Natural approach to decentralized wastewater management gains ground

Constructed and engineered wetlands, using natural biological processes to break down organics through bacterial action, are increasingly being favored over conventional, centralized systems to treat domestic and industrial wastewater. ***Dennis F. Hallahan*** *of Infiltrator Systems and* ***Scott D. Wallace*** *of Jacques Whitford NAWE explain this growing trend and provide several examples of current applications.*

Cities and towns throughout the world face complex wastewater treatment problems that call for new approaches to wastewater management and environmental demands. Decentralized wastewater management, including cluster systems and constructed wetlands, is one approach that continues to attract interest among developers, engineers, and regulators to solve these challenges; both in expanding, "new build" situations but also as "retrofit" options in areas lacking existing wastewater infrastructure.

Centralized sewers are still the preferred solution to wastewater problems in many urban areas. Yet in areas serviced by centralized sewers, serious pollution problems have resulted from inadequately treated effluent discharged to surface waters. This situation is compounded by the ageing of many sewage treatment works combined with the explosive growth of many urban areas around the world.

The lack of sufficient, even basic wastewater treatment in some areas threatens public health and water supplies due to pollution. People cannot safely consume contaminated water, even when water supply is plentiful; and this situation is exacerbated in drought-stricken regions.

Unsustainable wastewater management can also contribute to drought conditions when water is drawn from an aquifer and not replaced. This situation accelerates the depletion of water resources. Not just a residential issue, high volume commercial use of water and the lack of proper wastewater treatment and water conservation strategies constitute critical aspects of future and ongoing water challenges.

The traditional centralized approach to water use and wastewater treatment involves extraction, centralized treatment, and then discharging treated water into surface waters where it is carried downstream. This course of action adds pollutants to already impaired surface waters and prevents the restoration and resupply of aquifers. Consequently, each home or business that is added to the centralized sewer line consumes more water resources.

Two types of decentralized wastewater management are increasing being used. Cluster wastewater treatment systems, which provide high-quality, cost-effective wastewater management, are applicable to a wide variety of situations. Constructed wetland systems are another leading-edge treatment solution being used extensively in industrial, large residential, groundwater remediation, and a host of other applications to solve wastewater challenges.

A constructed wetland in bloom. ***Photo by Jacques Whitford-NAWE Inc.***

The need for new approaches for wastewater management and environmental demands is challenging scientists, engineers, regulators, and product manufacturers to develop innovative ways of testing new approaches and of thinking about how wastewater treatment is accomplished and managed. Another catalyst is a barrage of new health codes that regulate wastewater system design and installation. These codes continue to be amended to preserve and protect public health and natural resources. Growing awareness of nutrient loadings to the environment from nitrogen and phosphorus, aquifer protection, and the value of water as a resource are all factors that contribute to this new interest in decentralized wastewater treatment.

Each year decentralized systems discharge billions of gallons of wastewater. Homeowners, regulators, and the community-at-large depend on these systems to do one specific thing for them – work. In fact, everyone involved with these systems depend on these "hidden" workhorses to perform, and to do so for periods of 20 to 30 years or more with routine maintenance and inspection, little cost, and preferably, no expensive repairs or replacement.

The explanations of "working well" and "must perform" do not stop with simply discharging wastewater to the soil for treatment for all those years. These systems must maintain their structural integrity and storage capacity in order to perform for the long term. Companies who engineer and design these systems (and those that manufacture integral components), including tanks, distribution boxes, leach field chambers, and piping, design and engineer each component to last numerous years under various conditions for the best possible performance and structural integrity.

Constructed wetland treats sewage effluent in Israel

Water reuse is used to protect resources needed for irrigation and for water habitats in water-scarce areas. In Israel, the Yarqon River Authority (YRA) is employing this approach to protect and enhance the quality of the Yarqon River. Together, YRA and the towns of Hod H'Sharon and K'far Saba are working to improve the quality of municipal sewage effluent, which flows into the Yarqon via the Kana tributary.

