2020 Canadian Consulting Engineering Awards

AVOIDING CATASTROPHE THROUGH REDUNDANCY

NORTH THOMPSON EMERGENCY WATER INTAKE

WATER RESOURCES

wsp

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA

TABLE OF CONTENTS

AVOIDING CATASTROPHE THROUGH REDUNDANCY – NORTH THOMPSON EMERGENCY WATER INTAKE

EXECUTIVE SUMMARY

Kamloops is located at the confluence on the North and South Thompson Rivers. Potable water supply for 100,000 metropolitan residents relies on a single intake located in the South Thompson River with no redundancy, which is almost unheard of today for a major city in Canada with a surface water supply. The City is a major road and rail transportation hub, and is home to many industries both adjacent to, and upstream of the City – all potential contamination sources.

The City was extremely concerned that they were vulnerable to a complete shutdown of the entire potable water system in the event of a naturally occurring or accidental contamination of the South Thompson River. The North Thompson Emergency Water Intake (NTEWI) was planned and constructed to alleviate this concern.

The project consists of a wedge-style raw inlet structure, constructed in the North Thompson River, a 14m deep concrete wet well, vertical turbine supply pumps, disinfection system, and above- ground pumphouse building. The system will remain on active standby for perhaps years at a time, and then in the event of an unplanned or emergency shutdown of their main South Thompson intake the NTEWI is activated within a few hours.

Some of the NTEWI design challenges included:

- Integrating the facility seamlessly into an existing residential neighbourhood;
- Mitigating the impacts of in-river works required to build the 14m deep reinforced concrete inlet structure;
- Providing a facility that would operate during a major seismic event, and extreme river levels;
- Designing the facility to accommodate expansion to full scale treatment in the future; and
- Any fish drawn into the intake had be returned unharmed to the river.

WSP was retained to provide the engineering services including civil, structural, geotechnical, architectural, building services, and contract administration for this critical infrastructure.

The project was commissioned in Fall 2018 for a total cost of approximately $9,000,000.

“This is the most important piece of water infrastructure that we hope to never use.”

– Liam Baker, Utilities Engineer

Pumphouse interior showing 300 kW vertical turbine pumps

Deep construction below the water table required intensive attention to constructability and the sensitive river habitat

PROJECT OBJECTIVES, SOLUTIONS AND ACHIEVEMENTS

OBJECTIVES

Objective: Provide a secondary emergency water intake facility that can be used if the primary facility is inoperable for an extended duration for any reason. Size the facility for maximum summer day water demands.

Solution: The facility was developed and sized for an output of 60,000,000 Litres per day, which is 100% of summer demand for the 20-year population projection. The system uses three 300 kW vertical turbine pumps which take water directly from the North Thompson River and feed the distribution system. The pumphouse is located above flood levels and is several kilometers upstream of the confluence of the North and South Thompson branches of the main river stem to prevent cross-contamination of the two water sources. The system consists of an inlet system in the river, concrete wet well below the building, pumps, disinfection system, pumphouse, and piping to tie to the existing distribution system.

Objective: Provide a system that can remain on active standby for a period of years, but in the event the primary intake system is compromised, can be made functional within 8 hours.

Solution: A system was developed that can remain on standby for years at a time, but when necessary, can be made fully operational within only a few hours. The system features a remote monitoring system that allows operators to monitor the NTEWI while dealing with any number of other on-going emergencies during a disaster. Monthly maintenance and activation ensure that the system is prepared to function during an emergency situation. A plan was also developed for sourcing chlorine for disinfection in an emergency.

