Operational Costs of Two Pressure Sewer Technologies: Effluent (STEP) Sewers and Grinder Sewers

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Abstract

Alternative wastewater collection systems, such as pressure sewers, can save small communities millions of dollars in capital costs when compared with conventional gravity sewers. Pressure sewers can affordably serve small, spread-out communities, largely because they use small-diameter, shallowly-buried PVC or HDPE mainlines along variable grades to convey wastewater to a treatment facility rather than using large diameter, deeply excavated conveyance mains laid at a constant slope.

Because of their affordability, pressure sewers have been installed by thousands of communities over the past several decades, a number of which are more than 30 years old. Two of these technologies, effluent sewers and grinder sewers, are being proposed in an ever-increasing number of small communities.

Although pressure sewers appear to be an ideal solution for small communities, for a number of reasons most engineers continue to recommend conventional gravity sewers. One often-cited reason is a concern with the life cycle costs of pressure sewers due to the perception that they are more expensive to operate and maintain than gravity sewers. Operational data from long-term pressure sewer systems hasn't been readily available, mainly because of the variety of data, variability in equipment quality, variability in operational and management procedures, and a simple lack of documentation.

Because of the unknowns, consultants have conservatively overestimated operation and maintenance costs for pressure sewer systems. At the same time, consultants have typically underestimated operation and maintenance costs when designing and evaluating conventional gravity sewer systems.

Today, however, enough data is available to accurately summarize pressure sewer costs associated with proactive maintenance, reactive maintenance, equipment repair and replacement, and solids management. In fact, the actual costs for Orenco® Effluent Sewers (aka STEP Sewers) are a fraction of what consultants and long-time utilities previously predicted. With effluent sewers, for example, a single employee can provide O&M services for upwards of 1,000 residential connections.

The O&M costs for conventional gravity collection systems are not summarized in detail, and the range of operation and maintenance costs for gravity sewers is quite broad. However, industry professionals concur that O&M costs for gravity systems are significant, and they regularly exceed those of pressure sewers. Some agencies are reporting R&R costs approaching $100/foot or more.[1]

In regards to capital costs, gravity sewers installed in small communities are often more costly than pressure sewers because of the lack of a large and dense user base to provide economies of scale. With higher capital costs and higher R&R costs, gravity sewer life cycle costs can easily exceed those of pressure sewers. Lacey, Washington, for example, maintains a hybrid collection system consisting of 12,000 gravity sewer connections (with 47 lift stations and 245 km [152 miles] of mainlines), 3,000 effluent sewer connections, and 102 grinder pump connections and has tracked its O&M costs for nearly 20 years. In a paper presented at WEFTEC 2013, Orenco's Bill Cagle et al concluded that "With substantially lower up-front capital and repair/replacement costs, and with O&M costs that are virtually the same as those of gravity sewers, the life cycle costs of Lacey's STEP sewer are clearly lower than those of a typical gravity sewer."[2]

Introduction

In the 1960s and the 1970s, when many rural communities examined collection systems for unsewered areas, the cost of conventional gravity sewer collection lines was found to be very large — as much as four times higher than the cost of the treatment and disposal infrastructure that follows them (U.S. EPA, 1991). For small, spread-out communities, the cost of conventional gravity collection lines is often prohibitive. Alternative collection systems, specifically effluent sewers and grinder sewers, evolved out of the need for rural communities to install affordable sewer infrastructure.

The main advantage of pressure sewers lies in their ability to use small diameter (normally 2-4 inch diameter) variable grade conveyance lines as opposed to the large diameter (typically 8-inch or larger) pipe used in conventional gravity sewers that has to be laid at a constant slope with manholes at regular intervals and at changes in slope, direction, or intersections. Conventional gravity sewers also frequently require expensive lift stations at various points along the mainline.

Unfortunately, even today, thousands of small, rural communities are still unsewered and lack the necessary wastewater infrastructure to meet current environmental standards. “Small communities will need close to 21,000 wastewater treatment facilities by the year 2010 … This represents 71% of all facilities needed for all community sizes throughout the United States.”[3]

Consultants and industry experts agree that pressure sewers can often save communities hundreds of thousands of dollars in capital costs, but debate remains about their long-term operating costs. Consequently, even though conventional gravity sewers have higher up-front costs, many consultants conclude that they are a preferred choice, based on the assumption that conventional gravity sewers cost less over the life of the system.

Until now, consultants have relied on limited information to characterize life cycle costs of alternative collection systems. For example, a consultant for a small unsewered community of about 100 residences in Iowa claimed that a pressure sewer would cost more than $25,000 per year for equipment repair and replacement. That’s enough money to replace all the pumps every three years – pumps that can last 20 years or more. With accurate life cycle cost data, that consultant’s evaluation would have had a completely different conclusion, and the state and federal government could have applied hundreds of thousands of grant dollars to another community in need of sewer infrastructure.

Now that many pressure sewers have been in service for more than 30 years, wastewater utilities have gathered enough long-term data to accurately forecast costs for these systems. Fortunately, this data is readily available for preliminary engineering reports and for communities that need to evaluate options, set rates, and establish reserve funds, as the following cost summaries will show.