After securing public ownership of the land and the required budget, both parties determined that effluent from the Kana stream could be improved by creating a wetland treatment system. Beyond providing effluent treatment, the system design also includes a large water basin to provide aesthetic and recreational opportunities for nearby residents.

To design a constructed wetland system for wastewater purification, the YRA contacted the US-Canadian company Jacques Whitford NAWE (JW NAWE), which developed a phased approach that includes identifying constructed wetland alternatives, creating a preliminary design, finalizing a detailed design, construction observation, and finally providing one year of technical support during the first year conditioning of the project. The constructed wetland designed for the Yarqon River site will effectively treat sewage effluent and, moreover, produce significant long-term operations and maintenance savings over the life of the system. The natural system, will be robust, sustainable, and require low energy inputs to operate effectively and safely.

A constructed wetland in Four Corners, Montana, USA. *Photo by Jacques Whitford-NAWE Inc.*

Natural approach preserves land and restores resources

Decentralized wastewater treatment technologies that use natural approaches promote less land-intensive development patterns, provide suitable long-term treatment, create public green space, and are leading to better development practices. Due to the performance data now available that makes these systems increasingly popular with local health officials, the new on-site wastewater strategies and alternative methods of treatment are often the only solution for engineers and developers to obtain a code-compliant system. This is particularly true on sites with difficult soils and tough terrain. The same scenario also applies to large recreational and commercial developments in environmentally sensitive areas where a combination of technologies must also be considered.

A sustainable water use model can be employed in a system that includes decentralized wastewater treatment. For example, sustainable water use is possible where groundwater is extracted, consumed, treated, and returned close to its point of origin in order to recharge the aquifer. Onsite wastewater treatment also enables water reuse possibilities as irrigation – thus creating a sustainable system.

The introduction of chamber technology more than thirty years ago was a revolutionary step in increasing the effectiveness and acceptance of standard and advanced onsite systems. Since the US Environmental Protection Agency in 1980 US Environmental Protection Agency in 1980 first recognized concrete "gallery" chamber systems or "ameration chambers" for onsite septic leach field applications as more efficient than previous traditional stone and pipe systems, chambers have evolved dramatically in design. Several years of research and design culminated with the introduction of Infiltrator® plastic chambers to the marketplace in 1987. These chambers are now commonly used for onsite treatment in basic and advanced applications. The chamber is highly adaptable and effective for specialized system designs and treatment needs. Consequently, it is now a key element in septic system leaching trenches and beds, sand filters, mound systems, evapotranspiration beds, community (cluster) systems, constructed wetlands, large-scale wastewater treatment plants, with pretreatment devices, and toxic waste remediation.

Engineered wetlands are another natural wastewater treatment option that is gaining ground as an effective approach for communities. Engineered wetlands are unique from other treatment processes because they employ vegetation as part of the treatment process, and require very little energy input. On sites with adequate space, the application of engineered wetlands can result in substantial operations and maintenance cost savings, especially for systems that have to operate over long periods of time. The engineered aspect of this technology is the application of enhancements, such as Forced Bed Aeration™, a patented approach that was created by North American Wetland Engineering (NAWE), a US company that introduced process control to the operation of the wetland.

Wetland treatment systems use natural biological processes to break down the organics in human waste through bacterial action. Sufficient air (oxygen) provided to the bacteria enhances the process. Bacteria can provide a robust treatment system for domestic wastewater and recalcitrant, difficult-to-degrade synthetic compounds.

Not only is wastewater management an issue in rapidly growing areas, developers need to stay competitive by maintaining interactive areas and open space even in more rural areas. Creating and sustaining communities that have a nucleus of space and life in close proximity to clustered commercial services is a desirable, cost effective, psychologically appealing, and eco-friendly approach. Decentralized wastewater treatment is a viable option that allows for this type of lifestyle development. Several examples of decentralized wastewater treatment systems are elaborated upon in this article to illustrate the ways in which this approach can help solve wastewater challenges.

Wetland remediates contaminated groundwater

The wetland remediation system implemented by British Petroleum (BP) in Casper, Wyoming, can handle up to three million gallons per day of gasoline-contaminated groundwater, blends into the middle of a premier golf course, and has a lifetime operation of more than 100 years.

