Sewer mining toolbox helps evaluate reuse opportunities

As water becomes more precious than gold in much of the world, decentralized extraction and treatment of water for reuse is drawing increased interest. Bikram Sabherwal, Jesse Wallin, and Sandeep Sathyamoorthy of Black & Veatch describe how a sewer mining toolbox can help utility managers and developers determine whether water reuse is right for them.

Sustainably increasing the availability, reliability, and affordability of water supplies is one of the great challenges facing the global community of water professionals, and reuse is high on the list of alternative water supply solutions.

Although many utilities and regions gravitate toward large or megascale centralized reclamation and reuse programs, smaller-scale decentralized treatment systems may be more beneficial where specific drivers motivate them, such as limited budgets, smaller and spread-out demands, or lack of technical expertise. Decentralized treatment systems may be highly relevant to promote more water reuse at the micro-local scale, such as in residential communities or multi-neighborhood developments, and to help restore ecosystems.

Sewer mining can be used effectively to achieve these objectives in urban settings. A primary benefit of decentralized water reuse through sewer mining, for example, is that reuse water is collected and produced at or close to the end user, rather than being transported through distribution piping from a centralized treatment facility. Another benefit is the potential to integrate an educational component for local students of all ages.

Sewer mining, which can be a sustainable water reuse strategy, entails mining, or reclaiming, water from a wastewater collection system for reuse (see Figure 1). Sewer mining involves three critical aspects: (1) decentralized treatment is demand driven, and only the requisite volume or flow of water is extracted from the sewer; (2) the treatment process is designed to achieve fit-for-purpose water; and (3) residuals from the associated decentralized water resource recovery facility (WRRF) are typically returned to the sewer. These decentralized treatment systems are typically smaller than 1.9 million liters per day (mld) or 500,000 gallons per day (gpd), and potential users for small- to mid-size WRRFs include housing and condominium developments, athletic fields, universities, and distributed business parks. It is important to note that sewer mining is not a new concept and has been widely practiced in many countries for more than a decade.

Until now, the vast majority of sewer mining projects have been designed for unrestricted irrigation and other decentralized non-potable reuse (dNPR) applications. But change is at hand.

There is a significant increase in the global demand for potable water, particularly in urban areas. And there is growing confidence in the feasibility and reliability of direct potable reuse (DPR) in developed nations. Together, these trends suggest that strategically located decentralized DPR (dDPR) systems are poised to play an important role in efforts to close the engineered water cycle. Although sewer mining is a valuable element in the development of a broader water reuse portfolio that includes dDPR, important questions remain related to a range of issues, including:

- Appropriate technology selection
- Costs of treatment, particularly considering unit cost per treatment volume
- Risks related to public acceptance, given the proximity to neighborhoods, which is a particular concern for dDPR applications
- Impact on the sewer system and cost implications for sewer system maintenance
- Impact on the centralized WRRFs downstream

The potential impacts of sewer mining operations on centralized water resource recovery facilities downstream merit additional discussion. When water is mined from the collection system and treated for dNPR or dDPR applications, residuals from the decentralized treatment process are often returned to the sewer and sent to the centralized WRRF. With dNPR facilities, these residuals include screenings and grit, waste sludge from a biological treatment.
process, and backwash waste from a filtration process (e.g., disc or membrane). These solids have potential to cause sewer blockages and odor issues during low-flow periods in sewer system. The vast majority of the energy embedded in the wastewater has been oxidized in the dNPR facility, but the solids with more inert material are returned to the central facility. These inert solids reduce the biodegradability of the treatment facility influent, which is essential for denitrification or biological phosphorus removal, and take up space in the basins, thereby reducing process capacity. These residuals also have to be removed in the central facility but are of limited value for energy recovery, for example, through digestion at the central treatment facility. Furthermore, if the dDPR process implements full advanced treatment, the reverse osmosis (RO) reject could conceivably be sent to the central water resource recovery facility where it would adversely impact the plant’s biological treatment process due to potential toxicity issues associated with the increased total dissolved solids.

To enable utilities to assess the financial viability of small scale sewer mining opportunities for urban dNPR and dDPR, Black & Veatch has developed a Sewer Mining Toolbox (SM.Toolbox). When it is fully loaded with tools early in 2017, utilities can use this application in conjunction with the company’s consulting services to develop planning-level capital and operating costs and assess the impact of component-level modifications on these estimates. Additionally, the toolbox enables evaluation of the impact of adding sewer-mining facilities on the collection system and the influent to the centralized water resource recovery facility. A summary of the limited inputs required for the SM.Toolbox are shown in Table 1. Toolbox outputs include planning-level system capital expenses (CAPEX) and operating costs (OPEX) with uncertainty in three broad categories as illustrated here (left panel). Comparison of the CAPEX generated using the SM.Toolbox for a 100,000 gpd dNPR and dDPR system (right panel). Graphics by Black & Veatch

Figure 3. The SM.Toolbox outputs enable evaluation of the influence of significant project components. Shown here is an example of the impact of changes in four broad cost groupings on the capital cost of the modeled 100,000 gpd dDPR system. Graphics by Black & Veatch

Figure 2. Typical outputs related to capital costs from the SM.Toolbox. Capital costs associated with Non Potable Reuse for the model system evaluated here. The SM.Toolbox outputs include component level costs with uncertainty in three broad categories as illustrated here (left panel). Comparison of the CAPEX generated using the SM.Toolbox for a 100,000 gpd dNPR and dDPR system (right panel). Graphics by Black & Veatch

To the authors’ knowledge, this is the first integrated approach to developing a better understand-
Decentralized Treatment

As the global demand for water continues to rise, it falls on utility managers and their consultants to develop alternative water supplies. Among alternatives, reuse is king, and decentralized systems could play an increasingly important role in the engineered water landscape of the future.

Utility managers and developers see value in sewer mining and decentralized reuse systems. After all, modular systems can be relatively easy to construct and implement, and the smaller size of these projects requires less capital outlay. Such projects may also be appealing for public-private partnerships or other delivery approaches. But such advantages should be weighed against potential disadvantages associated with decentralization on a case-by-case basis.

Think of the Sewer Mining Toolbox as a cross between a scale and a crystal ball; it enables users to weigh pros and cons and conduct planning-level evaluations and scenario analyses to assess options and opportunities, in advance and with limited upfront investment.

Authors’ Note
Bikram Sabherwal is process engineer, Jesse Wallin is an engineering manager, and Sandeep Sathyamoorthy, PhD, is principal process and innovation leader in the water business of Black & Veatch, a global leader in engineering, procurement, and construction services for water, energy, and telecommunications (www.bv.com).

Figure 4

Figure 4. Typical OPEX related outputs from the SM.Toolbox. Breakdown of OPEX for the modeled 100,000 gpd dNPR and dDPR options (left panel). Influence of Variability in System/Component O&M costs on the overall OPEX costs. Note that labour costs have been specifically removed from this output for clarity (right panel). Graphics by Black & Veatch

an impact of approximately 10 percent on the baseline operations and maintenance (O&M) cost of a 378,500 lpd dDPR system. Any opportunities to reduce the power costs either through selection of a different process configuration or incorporation of energy recovery facilities, such as solar, would be highly beneficial. Again, with relatively limited inputs into the SM.Toolbox, the user is able to develop a planning-level evaluation of the influence and impact of various modifications. The CAPEX and OPEX outputs can be combined to output lifecycle costs and financial metrics relevant to project evaluation such as internal rate of return (IRR) or net present value (NPV).

Planning ahead
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