Pressure Sewer Technologies

The two main pressure sewer technologies available today are effluent sewers and grinder sewers. Both technologies use small diameter PVC or HDPE sewer mains, normally 2-4 inch diameter, that follow the contour of the land and convey the wastewater to a treatment facility or to a larger sewer main in a neighboring municipality, without the need for deep excavations, manholes, or lift stations.

Table 1, from Crites & Tchobanoglous’ Small and Decentralized Wastewater Management Systems, lists the main differences and advantages of pressure sewers over conventional gravity sewers.

Table 1. Comparison of Conventional Gravity Sewers to Pressure Sewers with Septic Tanks*

Issue	Conventional Gravity Sewers	Pressure Sewers
Infiltration and inflow	Usually encountered	Avoided
Minimum velocities	Required to avoid solids deposition	Not required
Minimum diameter	6-8 in. (150-200 mm)	2 in. (50 mm)
Downhill slopes	Must be maintained at all times	Not required, follow the topography
Cleaning access to main lines	Access ports regularly spaced	Cleanouts and pigging ports
Trench depth	Minimum depth to 20-30 ft. (6-9 m) depending on the slope of the sewer	Maintain minimum depth as with water transmission lines
Pump stations	Needed for low areas where downhill slopes cannot be maintained	Built in to each service or cluster of services
Conflicts with other buried utilities	May require redesign to avoid conflicts	Easily avoided
Ease of construction	Deep and wide trenches go in relatively slowly with traffic disruption	Narrow, shallow trenches go in relatively quickly with minimal traffic disruption

** Source: Crites & Tchobanoglous, Small and Decentralized Wastewater Management Systems, Chapter 6-1, 1998, p. 347*

For existing communities, the ability to use small diameter pipe reduces conveyance costs drastically, since many small communities are spread out and lack the density to distribute costs among a large number of connections. Pressure sewers can reduce mainline costs for communities in areas with hilly or rocky terrain because their mainlines are pressurized and shallowly buried. Further, because they are under pressure, pressure sewer mains are largely immune to infiltration and inflow (I&I), a major problem with conventional gravity sewers, new and old. Eliminating infiltration and inflow can drastically lower treatment costs, as well. Many communities served by older gravity sewers have out-of-compliance treatment facilities that are overwhelmed during I&I events with unmanageable high flows.

Effluent sewers use 1,000 or 1,500 gal. interceptor (or septic) tanks, on-lot, to settle out solids and provide anaerobic digestion. Wastewater from the clear zone of the interceptor tanks is filtered through effluent screens with ⅛ in. mesh, and then it is transported to a conventional municipal sewer system or a wastewater treatment facility.

Depending on system hydraulics, an effluent sewer can use septic tank effluent gravity (STEG) systems, septic tank effluent pumping (STEP) systems, or both. STEG systems use an effluent filter installed in the interceptor tank to allow gravity discharge. STEP systems typically use ½ hp effluent pumping packages installed in the interceptor tank. These pumps typically weigh 30-40 lbs and require 115 VAC power.

Figure 1 shows a typical STEP system.

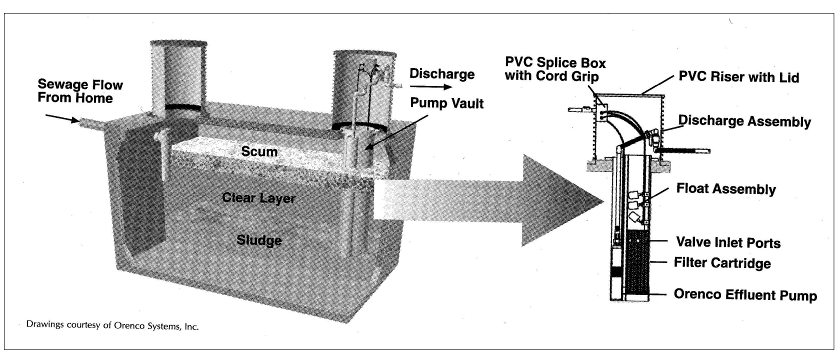

Figure 1. Typical household STEP system[4]

In contrast, grinder sewers collect all of the wastewater from the home into a 70-100 gallon basin and grind it into a slurry, then convey the entire waste stream to a conventional municipal sewer system or to a wastewater treatment facility. Household grinder pumps are usually from 1.5 to 2 hp, weigh in excess of 100 lbs, and normally require 230 VAC.

Figure 2 illustrates a typical grinder pump.

When researching, bidding, and selecting a sewer system, decision-makers will make a more financially sustainable decision if they evaluate all the costs of any given technology: capital costs, ongoing O&M costs (operation and maintenance), and future R&R costs (equipment repair and replacement). These life cycle costs differ greatly by technology and manufacturer. Therefore, rate structures vary widely for different technologies and manufacturers. The following summary outlines approximate pressure sewer costs and shows some basic differences between common pressure sewer technologies. Due to variations in system design, labor rates, and power usage costs, O&M comparisons are approximate only. The costs outlined in the following sections exclude consultant services, permitting, bonding, insurance, billing, accounting, auditing, administration, sampling, and laboratory testing.