The largest remediation wetland in the USA, the site was one of the oldest and largest Amoco Oil Company refineries in the American West, which started operating in 1908. It was the largest refinery in North America during the 1920s and continued operation until 1991. Much of the site is underlain with residual hydrocarbons, resulting from common operating practices during the first 50 years of operation. Since 1981, more than nine million gallons of light non-aqueous phase liquids (LNAPL) have been removed from the groundwater.

The rising cost of environmental cleanup forced Amoco to close the refinery in 1993. BP negotiated an innovative agreement with the City of Casper to clean up the site. This involved demolishing the old refinery structures and converting the property into an 18-hole premier golf course (designed by Robert Trent Jones II), complete with an office park, river front trails, and a whitewater kayak course (designed by Recreation Engineering and Planning)

The large amount of contaminants on the site below the water table posed a problem. Maintaining gradient control requires groundwater pumping for decades before the contaminants can be adequately removed. BP opted for biological treatment given the potential cost savings for the lengthy time required, 50 to 100 years, for effective remediation. The constructed wetland was considered a low-maintenance alternative to conventional options that was aesthetically compatible with the golf course on the property.

Environmental issues catalyst for community systems

Residents of the rapidly growing Four Corners community located near Bozeman, Montana, USA, were deeply concerned about sewage contamination within their wells and the health of the nearby river. Located very close to the Gallatin River, homeowners were convinced that their sewage treatment plant would discharge sewage and contaminate their drinking water.

The Utility Solutions—Four Corners Water and Sewer District realized that development in this area would go beyond the capacity of existing infrastructure very quickly, so the utility designed a new small-scale sewage treatment to serve community needs and solve the controversy.

The new discharge facility uses 2700 Quick 4 High Capacity chambers from Infiltrator Systems Inc that will ultimately expand coverage to 31 zones. Twelve zones have been completed. The State of Montana Department of Environmental Quality approved the facility. Originally gravel was considered for the discharge area, but infiltrator chambers were ultimately chosen due to cost and storage volume. Currently equipped for up to 946 m^3 (250,000 gpd), the facility will be equipped to serve 2000 homes and handle flows of 5678 m^3 (1.5 million gpd) upon completion in 2010.

Cluster treatment systems

The community of Lake Elmo in the US state of Minnesota refused to connect to the regional sewer in order to preserve open space and protect its rural character. This decision was in conflict with growth plans created by the regional planning agency, the Metropolitan Council, so a legal battle ensued that went all the way to the State of Minnesota Supreme Court. Consequently, Lake Elmo was forced to accept a regional sewer along the Interstate 94 corridor and limited use elsewhere. The remaining areas of the community, however, retained their current wastewater systems.

In 1995 local developer Robert Engstrom proposed a development near the "Old Village," the central area of Lake Elmo. His plan, called "The Fields of St. Croix," was to mirror the Old Village with large tracts of open space surrounding a cluster of homes to be served by a decentralized water and sewer system. No ordinances existed to accommodate such a request and wastewater treatment was a concern. After months of working with city and state government, the developer began proceeding with plans to establish the first state-permitted, subsurface flow-engineered wetland in Minnesota.

This marked the beginning of open space developments using decentralized wastewater technology within the community of Lake Elmo. Currently, eight cluster treatment systems in the area now treat a combined flow in excess of 440 cubic meters per day (118,000 gallons per day) using both horizontal subsurface flow and vertical subsurface flow engineered wetland wastewater treatment systems. Subsurface infiltrator chambers treat wastewater disposal using infiltration beds and trenches. The chambers are engineered to increase the surface area available for infiltration of treated wastewater to the subsurface. The lightweight and compact design of infiltration chambers makes them easy to install even on challenging sites.

Sustainability through balance

Sustainable development through sustainable designs for water and wastewater infrastructure is a means of accomplishing balance. Solutions that enable society to meet human needs of food, water, and housing without exhausting or overloading resources are critical to human welfare and, ultimately, survival. Therefore, moving away from extractive and disposable wastewater management methods and toward recycling, closed loop approach, and the restoration of existing systems is essential.

