Ensuring safe drinking water in a small Yukon community using a multi-barrier approach

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Introduction

The White River First Nation (WRFN) in Beaver Creek, Yukon has completed several projects in recent years to ensure a safe and reliable potable water source for its members. This work has culminated in the construction of two small piped water distribution systems, the largest infrastructure project ever completed by this small northern community. This project is interesting because of the setting, climate and remoteness, and the unique challenges that these present. The water system improvement project has been carried out by a multi-disciplinary team of local engineering consultants and a group of local Yukon contractors with northern experience.

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People and community

The majority of WRFN community members reside in Beaver Creek, Yukon. Beaver Creek is an unincorporated community of approximately 100 people. It is the western-most community in Canada, and the second most remote community in Yukon. Since 1991, WRFN has been providing services to its membership such as health, education and social assistance under the *Indian Act*.

Setting and climate

The community (Lat. 62° 25′ N, Long. 140° 52′ W) is at an elevation of approximately 760 m and has a sub-arctic climate. Average daily temperatures range from highs of 20 °C in July to average lows of minus 32 °C in January. The lowest recorded temperature in Beaver Creek is –60 °C. Beaver Creek is in an area of discontinuous permafrost and ground frost can penetrate as deep as 7 m below grade (assuming bare, dry, granular soils with no snow).

Similar to most Yukon communities, the residents of Beaver Creek have relied on groundwater as their primary water source. The Beaver Creek aquifer underlying the community is extensive, productive and has water of very good aesthetic quality that typically meets all parameters of the *Guidelines for Canadian Drinking Water Quality* (Health Canada).

However, the Beaver Creek aquifer is unconfined and vulnerable to potential contamination, making it even more important to properly locate and construct water wells and to implement strategies to protect the resource.

First Nation Water Management Strategy

The water system assessment and improvement work that has been completed over the past four years was funded by the federal government and the First Nation. In the wake of Walkerton, North Battleford and other serious water issues, the Government of Canada established a program called the *First Nation Water Management Strategy* (*FNWMS*) in 2003 and committed $600 million of new funding over five years to ensure the safety of water supplies in First Nation communities across Canada. A multi-barrier, source to tap approach was the goal of this program. This approach included implementation of infrastructure upgrades, training and certification of operators, improved operation and maintenance, and more rigorous inspection, monitoring and reporting programs. The strategy was developed and delivered by Indian and Northern Affairs Canada (INAC) and Health Canada. The funding has been extended for another two years to continue operator training, technical support and system upgrades.

Project history

The White River First Nation Water Project has proceeded in phases from 2004 to 2008. Infrastructure improvement has included: assessment of existing water and wastewater systems (2004/2005); feasibility study (2005); conceptual design for improvements (2006); pre-design for improvements (2006); detailed design for improvements (2006 and 2007); and construction (2007 and 2008).

Consistent with the multi-barrier source to tap approach, there have been other ongoing projects to address public awareness, operator training and resource protection including:

- an aquifer and wellhead protection plan completed in 2007;
- the First Nation sending water system operators to small water system training (provided through the *Continuing Education for Operators* program put on by the Yukon Water and Waste Association in conjunction with BCWWA);
- post-commissioning field reviews being completed; and,
- the INAC Circuit Rider Training Program providing ongoing on-site support and training to water system operators (funded through FNWMS).

Project team:

The same project team has been involved throughout the duration of the project:

- White River First Nation (Capital Projects Director and Chief and Council);
- Indian and Northern Affairs Canada (Water Resource Engineer);
- EBA Engineering Consultants Ltd. (Hydrogeological, Geotechnical, Environmental and Project Management);
- Lessoway Moir and Partners (Mechanical);
- FSC Architects and Engineers (Electrical and Mechanical);
- Niels Jacobsen, P.Eng. (Structural, Architectural and Water Treatment); and
- Quest Engineering Group (Municipal).

Why the need for water system improvements?

The 2002 FNWMS National Assessment identified White River as a 'high risk' com-

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munity, due to the fact that the community systems at that time did not have any means of disinfection in the event that bacteria or viruses found their way into the source or distribution systems. As well, water system improvements were needed because existing wells were not properly constructed (lacking sanitary seals, completed in pits below grade and several had elevated turbidity associated with improper well screen design). In addition, the freeze protection and mechanical systems were not constructed in compliance with existing codes and best management practices.

Community water systems design

There has been significant effort in the design to meet WRFN needs and preferences, and to design systems that will perform reliably and sustainably with proper operation and maintenance. INAC's preference to have similarly constructed community systems with chlorination disinfection for residual protection has been incorporated into this design, and the INAC design guidelines and *Safe Drinking Water Protocol* published by INAC influenced the design standards for the new systems.