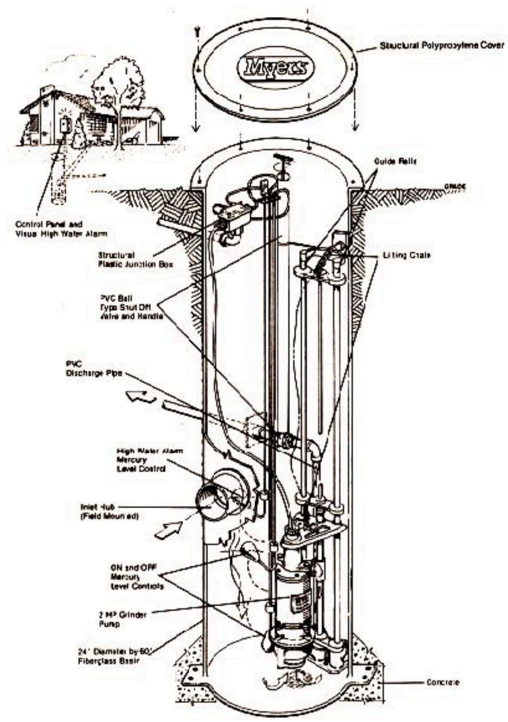

Figure 2. Typical household grinder pump system[5]

Effluent Sewer Operational Costs

Hundreds of communities throughout North America and around the world have selected effluent sewers for their wastewater management needs, and Orenco has maintained contact with most of the systems that have installed Orenco's equipment.

Based on data from Orenco's effluent sewer systems and numerous others, not only are effluent sewer capital costs frequently lower than those for gravity sewers, O&M and R&R costs are generally lower as well.

This position was first taken by the US Environmental Protection Agency in 1997,[6] and it was reiterated by the EPA again, in a March 2009 article surveying multiple effluent sewer systems in Alabama, Tennessee, and Georgia. According to the EPA's Robert Freeman and Joyce Hudson, effluent sewer systems in Mobile, Alabama (for example) "... have provided savings of 25% to 50% over centralized collection and treatment."[7]

In fact, based on the documented performance of thousands of households, Orenco estimates that the operational costs for an Orenco Effluent Sewer are about $7/month/Equivalent Dwelling Unit (EDU).[8]

As Table 2 shows, O&M and R&R costs for Orenco Effluent Sewers fall into four main categories. These categories and costs are summarized in Table 2, and then explained in greater detail, in the following sections.

Table 2. Uniform Equivalent Monthly O&M and R&R Costs for Orenco Effluent Sewers (4% Interest Rate)

I.	Proactive Maintenance (PM)	$1.60/month/EDU
II.	Reactive Maintenance (RM)	$0.60/month/EDU
III.	Equipment Repair & Replacement (R&R)	$2.81/month/EDU
IV.	Tank Pumping	$2.04/month/EDU
	TOTAL	**$7.05/month/EDU**

Effluent Sewer O&M Requirements

Operation and maintenance of effluent sewers is relatively simple and, for most small communities, only requires a part-time operator and inexpensive equipment and tools.

Operation and maintenance requirements for the mainlines of an effluent sewer system are, by and large, insignificant. Occasionally, the operator services or exercises the mainline valves, including air release valves. If the system includes odor control filters, these are periodically maintained or replaced accordingly. While it's possible to pig or flush the mains in an Orenco Effluent Sewer, it's rarely, if ever, necessary. Also, breaks or leaks from collection mains are rare and generally inexpensive to repair.

Most of the operator's time will be allocated to maintaining the on-lot part of the system. Maintenance typically consists of periodic inspection of the STEP components and cleaning, as needed. This includes cleaning the filter or screen, as well as servicing the pump, floats, and controls.

Due to the number of components and products in the on-lot part of effluent sewers, the quality of the equipment purchased by utility managers and operators has a profound impact on the overall life cycle cost of the system. Purchasing and installing high-quality equipment will help to keep life cycle costs low. It is also important to standardize on an equipment package so that operators can stock and carry a limited number of items that are designed to work together.

According to Mike Saunders, who served nearly 10 years as a Utility Engineer and Technical Services Manager for Charlotte County, Florida, a single technician with a small maintenance vehicle can maintain 2,000 STEP connections in an effluent sewer system, as long as the system has been installed correctly with high-quality products. Saunders was responsible for coordinating and planning a system that included 360 miles of gravity sewer lines, 200 miles of force mains, 250 miles of effluent sewer lines, more than 6,000 STEP connections, and 300 conventional lift stations.

Following is additional information on the four main categories of O&M and R&R costs for effluent sewer systems. Unless otherwise noted, the economic calculations in the following sections assume a 4% effective annual interest rate.

I. Uniform Equivalent Monthly Cost of Proactive Maintenance (PM) = $1.60/month/EDU

Proactive maintenance (PM) protocols vary widely between systems, which is one reason why system operators and their utilities report widely different O&M costs. Typically, a PM program includes the servicing of the on-lot components listed below:

- Interceptor tank – measure sludge/scum and pump as needed
- Pump and effluent filter or screen – inspect and clean as needed
- Control panel and float switches – verify control panel and float switch operation

Some utilities have elected to operate their effluent sewers with little or no PM. In a 2009 article titled "O&M Considerations for STEP Systems,"[9] Saunders notes that this approach can yield low PM costs in the early years but "major repairs and replacement activities will escalate as the system suffers from neglect." This increases reactive maintenance (RM) requirements and total operational costs.

