Decentralized Solutions for Global Wastewater Challenges

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While urban areas are well serviced by large centralized wastewater systems, lower density and isolated communities (suburban, peri-urban and rural) are often better served by decentralized communal systems. Decentralized systems offer flexibility of servicing with a variety of possible wastewater treatment solutions to suit local conditions and regulatory requirements. The most common configuration of decentralized systems is a septic tank with subsurface leaching bed. However, more advanced forms of decentralized servicing are becoming more popular as a result of more stringent environmental regulations and the decreasing cost of wastewater treatment technologies.

One such form of decentralized wastewater servicing is a small diameter gravity sewer (SDGS) system, which features primary treatment and partial digestion of raw sewage in on-site interceptor tanks and conveyance of liquid effluent through small diameter gravity sewers to a final treatment facility. This system enables the benefits of solids-free wastewater conveyance with the efficiency of a dedicated treatment facility and a single effluent discharge. The quality of wastewater treatment can be tailored to meet the local environmental requirements—anything from communal leaching beds to aerobic treatment units to packaged mechanical plants.

Clearford Water Systems is a provider of SDGS servicing solutions. The technology was developed from an assignment by the Ontario Ministry of the Environment in 1985 to determine a cost-effective wastewater collection solution for northern communities situated in areas with shallow bedrock. Over the past decades, the company has refined the design and delivery of SDGS systems to communities in Ontario, Alberta, Peru, Colombia and India. Experience has proven that this type of decentralized system offers many advantages for construction and operation, and is suited to many more communities than just those with geotechnical constraints. The following case studies are presented to show how decentralized SDGS systems with custom treatment solutions enabled effective servicing in three communities in Ontario, India and Colombia.

Mobile Home Park in Ontario

In 2008, the Municipality of North Grenville was ordered by the Ontario Ministry of the Environment and Climate Change (MOECC) to take over operation of the failing communal septic systems at a private year-round mobile home park with 41 units near Kemptville, Ontario. The park did not have adequate funds to rectify the failing system, so residents were faced with the grim prospect of eviction from their homes. A made-in-Ontario solution was developed showcasing advanced wastewater technology and funded through a Design-Build-Operate-Finance (DBOF) model. The solution provider, residents and municipality worked together to implement suitable ownership, funding and responsibility mechanisms. These included formation of a residents' park association, an all-inclusive water and sewage DBOF service agreement between the park and service provider, and a municipal responsibility agreement.

The technical aspects were planned though a Municipal Class Environmental Assessment study. The preferred site servicing solution was a decentralized SDGS collection system and communal wastewater treatment facility with surface water discharge rated for an average daily flow of 30 m^3/day. Stringent treated effluent limits (BOD$_5$: 5 mg/L, TSS: 5 mg/L,

Figure 1 – Installation of a watermain and 75 mm SDGS within a common trench at a mobile home park in Ontario.

Figure 2 – Installation of the containerized membrane bioreactor at a mobile home park in Ontario.

TP: 0.1 mg/L, TAN: 2 mg/L) were identified because of proximity of the discharge to residences and water quality concerns in the local watershed. A membrane bioreactor (MBR) process was selected because of its compact size and reliably high quality treated effluent. Further treatment process efficiencies were enabled by the use of a SDGS collection system, namely, reduced peak and wet weather flow equalization, and no requirement for headworks or primary sedimentation. The final design for the proposed sewage works was reviewed by MOECC and it was issued an Environmental Compliance Approval.

Construction started in September 2015 and lasted five months. Since the location of existing buried services was unknown, thirty 4,000-L polypropylene interceptor tanks were installed with plugged outlets and connected to each of the homes for temporary sewage holding during construction. Then, approximately one kilometre each of 75-mm high density polyethylene (HDPE) small diameter sanitary sewer and HDPE watermain were installed in a common trench with thermally fused joints to eliminate infiltration and exfiltration (**Figure 1**). Instead of concrete maintenance holes, small system access points were installed throughout the sewer system to allow access for inspection. Both systems were fully commissioned before making all of the final connections.

The MBR treatment system consisted of a lift station tank with flow equalization storage, aeration tank with membrane fine bubble diffusers, alum injection for phosphorus removal, membrane tank with hybrid hollow-fibre/flat-plate membranes, ultraviolet light disinfection, and a waste sludge holding tank with provisional aeration for odour control. The discharge from the plant was an open pipe outfall to a nearby drainage ditch. Due to time and space constraints the MBR plant was manufactured and pre-tested inside a modified 12-meter shipping container. The plant was delivered to site and placed onto a granular pad, where final connections were made and the plant was commissioned (**Figure 2**). The operator can fine-tune the operation manually or remotely through a custom integrated control panel.

Rural Village in India

The second case study is a rural agricultural village in Gujarat State, India with a population of approximately 250 people living in 56 family homes with a small daycare and elementary school. More than 90% of households did not have access to toilets and bathing rooms. Open defecation and accumulation of bathing water, made worse by seasonal monsoon flooding, were a public health concern, creating the potential for contamination of crops and a nearby creek. Hence, there was a need for a low-cost, low-maintenance sanitation system with toilet and bathing facilities, wastewater collection and treatment.