Two new community systems were designed to replace three existing community systems that were in disrepair; and to include other domestic systems that were deemed to be high risk (due to well construction, system construction, or water quality). The two new community systems are similar in design and function. Each system consists of two drilled wells (one primary and one back-up). The wells were sited to ensure compliance with existing regulation, and constructed in accordance with the *Canadian Groundwater Association – Well Construction Guidelines*. Wells were drilled and developed by Double D Drilling Ltd. of Terrace, BC; and the well screens were designed by EBA Engineering Consultants Ltd., based on grain size analyses. The wells are completed with pitless units, heat trace, and insulated stick-up casings with fenced enclosures.

Water is delivered from the wells to each pumphouse by submersible pumps, and buried pre-insulated heat traced water lines. Upon entering the pumphouse, the water is filtered (10 micron and one micron) and chlorine is injected by digital dosing chlorine pumps prior to discharge into a storage tank. The storage tank provides the required retention/contact time for primary disinfection, as well as equali-

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zation for peak hour water demands. Service pumps draw from the tank and deliver water to a shallow buried, insulated high density polyethylene (HDPE), looped potable water distribution system. Continuous circulation is provided by a dual pumping system connected to each distribution loop. Fire protection is provided by other means.

Since ground frost can penetrate up to 7 m at this site, and permafrost is present in some areas, the project team determined that a shallow bury (1 to 1.5 m) HDPE system with insulation, monitoring and tempering for freeze protection was most economical. The temperature of the return loop water is monitored and heat is added to the supply water line as necessary with a propane fired boiler. A back-up generator is installed in each pumphouse building to provide power so that water supply can be maintained in the event of a power outage. Service connections consist of two pre-insulated water lines (supply and return) within a carrier pipe, and a recirculating pump at the entrance to each building.

All system components are designed to allow for some minor future expansion, and the pumphouses have been designed to accommodate more equipment for potential expansion in the future.

Some WRFN residents are averse to having chlorine in their drinking water, for aesthetic reasons and possible health concerns. Inline granular activated carbon filters have been installed at the point of entry to each residence, or at the point of use at a dedicated tap in the kitchen for drinking and cooking.

Construction was carried out under the direction of the First Nation and engineering team in the summers of 2007 and 2008. The construction contract was awarded to Norcope Enterprises Ltd. of Whitehorse. Sub-contractors (all from Whitehorse) included: Keith's Plumbing and Heating (mechanical), Arcrite Northern Ltd. (electrical and controls), Bomac (building construction); Aqua Tech Supplies and Services Ltd. (well connections and chlorination systems).

Due to the remote location and cold climate, the following design considerations were made:

- Redundancy – all major components are in duplicate to provide redundancy in event of a component failure (water wells, boilers, chlorine injection pumps, filter assemblies, circulation pumps, booster pumps).
- Control systems and alarms – in the event of a system component failure, the controls system will alarm.
- A remote on-line monitoring and control system has been installed to facilitate support to the operators.
- Freeze protection – because there is discontinuous permafrost and very deep ground frost penetration, the entire underground system consists of pre-insulated pipe. The recirculation system and tempering system ensure that the water will remain above freezing during normal operation.
- Thaw/bleed points are provided at four locations on each distribution system for clean-out or thawing (if necessary).
- A steam thaw unit was also provided for use in the unlikely event of a system freeze-up.

The project was deemed to be substantially complete on September 5, 2008, at which time the system was handed over to the First Nation. The First Nation has two water system operators who share a half-time position operating the systems.

Conclusions and outlook

There have been significant improvements in the infrastructure, planning and training related to the WRFN water systems. With funding from the federal government, a supportive council, new INAC protocols, and training offered through YWWA, community water systems and high-risk domestic water systems are being addressed. The system design was significantly influenced by the remote location, cold climate and client preference.

The multi-barrier approach is as important in small communities as in large communities. In order to ensure the success of these community water systems, the operators must be diligent in their ongoing training, and in the monitoring and maintenance of the systems. Plant operations and water quality monitoring must comply to *INAC's Protocols for Safe Drinking Water in First Nation Communities* (March, 2006). Pending Yukon public drinking water system regulations (for small public water systems) will also impose regulatory requirements for monitoring and maintenance. The First Nation community must also be diligent in the protection of their resource by implementing their wellhead protection strategies, and by updating their aquifer and wellhead protection plan routinely.

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