Conversely, some utilities have elected to operate effluent sewers with highly aggressive — even excessive — PM schedules. This, says Saunders, can also "result in higher overall O&M costs when PM activities unnecessarily target components that have a significant level of reliability with less frequent PM." Saunders concludes, "The most cost-efficient STEP management approaches balance PM and RM to achieve the lowest overall cost for O&M."

Managers and operators of utilities that start out with aggressive PM programs often find that, over time, they can relax these PM activities and adapt them to the needs of the system. Specifically, that means scheduling PM activities every 3 to 5 years. Conservatively estimating a service visit every three years at about 1.5 hours per service visit and a $40.00/hour labor rate results in a uniform equivalent monthly PM cost of $1.60/month/EDU.

An Orenco Effluent Sewer should be managed with a good balance of PM and RM protocols to maintain its on-lot components. PM activities will consist of effluent screen cleaning, verification of float operation, and sludge/scum measurement and documentation. These procedures can typically be completed in less than two hours per site; consequently, PM requirements can be considered minimal.

II. Uniform Equivalent Monthly Cost of Reactive Maintenance (RM) = $0.60/month/EDU

In the initial year of operation, Reactive Maintenance (RM) requirements tend to be related to installation issues rather than to user practices or material problems. After the first year, as noted in the previous section, RM is affected by PM schedules and activities. However, to arrive at a "typical" RM cost, Orenco has compiled the RM data in Table 3 from eleven Orenco Effluent Sewer Systems totaling nearly 3,100 connections, all of which were installed more than 10 years ago.

Table 3. Residential Service Call-Out Requirement per 100 Connections

State	Community	EDUs	Screened	Hrs/month/100 EDUs
CA	Mt. Lake Estate	8	yes	1.0
CA	Villa Verona	337	yes	2.5
MT	Missoula	350	yes	1.5
OR	Elkton	135	yes	0.7
OR	Glide	1,054	30%	1.5
OR	Lakeside	51	yes	0.3
OR	La Pine	215	yes	1.8
OR	Tangent	180	yes	2.5
WA	Boston Harbor	166	yes	1.6
WA	Conconnully	75	yes	0.5
WA	Diamond Lake	525	yes	1.2
			Average Annual Hrs/month/100 EDUs	**1.4**

These systems average 1.4 hours/month of RM per 100 EDUs. Conservatively estimating 1.5 hours/month/100 EDUs at a $40.00/hour labor rate results in a uniform equivalent monthly RM cost of $0.60/month/EDU. Because Orenco Effluent Sewers have interceptor tanks with sufficient storage capacity to allow operators to handle after hours calls during normal business hours, the RM estimate does not include an overtime labor rate.

III. Uniform Equivalent Monthly Cost of Equipment Repair & Replacement (R&R) = $2.81/month/EDU

Before discussing Equipment Repair & Replacement (R&R) costs for effluent sewers, it is important to note that of the four cost factors in operating effluent sewers, R&R costs are the largest and are directly related to equipment quality.

For effluent sewers, R&R costs are primarily for pumps, floats, and various other miscellaneous components, with pumps contributing the majority of the cost. Costs are relatively low when properly designed pumps are used. A high-quality, multi-stage effluent pump should have run-dry capability, a UL listing, a continuous operation rating, and a 3- to 5-year warranty. Additionally, the pump should be corrosion-resistant and rebuildable, either by replacement of individual components or by replacement of the liquid-end or the motor-end. Used in conjunction with an effluent filter or screen, such a high-quality pump will provide, on average, more than 20 years of service in the environment of the interceptor tank. To arrive at a typical monthly R&R cost, Orenco empirically derived costs from a number of Orenco Effluent Sewer systems and compiled it into Table 4. In these systems, R&R costs average $2.81/month/EDU, partly because Orenco's pumps are small (10 gpm, ½ hp, 115 VAC) and relatively inexpensive.

In reality, R&R costs for Orenco Effluent Sewers may be even lower, since pump R&R assumes complete replacement of the pump every 20 years at approximately $600 per event (materials plus labor). Orenco effluent pumps are repairable, and repair costs are often only half the cost of replacement. At the Orenco Effluent Sewer System in Yelm, Washington, which includes 1,700 pumps, only 28 effluent pumps have been replaced since 1994.[10]

Table 4. Uniform Equivalent Monthly R&R Costs for On-Lot Components of Orenco Effluent Sewers (4% Interest)

Component	Frequency	Cost/Event (Materials + Labor)	Amortized at 4% Interest
Pump Replacement	20 years	$600	$1.62/month/EDU
Float Replacement	10 years	$100	$0.68/month/EDU
Misc. Component R&R	10 years	$75	$0.51/month/EDU
			Total: ~ $2.81/month/EDU

IV. Uniform Equivalent Monthly Cost of Tank Pumping = $2.04/month/EDU

As with PM and RM protocols, tank pumping costs and mandated frequencies vary widely. Based on an 8-year audit of watertight tanks in Glide, Oregon, and a 5-year audit in Montesano, Washington, Orenco established reliable pump-out intervals for households with various sizes of tanks and number of occupants, as shown in Figure 3.[11]

Assuming a 1,000 gallon tank and 2, 3, and 4 people per residence, Orenco projects a pump-out interval of ~21 years, ~11 years, and ~7 years, respectively, calculated at a 95% level of confidence.