An Indian company constructing a nearby local highway decided to meet its corporate social responsibility mandate by implementing *open defecation free* sanitation for the village. The key objectives for the project were to:

– provide safe access for all households to private toilet and bathing facilities
– provide training to the villagers to take over operation of the new low-maintenance sanitation system.

The developer selected a partner to design and build a cost effective sanitation solution to meet the project objectives and budget. Although the developer funded most of the project capital cost, residents were asked to contribute a nominal amount upfront as a commitment to the project.

At the design planning stage, the major focus was the evaluation of different wastewater collection and treatment technologies, as well as on toilet and bathing facility features. The reported water consumption in the village was 70 L/capita/day for both domestic and agricultural (cattle) uses. With such low flow and high solids concentration in the wastewater, it was determined that a conventional sewer system would be difficult to maintain because of solids accumulation; therefore, a SDGS collection system was selected for solids-free wastewater conveyance. Various wastewater treatment technologies were considered; however, a constructed wetland was chosen by the developer because of low construction cost, easy operation, minimal maintenance, and low power requirement. The toilet and bathing facility design was developed to meet the villagers' preferences,

Figure 3 – Constructed toilet facilities and interceptor tanks at a rural village in India.

Figure 4 – Vertical flow constructed wetland at a rural village in India.

including a covered outdoor washbasin and a small rooftop water storage tank. Side-by-side enclosed squat toilet and bathroom stalls were provided with lockable doors and high windows for privacy and safety.

Construction started after the monsoon season had finished in late November 2015 and lasted for six months. A local contractor was retained to construct the toilet facilities and 2,000 L interceptor tanks in each backyard, including plumbing, concrete and brick work (**Figure 3**). Shallow, buried, small diameter HDPE sanitary sewers were installed along rear yards and connected to a constructed wetland near the discharge creek. The constructed wetland, designed by an Indian supplier, is a proven soil biotechnology treatment process utilizing vertical flow through a proprietary media that can achieve the local regulatory effluent standards for discharge (**Figure 4**). The final stage before operation was testing and commissioning of the sewage system components, including leakage testing of the interceptor tanks and sewers and hydraulic testing of the constructed wetland.

Residential Development in Colombia

The third case study is a private high-end residential development of 115 homes located in a rural valley 10 kilometres outside of Bogotá, Colombia. The developer wanted to build a sustainable community with a reduced ecological footprint, including preservation of natural features and minimal impact to the surrounding environment. A design-build contractor was retained to develop the water management concept and details, and to deliver the site services in advance of new home construction, to be phased over several years.

Regulatory approval for the development was contingent on conserving a primary forest and achieving zero discharge of wastewater from the site. To meet the conservation requirement, it was necessary to restrict clearing to only those areas required for construction of roads and site services. Therefore, constructing narrow and shallow trenches with a flexible layout was preferable. Thermally-fused HDPE pipe was specified to enable safe common trench installation of water and sanitary services. The greater challenge was designing for zero wastewater discharge from the site. An overall onsite water management plan was developed with two main objectives:

1) effective collection, treatment and reuse of domestic wastewater and stormwater; and
2) safe treatment, storage and distribution of drinking water.

The onsite wastewater and reuse scheme incorporates an SDGS system with 4,000-L polypropylene interceptor tanks on each lot (**Figure 5**). The SDGS system enables

Figure 5 – Installation of an interceptor tank at a new development in Colombia.

Figure 6 – Construction of a modular horizontal flow constructed wetland in Colombia

solids-free conveyance for phased flow development and alleviates loading at the final wastewater treatment facility. The developer preferred to delay the capital cost of installing a large treatment plant for the initial phases of development. Therefore, a small 20-m^2 constructed wetland was installed to treat the first phase of development up to 3.6 m^3/day (for approximately three homes). The wetland is intended as a modular solution, whereby additional wetland areas can be added as new homes are connected to the system. The treatment performance of the wetland is being monitored to determine when additional wetland treatment capacity is required.

The constructed wetland design, created by a local engineering consultant, is a subsurface horizontal flow wetland consisting of a shallow excavated basin lined with an impermeable geomembrane and filled with layered media including river stone, gravel, sand, zeolite and activated carbon. Native macrophytes, including rushes, cattails and ferns, were planted in a topsoil layer (**Figure 6**). The wetland is designed to achieve the local regulatory effluent quality for water reuse for land irrigation, namely BOD_5: 200 mg/L, TSS: 200 mg/L and total coliform <1000 MPN/100 mL. The treated effluent is collected in a small pond then pumped to an elevated storage reservoir. A dedicated reuse water distribution network is provided for landscaping irrigation throughout the site.

Discussion

Decentralized wastewater collection and treatment technologies were thoughtfully selected to match the requirements for each project. The application of SDGS and interceptor tanks enabled servicing where there were challenges associated with construction constraints, low water use and development phasing. Furthermore, suitable wastewater treatment technologies were selected to meet local environmental objectives and operation and maintenance preferences. In Ontario, a membrane bioreactor process was selected to meet the strict nutrient limits and to reduce the footprint of the treatment plant. In India, a locally-designed constructed wetland provided low cost treatment with sustainable operating requirements. In Colombia, a modular-constructed wetland will be expanded for phased development, while meeting the overall wastewater reuse objectives for the site.

References

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