CHALLENGES

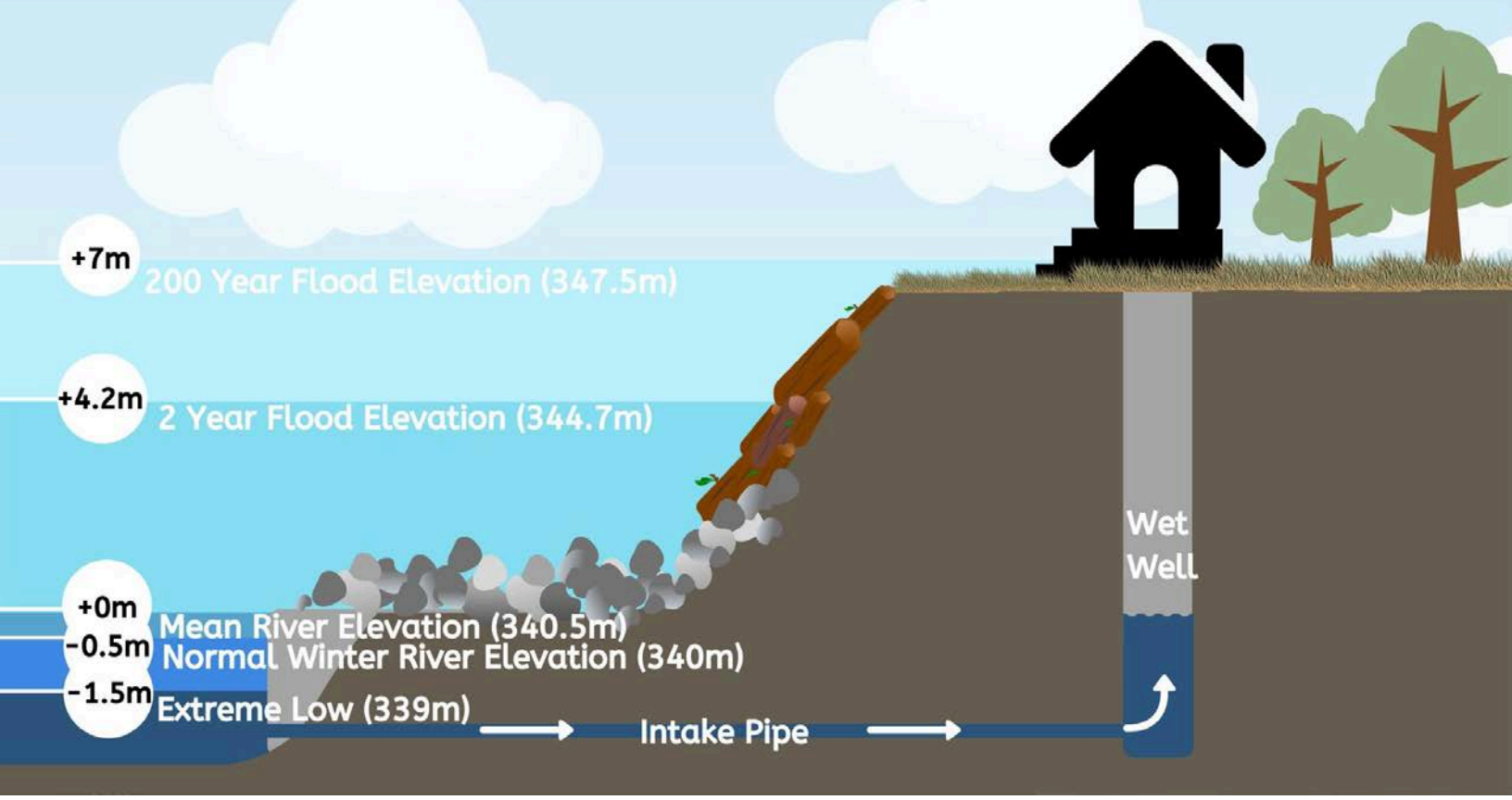
Challenge: The site for the facility was in an established residential neighbourhood.

Solution: Consultation with the neighbourhood and the City staff resulted in incorporation of significant architectural and landscaping features into the project to ensure the design blends seamlessly into its surroundings so that it looks like it's always been part of the neighbourhood.

Challenge: Constructability concerns due to the extensive in-river works and 14m deep wet-well and 30m piles below the water table.

Solution: During the design phase, constructability reviews were performed to minimize both costs and extent of in-river construction, to allow construction methods that minimized building footprint, and to schedule construction during the lowest river levels.

Challenge: Adhere to design requirement that no maintenance will have to be done in or near the river.



Intake can accommodate low winter flows with pumphouse sitting above 200-year flood levels

Solution: Screens were incorporated into the wetwell below the building rather than in the river. This required an innovative method for removing and cleaning the screens inside the building while keeping the system operational. Fish encountering the screens were continuously returned to the river with a fish- friendly pump. The pump is designed to ensure only 2% mortality of fish up to 45 cm long.