High-strength wastes challenge experts

The aerated subsurface flow constructed wetland at the Williams Pipeline Company terminal facility in Watertown, South Dakota, USA, processes high-strength petroleum contact wastes.

The Williams facility generates large quantities of petroleum contact waste in spring and summer months. Petroleum contact waste includes storm water runoff, hydrostatic test water, and other water sources that have come in direct contact with petroleum products. An oil-water separator transports combined petroleum/water discharge to an outside storage area.

High levels of BTEX, elevated concentrations of carbonaceous biochemical oxygen demand ($CBOD_5$), and ammonia are found in the waste. An existing physical/chemical treatment works could not effectively reduce or eliminate these levels, which prevented the facility from complying with permit requirements. Following unsuccessful testing of several package treatment processes, NAWE designed and installed a subsurface flow constructed wetland onsite.) The 1486-m^2 (16,000-ft^2) wetland processes a flow-equalized input of approximately 1514 liters (400 gallons) per day on a seasonal (May - October) basis. Adequate oxygen transfer is provided by a Forced Bed Aeration™ system that NAWE built into the wetland bed. The processing capability of the wetland exceeded initial design expectations, so wastes from other facilities in North and South Dakota are transported to the Watertown wetland for treatment.

The focus on decentralized treatment continues to increase, so those professionals involved in the design and use of these systems need to become better educated regarding performance. There must be a solid understanding of desirable long-term operational standards and the structural capacities to design systems accordingly. Governments, engineers, contractors, regulators and home or commercial system owners and operators all share the same goal – they want these systems to perform well for many years.

Authors' Note

Scott Wallace, P.E. is a founding partner and senior water services director of Jacques Whitford NAWE, Inc., an ecological engineering firm that has received the 2005 Grand Award for Engineering Excellence from the American Council of Engineering Companies (ACEC). He is the co-author of Treatment Wetlands, 2nd Edition, the definitive textbook on wetland treatment systems. He was also principal investigator for Small-Scale Constructed Wetland Treatment Systems; Feasibility, Design Criteria, and O&M Requirements on behalf of the US-based Water Environment Research Foundation (WERF). Scott holds one Canadian and four US patents for wastewater treatment processes, including Forced Bed Aeration™. He has designed more than 200 wastewater treatment systems, the majority of which involve wetlands. The author can be reached by Email at: scott.wallace@jacqueswhitford.com.

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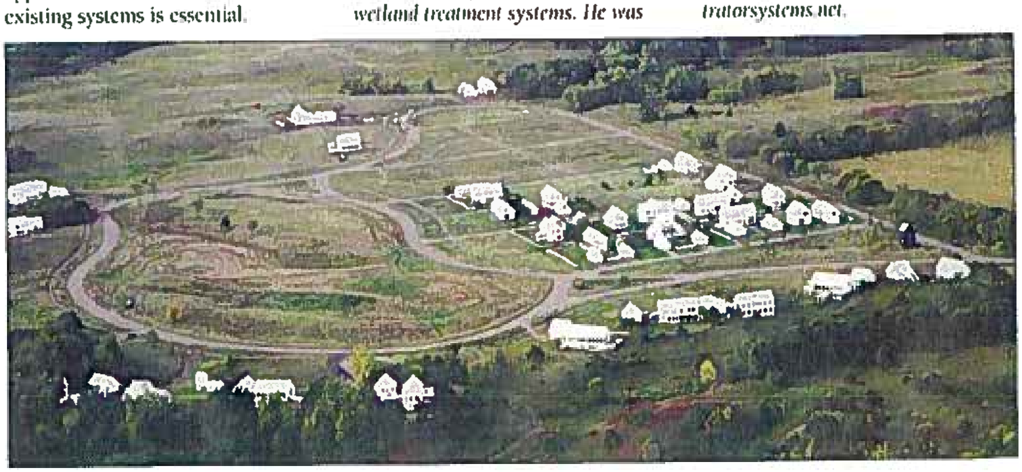

Jackson Meadow. ***Photo by Jacques Whitford-NAWE Inc.***