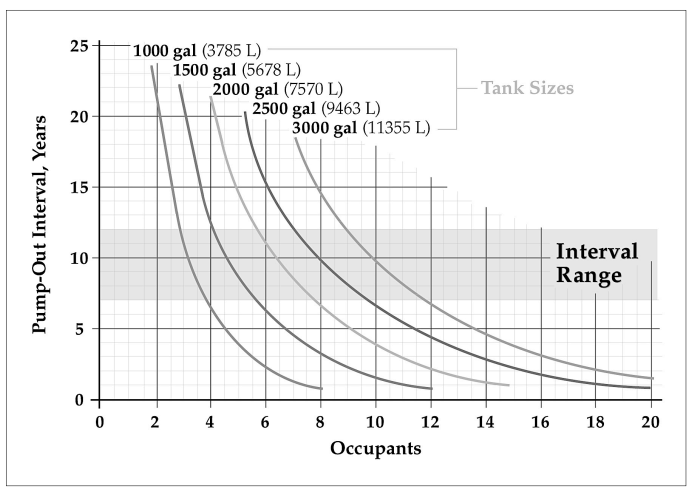

Figure 3. Pump-out intervals at 95% level of confidence

Estimating a pump-out frequency of 10 years with a per-event fee of $300.00, compounded at an annual interest rate of 4%, the equivalent monthly pump-out cost is $2.04/month/EDU.

Yelm, Washington reports the following tank pumping costs: “Most residential units have 1000-gallon tanks, which are pumped out every 6 years, on average, at a cost of $0.24 per gallon. Amortized at 4% interest, the equivalent monthly cost comes to $2.96/month/EDU to manage sludge.” [12] Pump-out costs for the STEP system in Glide, Oregon, average about $1.10/month/EDU. At the more typical pump-out fees of $200.00 or $250.00 per event and a 10-year pump-out frequency, the cost/month/connection is reduced to $1.36 and $1.70, respectively.

Effluent Sewer Treatment Facility and Power Costs

The four O&M/R&R cost categories described above are the costs assumed by the utility or municipality and therefore must be calculated into user rates. Please note that there are no power costs included in the calculation. It costs little more than $1.50 per month to run each household’s pump,[13] and that negligible cost is part of each household’s monthly electric utility bill. Typically, energy-consuming lift stations are not required with effluent sewers – unlike conventional gravity sewers.

Effluent sewer systems also provide primary treatment, reducing solids by about 80%. Therefore, they are often followed by downsized and less costly secondary treatment facilities, such as a media filter, constructed wetland, or lagoon.[14] Treatment facilities following effluent sewers also exclude costly headworks components such as bar screens, grit chambers, and primary clarifiers. Additionally, infiltration and inflow rates are nearly eliminated with effluent sewers, thus further reducing treatment facility costs.

Grinder System Operational Costs

Grinder sewer operational costs can also be separated into four main categories: proactive maintenance (PM) activities, reactive maintenance (RM) activities, equipment repair and replacement (R&R) activities, and solids management (SM) requirements. Solids from grinder sewers are typically managed at a downstream treatment facility, whereas the majority of solids for effluent sewers are managed on-lot. Because effluent sewers provide on-lot solids management, when evaluating and comparing collection systems, solids management costs must be accounted for with all of the collection system types.

Based upon conservative industry-accepted costs and frequencies, the total uniform equivalent monthly costs (O&M and R&R) are approximately $16.91/month/EDU (excluding solids management). These categories and costs are summarized in Table 5, and then explained in greater detail in the sections below. Unless otherwise noted, the economic calculations in the following sections assume a 4% annual interest rate.

Table 5. Uniform Equivalent Monthly O&M and R&R Costs for Grinder Sewers (4% Interest)

I.	Proactive Maintenance (PM)	$1.60/month/EDU
II.	Reactive Maintenance (RM)	$1.90/month/EDU
III.	Equipment Repair & Replacement (R&R)	$13.41/month/EDU
IV.	Solids Management	$ (Required at WWTP)
	TOTAL	**$16.91/month/EDU (Excludes solids management)**

Grinder Sewer O&M Requirements

Operation and maintenance of grinder sewers is comprised of on-lot and off-lot (mainline or force main) activities.

The most significant O&M cost for mainlines is mainline cleaning, primarily for grease and oil accumulation. The need for mainline cleaning varies depending upon the community's wastewater flows, wastewater characteristics, pipe diameter, and scouring velocities. Mainline cleaning is required when scouring velocities (typically 2 ft/second) aren't achieved, as in slow build-out subdivisions or in communities that oversized mainlines to accommodate future growth. Mainline cleaning normally includes pigging devices to physically clean the solids that are deposited on the surfaces of pipes.

Additionally, the operator must service or exercise the mainline valves, including air release valves. If the system includes odor control filters, these are periodically maintained or replaced as needed. Mainline maintenance activities outside of mainline cleaning are financially insignificant.

As with effluent sewers, most of the operator's time and costs will be allocated to maintaining the on-lot components of the system: proactive maintenance visits, re-active maintenance activities, and periodic equipment repair and replacement.