Challenge: Adhere to the design requirement that the facility must remain operable during post-disaster conditions such as those following earthquakes and floods.

Solution: The concrete wet-well chamber is supported on a series of 30m deep piles to ensure it can resist earthquake loads. Building and exterior electrical equipment was placed above the 1-in-200-year maximum flood level possibility to ensure the system will continue to operate during extreme events.

Challenge: Designing and constructing the intake and wet-well with consideration to the 200-year river level variability, which ranges by 8.5m from extreme low to extreme high. Typical seasonal river levels also change drastically - by up to 3m every year.

Solution: To account for the 200-year river level variability, the wet-well and intake were designed to extend a depth of 14m, requiring its construction to be executed behind coffer dams within the river. Executing difficult construction in a small area required the design team to work in collaboration with the contractor to continuously improve safety and address constructability concerns.

COMPLETION

Project was completed **on budget** for a total value of approximately

$9,000,000. The project was commissioned and operational in **Fall 2018**.

WSP CANADA LTD. PROJECT SERVICES

WSP provided the following services to the City of Kamloops for this project:

- Primary Consultant: Civil, Architectural, Mechanical, Electrical, Structural, Geotechnical
- Project Management
- Preliminary & Detailed Design
- Contract Administration and Site Reviews

Gravity intake from the North Thompson River to the pumphouse

TECHNICAL EXCELLENCE AND INNOVATION

INTAKE DESIGN

The wedge-style concrete intake structure was configured to force the river water away from the intake structure. This ensures debris will float past the intake rather than entering the wet-well. The main river channel will be pushed away from the intake structure, minimizing silt entering the system and diverting fish from the coarse screen while the pumps are in operation.

TREATMENT

Treatment to a potable water standard was not included as part of this initial phase of the project due to the cost and the high unlikelihood the system would ever be used. Initial system functionality testing involved back-feeding treated water from the current distribution system into the wet well, before pumping it back into the existing distribution system. This allowed for testing the ability of the pumps to reach the entire city, while ensuring that the existing system was not contaminated with partially treated raw water. Future on-going monthly operational testing will only include recirculation of raw water within the pump station.

A chlorine system was installed for primary disinfection, however, a “boil water advisory” will need to be issued each time the system is put online, and stay in place until the emergency is over, the primary system is back online, and the whole system can be flushed thoroughly with properly treated water.

ENERGY EFFICIENCY

High levels of energy efficiency were achieved on this project. Some of initiatives included:

- Installing variable frequency drives on the pumps which allow the motor power usage to vary with the water volumes pumped, rather than the more traditional style of pumps which are either fully powered off. This ensures that the pumps are operating at maximum efficiency for water-to-power ratio, no matter what flow they are producing.
- The building will sit unused a majority of the time with no operators, and no pumps running unless there is an emergency, or if monthly maintenance is underway. Automatic and remote heating and cooling controls prevent unnecessary power consumption. Extensive air conditioning is required due to the extreme heat experienced by Kamloops during summer months, as well as the heat produced by the pumps during operation. In addition to a conventional cooling system, the facility features automatic louvres, and a large overhead door to control temperatures. In addition, the exposed water piping in the building and the deep wet well help keep the building cool during summer operations.
- LED lighting and other low-power fixtures were installed throughout the facility to reduce electricity consumption.

Very low river flows in winter, exposing the intake structure to flowing ice

CONSTRUCTABILITY

The construction site was very small in proportion to the size of the project. A single residential lot housed all construction activity for the in-river works, the footprint for the 14m deep wet well, and all equipment and material storage. WSP was instrumental in developing a compact design that could be safely constructed in a cost-effective, and environmentally sensitive manner. The contractor's cooperation in the coordination and sequencing of events was critical for ensuring the neighbourhood was not unduly impacted by the construction.

