a wood chip biomass heating plant. The biomass system provides the base-load heating, supplemented by traditional oil-fired boilers to heat the process water and the hydronic building heating system.

Building power is supplemented by a solar photovoltaic system in the summer to lower power consumption and cost. External buried watermains are insulated and above-ground pipes are heat-traced for freeze protection.

To address risks of commissioning under freezing temperatures, the team prepared a detailed commissioning plan. During commissioning, water was constantly circulated through the underground pipes and adjacent reservoir to prevent freezing.

Situated on the confluence of the Yukon and Klondike Rivers, Dawson City has been subject to large-scale flooding. The new water treatment plant provides an essential service to the community and, hence, has to be protected against flooding.

The team evaluated the 1:200 year flood elevation, considering climate change impacts, and determined that flood levels exceeded the building's ground elevation. The team designed the foundation and walls of the building

to withstand a major flood event. Sensitive electrical and controls equipment were placed on the second floor, above flood level.

DESIGN EMPLOYED RENEWABLE ENERGY,  
LOCALLY SOURCED MATERIALS, AND WOOD  
CONSTRUCTION.

Sustainable building materials included wood frames and dowel laminated timber (DLT) roof panels. The DLT roof also provides sound absorption, reducing exterior noise from the plant operations.

Building materials were sourced locally where possible to minimize the carbon footprint of the project, as well as reduce cost and expedite construction.





## MEETING CLIENT'S NEEDS

The Dawson City Water Treatment Plant meets the Yukon Government's requirements for an energy efficient water treatment facility that is simple-to-operate with low operating and maintenance costs.

Demonstrating ingenuity, Associated Engineering's design team developed a treatment process utilizing cartridge filtration, a treatment technology typically used for smaller water systems, followed by ultraviolet and chlorine disinfection. The treatment process requires little specialist training, is easy-to-operate, minimizes chemical use, and is environmentally friendly, as filter cartridges can be washed and reused.

In addition, northern climate engineering and construction detailing appropriate for a remote community led to the successful implementation of a plant that has low operations and maintenance costs compared to traditional water treatment plants.

Project and construction planning considered stakeholder consultation, use of local materials wherever possible, as well as the limited construction window of the far North. As a result of this attention to detail, the \$15 million treatment plant was completed under budget and ahead of the Yukon

Government's schedule, and employed local trades.

Planning and design began in 2016, with construction beginning in May 2018. By December 2019, Dawson City residents were drinking water from their new, modern water treatment plant, the largest municipal cartridge filtration system in Western Canada.

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DAWSON CITY'S WATER TREATMENT PLANT WAS COMPLETED UNDER BUDGET AND AHEAD OF SCHEDULE.

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Dawson City is proud of its rich history linking it to the Klondike Gold Rush. All new buildings are subjected to rigorous review by the town's Heritage Advisory Committee. Through engagement with the Committee and Town Council, it was agreed that the water treatment plant building would be a replica of the early 1900's Cold Pacific Storage Building. Working with Heritage Advisory Committee, the team re-created the design of this iconic structure in Dawson City's history. Already a community landmark, the new water treatment plant reflects the town's rich history and frontier-style architecture, while meeting its water supply needs for many years to come.



## CONCLUSION

Dawson City's new water treatment plant is a model for resiliency and energy efficiency, employing renewable energy for heating and power. The plant employs cartridge filtration for treatment, the largest facility of its type in Western Canada.

The innovative application of this technology provides a robust treatment system for the community of 1400 which swells to over 5000 during the summer.

Dawson City residents and visitors will enjoy a safe and reliable source of drinking water for many years to come. Already a local landmark, the architecture of the facility reflects the town's unique character and history.

"I just wanted to reach out and let you know how excellent your team has been to work with for the past three years on designing and administering the construction of the Dawson Water Treatment Plant, I know as a manager that far too often we only hear about when things go wrong, but in this case and since we are only days from substantial completion on the project I thought it would be nice to give some recognition to your team for their professionalism, dedication and attention to detail on this project. This project has been extremely important to the Yukon Government and the City of Dawson. We are pleased to see the project come in within budget, ahead of anticipated schedule and overall fit for use."  
- Rick Kent, Infrastructure Program Manager, Yukon Government.

## PROJECT FEATURES

### WATER TREATMENT

- Largest 2-stage cartridge filtration installation in western Canada
- Uses cleanable and replaceable filters
- Compact layout of UV and chlorine disinfection equipment



### CONSTRUCTION LOGISTICS

- Complex piping design and construction due to compact footprint
- Challenging piping tie-ins, pipe pressure testing and disinfection program required
- Cold weather piping and materials used
- Complex sanitary and water piping relocation and district energy tie-in



### FIRE FLOW SUPPLY

- Fire pump powered by electric drive on variable frequency drive for energy efficiency
- Fire pump sized for future fire flow demands
- Facility equipped with fire suppression system



### ENERGY EFFICIENCY

- Biomass heat exchanger provides heat to the system from the district energy system
- Photovoltaic system installed on roof - in keeping with the Yukon Government's sustainable energy savings initiative
- Fuel oil boilers add heat to process water for freeze protection



### STRUCTURAL CHALLENGES

- Roof structure built by local builders for on-site assembly
- Sustainable locally sourced dowel laminated timber panels
- Steel ridge beam and column superstructure
- Geotechnical assessment required removal of foundation material susceptible to frost



### CLIMATE CONSIDERATIONS

- Designed for a 1:200 year flood event due to frequent ice damming in Yukon River
- Mitigation for future climate change impacts:
  - Placed sensitive electrical and controls equipment on second floor
  - Built first floor using cast-in-place concrete to withstand any flooding events



### ARCHITECTURAL FEATURES

- Circular staircase required to fit into the tight space
- Board and batten exterior on stairwell, in-keeping with historic architectural style
- Building façade and proportions to match with Dawson City's gold rush era theme