I. Uniform Equivalent Monthly Cost of Proactive Maintenance (PM) = $1.60/month/EDU

As with any wastewater product or system, appropriate PM can help prevent excessive RM requirements. PM for grinder systems includes but is not limited to sharpening cutters/blades, confirming liquid level sensor operation, and inspecting pumps. Utilities generally select PM frequencies of 3 to 5 years. Estimating a service visit every three years at about 1.5 hours per service visit and a $40.00/hour labor rate gives a uniform equivalent PM cost of $1.60/month/EDU.

II. Uniform Equivalent Monthly Cost of Reactive Maintenance (RM) = $1.90/month/EDU

Grinder system reactive maintenance visits are typically immediate in nature, due to the relatively small volume of reserve storage in 70-100 gallon grinder pump basins. Operators must respond to alarms immediately, even outside of normal work hours. Thus, reactive maintenance costs for grinder systems typically include overtime charges on a percentage of the service calls, due to the immediate response required.

According to a 1999 article titled "Introduction to Pressure Sewers" by R. Paul Farrell and Stephen Kreitzmann of Environment One Corp., manufacturers of grinder sewers, the Mean Time Between Service Calls (MTBSC) for several grinder sewer systems (after deleting a newly-installed "outlier") averages 7.2 years,[15] as shown in Table 6.

Table 6. Reactive Maintenance Costs for Selected Grinder Sewer Systems

Location	Number of Pumps	Average Age (years)	O&M $/pump/year	MTBSC (years)
Cuyler, NY	41	16	$41.39	4.9
Fairfield Glade, TN	955	16	$36.07	5.6
Pooler/Bloomingdale, GA	998	11	$13.24	10.4
Pierce County, WA	900	9	$51.00	7.9
		Average	**$35.43**	**7.2**

Farrell and Kreitzmann define MTBSC (years) as follows: [16]

$$\text{MTBSC (years)} = \frac{\text{\# pumps in service (P) x years in service (T)}}{\text{Total \# of service calls in T yrs (S)}}$$

Farrell and Kreitzmann's article does not differentiate between proactive maintenance, reactive maintenance, or equipment repair & replacement. And it does not detail what is done during service visits. Reactive maintenance visits vary widely due to differences in equipment and construction practices; however, most consultants conservatively estimate one service call every eight years. At $180 per visit (3 hours at $60/hour), the cost per month per residence is approximately $1.90/month/residence.

Note that some utilities experience much higher costs. For example, an article in the *Leavenworth Times* titled "County to increase sewer district budget" stated that, "In 2007, Sewer District 3 had 29 calls for grinder pump repairs. Public works has received 31 calls for grinder pump repairs in 2008, Forslund said. Each call in 2008 has cost about $670, Forslund said."

III. Uniform Equivalent Monthly Cost of Equipment Repair & Replacement (R&R) = $13.41/month/EDU

Equipment repair and replacement frequencies and costs vary greatly since the quality of the equipment has a significant impact. Consequently, the following numbers are approximate and are intended to provide a general guideline. When evaluating system options, equipment manufacturers should be solicited to provide detailed life cycle cost breakdowns and warranty information so that engineers and utility managers can evaluate systems appropriately and set rates accordingly.

Equipment repair and replacement (R&R) costs for grinder sewers are primarily for pumps, floats (or liquid level sensors), and various other miscellaneous components. The cost associated with grinder pump R&R is the single largest cost factor in the operation of a grinder system.

Pump repair frequencies from reputable, long term grinder pump manufacturers are generally assumed to occur at an 8- to 10-year interval with a cost of approximately $800 per event, including labor and materials. Pump replacement frequencies generally occur on a 16- to 20-year interval with costs ranging from $1,500 to $2,500 per event.

<u>R&R Data from Grinder Sewer Utility Districts & Grinder Pump Service Center</u>

Many utilities report more frequent grinder pump R&R events.

For example, in a November 13, 2008 letter, Southeast Brunswick Sanitary District informed homeowners that, "Under the new [grinder system] maintenance policy, the District will pay for repairs and/or replacement of the system as defined in the attached policy. The cost of the policy will be billed on your District sewer utility bill for a monthly fee of $10 … Historically, the typical cost to repair a system ranges from $300 to $500, and a pump replacement is $2,500 … The average life expectancy of a grinder pump is 10 years, so repair and/or replacement is inevitable."

In a November 15, 2006 article titled "City weighs options for fund deficit," the *Kansas City Star* reported that "The fee – currently around $20 a month – is collected in exchange for the city repairing and maintaining the pumps with funds collected in a grinder fund."

And the James City Service Authority's "Current Customer Rates and Charges" (as of July 1, 2006) notes that, "A Grinder Pump Maintenance Charge of $210 shall be paid annually by each customer who has requested the JCSA to provide that service."

The grinder system installed in Weatherby Lake, Missouri, offers another good example. Weatherby Lake installed a grinder system in 1974-1975, which initially consisted of 309 homes. Approximately 100 homes were added in the 70's and 80's. Another 100 homes were added between 1990 and 1995. The annual budget for grinder pump repairs/replacements only (excluding administration, labor, payroll, benefits, etc.) in 2009 and 2010 was $87,000, and $90,000, respectively. Assuming an annual budget of $90,000 and 621 connections, the resulting annual cost per connection is $144.93 (or $12.07/month/connection, materials only, labor excluded). The operator at Weatherby Lake reported a repair frequency of 1 to 5 years, an average repair cost between $250 and $500, and a replacement cost of $1,900. With labor included, the cost appropriation will likely approach the values reported by the Water Environment Research Foundation (WERF), below.