COMPLEXITY

This highly complex project was further complicated by several factors:

- The City of Kamloops water system includes nearly 50 pump stations and 50 reservoirs. This highly complex system is supplied with raw water from a single water source, that is conveyed to a central water treatment plant, after which potable water is distributed throughout the City by a high lift pump station. Water from the new source must be fed into the distribution system and then transported backwards several kilometers through the system to the high lift pump station from which is can be pumped to the rest of the city. To ensure the best piping / pumping configuration, extensive water modelling, and piping / pumping scenario development was completed during the planning stages.
- Extensive project planning of the new intake system involved several considerations such as the method by which it will connect to the existing system, amount of treatment required, location and configuration, and operation and maintenance. Emergency management and operating plans were developed in consultation with the City's existing emergency response teams.
- Project management and contract administration was complex due to the many stakeholders, high value of the project, and high public expectations for a critical piece of infrastructure financed by public funds.
- The construction sequencing and schedule added complexity to the project due to the highly variable seasonal river levels. River works and deep wet-well construction were required to be carried out in the winter prior to rising river levels.

Riverbank armouring and wedge style intake to control erosion

SOCIAL AND/OR ECONOMIC BENEFITS

AESTHETICS

The project setting required that the aesthetics of the industrial facility be designed to mesh seamlessly into the existing residential neighbourhood. The building was designed to mimic a residential house, with natural vegetation and xeriscape landscaping treatment. The site was purposely left unfenced to welcome neighbourhood use of the grounds. There are no large exterior lights, preventing both light pollution and illumination of the more subdued subdivision.

The facility will be resilient against climate change where it affects river levels. The building location is placed well above any anticipated flooding for the foreseeable climate change models.

COLLABORATION

- Interior Health was a significant stakeholder in the determination of the method by which the system operates, emergency circumstances necessary to invoke operation, public notices required for system operation, and criteria to assess when the primary system may resume function. Design sessions included consultations with local health officials.
- Extensive design sessions with the City's operators ensured full adoption by the City's staff once the facility was constructed.
- T'kemlups First Nation Band was integral in the archeological investigation prior to construction. This helped ensure the project moved forward in their traditional territory without delays.

This project illustrates the **importance of engineers and other design professionals** in the planning and construction of critical infrastructure with many stakeholders. These professionals helped facilitate design decisions, integrate public input, involvement of stakeholders, contract management, and commissioning to ensure all parties were pleased and satisfied with the result.

Sensitive salmon habitat in the North Thomson River meant extra care and innovation were necessary in designing the intake and fish return system

ENVIRONMENTAL AWARENESS/BENEFITS

The North Thompson River has important salmon spawning grounds with sensitive habitat. To address this issue, the water intake was designed and built with 50mm wide coarse intake screens, preventing any large fish or large debris from entering the wet well. Further, the wet well was built with micro screens dividing the middle, ensuring that any fish who do come through the intake will be kept safe. While the main vertical turbine supply pumps are pumping, a centrifugal fish-friendly pump will continuously pump the river side of the wet-well to deposit any fish and debris safely back into the river, while the main water pump on the other side of the micro screens will pull water up into the pumphouse. The pump locations and wet well configuration ensure that fish are not sucked up against the fine screens in the wet-well.

Fish up to 45 cm long can be safely handled by the pumps with only 2% mortality.

MEETING THE NEEDS OF THE CITY OF KAMLOOPS

The City of Kamloops is located at the confluence of the North and South Thompson River. The potable water supply for 100,000 metropolitan residents relies on a single intake located in the South Thompson River with no redundancy, which is almost unheard of today for a major city in Canada. The City is a major road and rail transportation hub, and is home to many industries both adjacent to, and upstream of its location.

With the reliance upon a single intake and the absence of an alternative source of supply, an extended duration naturally-occurring or accidentally-induced contamination of the South Thompson River would result in a complete shutdown of the City's water supply system.

To ensure a continuous supply of backup raw water to the City, the North Thompson Emergency Water Intake (NTWEI) was planned and constructed. This important facility would take over if the main intake on the South Thompson was rendered inoperable for more than half a day.

100,000 people can sleep better knowing their water system is secure

WSP is one of the world's leading professional services consulting firms. We are dedicated to our local communities and propelled by international brainpower. We are technical experts and strategic advisors including engineers, technicians, scientists, architects, planners, surveyors and environmental specialists, as well as other design, program and construction management professionals. We design lasting solutions in the Transportation & Infrastructure, Property & Buildings, Environment, Power & Energy, Resources and Industry sectors, as well as offering strategic advisory services. With approximately 50,000 talented people globally, including more than 8,000 in Canada, we engineer projects that will help societies grow for lifetimes to come.

wsp.com