Finally, an E One service center in the Midwest (that asked to not be named) operates hundreds of grinder pumps and reported a repair frequency of 8 to10 years, a repair cost of $500, a replacement frequency of 20 years, and a replacement cost of $2,300. Neglecting interest, this equates to an equivalent monthly cost of $14.79/month/connection (materials only, excluding labor).

Grinder R&R Data from WERF

The Water Environment Research Foundation reports much higher annual O&M costs for grinder systems than those cited above, although they incorporate labor, grinder pump repair and replacement costs, alarm call-outs, etc. WERF developed a series of Fact Sheets on "Performance & Cost of Decentralized Unit Processes," as well as a cost-estimating tool* that provides capital and annual O&M costs for various collection system technologies. The following table provides WERF's capital and operational cost summary of grinder and effluent sewers, based on its "Wastewater Planning Model, Version 1.0." Model output is based on a 200-unit example.

* http://www.werf.org/i/c/DecentralizedCost/Decentralized_Cost.aspx

Table 7. WERF Wastewater Planning Model: Low Pressure Sewer (Grinder) and Effluent Sewer

Cost Description	Low Pressure (Grinder) Sewer			Effluent Sewer		
Cost of Collection Network	$525,950	to	$788,925	$516,179	to	$774,268
Installation Cost of On-Lot	$4,291	to	$6,436	$2,625	to	$3,938
Total Installation Cost	$1,384,090	to	$2,076,135	$1,041,232	to	$1,561,848
Total System Cost / Conn.	$6,920	to	$10,381	$5,206	to	$7,809
Annual On-Lot O&M	$224	to	$336	$63	to	$78

Table 7 shows that WERF estimates an annual (on-lot O&M) cost of $224 to $336 for grinder pumps, which is equivalent to $18.67 to $28/month/connection.

Grinder R&R Cost Summary

Given data from all these sources, we can assume a pump repair frequency of 10 years and a pump replacement frequency of 20 years, resulting in a uniform equivalent monthly R&R cost of approximately

$12.22/month/EDU.

Other equipment replacement costs are conservatively covered with a uniform equivalent monthly cost of $1.19/month/EDU. This assumes float or liquid level replacement every 10 years and replacement of various other miscellaneous components.

Thus, a total uniform equivalent monthly cost of $13.41/month/EDU for R&R, shown in Table 8, is in line with grinder O&M costs from numerous sources.

IV. Uniform Equivalent Monthly Cost of Solids Management = $ (Required at WWTP)

Solids management costs for grinder sewer systems are all too frequently ignored in sewer system evaluations, especially when grinder sewers are evaluated against effluent sewers. With grinder sewers (and conventional sewers), solids are managed at the secondary treatment facility. With effluent sewers, solids are managed onsite. Both have associated solids management costs, but in different amounts and at a different stage in the collection and treatment process. Solids management costs must be factored into any comprehensive and equitable sewer system evaluation.

With grinder sewers, the wastewater slurry from the household is ultimately conveyed to a treatment facility for sludge management and processing. Sludge processing includes primary sludge and waste activated sludge (secondary sludge) management, and typically includes thickening of waste sludge, sludge digestion, dewatering, and disposal.

With effluent sewers, solids are retained on-lot in an underground interceptor tank and typically managed by periodically pumping the interceptor tank to remove them. Interceptor tanks normally provide upwards of five days' hydraulic detention time. Pump-outs for interceptor tanks typically occur only once every ten years, thus a high degree of anaerobic digestion is accomplished. This produces minimal solids – 1/5th to 1/20th of that produced under conventional sewering technologies.

Grinder System Power Costs

The four cost categories described above are borne by the utility and therefore must be calculated into rates. Significant power costs, however, are also typically the responsibility of the property owner. Power costs for pumping in grinder sewer systems are higher than power costs for pumping in effluent sewer systems due to the differences in pump hp and amperage draw. Assuming a 230 VAC, 1.5 hp pump operating at 16 amps, a run time of 20 minutes/day, and $0.10/kWh power cost, the cost to operate a grinder pump is approximately $3.70/month/EDU.

Operational Costs of Effluent Sewers Versus Grinder Sewers

As summarized in Table 8, the life cycle costs for grinder sewers and effluent sewers differ greatly:

Table 8. Uniform Equivalent Monthly Costs for Grinder Sewers & Orenco Effluent Sewers

	Proactive Maintenance ($/month/EDU)	Reactive Maintenance ($/month/EDU)	Equipment R&R ($/month/EDU)	Solids Management ($/month/EDU)	Equivalent Monthly Costs ($/month/EDU)
Grinder Sewer	$1.60	$1.90	$13.41	Required at WWTP	**$16.91**
Orenco Effluent Sewer	$1.60	$0.60	$2.81	$2.04	**$7.05**

The figures in Table 8 show that, over a typical 30-year time-span at a 4% effective annual interest rate, the difference in present worth between an effluent sewer and a grinder sewer for a 100-home community is $204,598.94.

Operational Costs of Pressure Sewers versus Gravity Sewers

It is not the purpose of this article to provide operational cost data for conventional gravity sewers. However, it's important to note that, while operational costs for pressure sewers are far lower than consultants frequently claim, operational costs for gravity sewers are typically higher. Accurate operational data for gravity sewers is hard to come by and difficult to quantify; but gravity sewers require routine mainline inspections (smoke/dye testing), cleaning to flush solids, and rehabilitation; root removal; odor control at lift stations and ends of transport lines; routine lift-station inspections; and infrequent but expensive lift station R&R. Moreover, gravity sewers are often neglected, so there are large costs for other O&M variables, such as pipe failures, manhole overflows, SSOs, and lost treatment capacity from excessive I&I. Some agencies are reporting R&R costs approaching $100/foot or more (National Regulatory Research Institute).

Consultants routinely underestimate O&M costs for gravity sewers in their studies, and utilities often don't plan for future equipment repair and replacement costs, forcing them to unexpectedly locate private or government money to fund upgrades. According to an article published by the American Society of Civil Engineers, "Many agencies have not provided the collection system maintenance necessary for an adequate level of customer service and to protect the sizable investment in their facilities."[17] Consequently, plans and priority lists for state clean water programs are filled with projects for lift station and treatment facility upgrades. These can cost utilities hundreds of thousands of dollars over the long run, and such costs should not be considered negligible, especially since these projects are taxpayer funded.

The EPA has long recognized that operational costs for centralized (conventional gravity) systems exceed the operational costs for decentralized cluster systems. In its 1997 "Response to Congress on Use of Decentralized Wastewater Treatment Systems," in Tables 1 and 2, the EPA has compiled data that show annual O&M costs for centralized systems are from four-to-five times higher than O&M costs for decentralized cluster systems.[18]

Capital costs for gravity sewers serving small, rural communities are often so much higher than those of effluent sewers that the deficit is difficult to overcome when calculating and comparing the life cycle costs of the two technologies. For example, Orenco has collected and analyzed constructed costs from more than forty publicly funded and bid collection systems (Orenco effluent "STEP" sewers, gravity sewers, and grinder sewers) serving small communities. Based on that analysis, Orenco effluent sewers cost 41% less than gravity sewers, as shown in Table 9. All costs in Table 9 are USD 2014 per connection.

Table 9. Constructed Costs for Various Collection System Technologies (USD 2014).

Type	Average	Median	Minimum	Maximum
STEP	$9,702	$9,283	$6,666	$15,687
Gravity	$16,394	$15,304	$10,247	$25,112
Grinder	$11,468	$11,258	$6,488	$15,693

**USD 2014 costs adjusted per ENRCCI.*

Based on the data listed in Table 9 the average difference in cost between an effluent sewer ($9,702/connection) and gravity sewer ($16,394/connection) is $6,692. If the average difference in cost (between gravity sewers and Orenco Effluent Sewers) were financed over 30 years at 3% interest, the monthly debt retirement cost per connection would be $28.44 — an insurmountable deficit to overcome even with perceived lower operation and maintenance costs of gravity sewers. According to Cagle et al, "With substantially lower up-front capital and repair/replacement costs, and with O&M costs that are virtually the same as those of gravity sewers, the life cycle costs of Lacey's STEP sewer are clearly lower than those of a typical gravity sewer."[19]

Not surprisingly, then, in 2010, when WERF developed its Fact Sheets and Wastewater Planning Model for gravity sewers, effluent sewers, grinder sewers, and vacuum sewers, this research organization's results show that effluent sewers are the lowest cost alternative, with respect to up-front and life-cycle costs. The fact sheets include design characteristics, performance, and costs for each collection system technology. And the Wastewater Planning Model (cost estimating tool) allows users to compare capital and life cycle costs of effluent sewer to those of grinder, vacuum, and gravity sewers. An example for a 200-unit subdivision is shown in the following tables.

Table 10. WERF Wastewater Planning Model: Effluent and Grinder Sewers (200 EDU).

Cost Description	Effluent Sewer			Grinder Sewer			Vacuum Collection			Gravity Sewer		
Cost of Collection Network	$516,179	to	$774,268	$525,950	to	$788,925	$2,120,188	to	$3,180,283	$3,092,330	to	$4,638,494
Installation Cost of On-Lot	$2,625	to	$3,938	$4,291	to	$6,436	$3,761	to	$5,641	$726	to	$1,088
Total Installation Cost	$1,041,232	to	$1,561,848	$1,384,090	to	$2,076,135	$2,120,188	to	$3,180,283	$4,638,494	to	$5,001,322
Total System Cost / Conn.	$5,206	to	$7,809	$6,920	to	$10,381	$10,601	to	$15,901	$23,192	to	$25,007

Conclusion

Communities and their consultants have, for a long time now, had access to information about the reduced capital costs for small diameter, shallowly buried pressure sewers, compared with large diameter, deeply excavated gravity sewers. However they have not had access to accurate, long-term data on the differences in operational costs.

Consequently, while many communities have been selecting pressure sewers and alternative treatment technologies, most are still plagued by studies and preliminary engineering reports that conclude everything is expensive and nothing is affordable.

These communities can find themselves in a never-ending cycle, often lasting 5 to 10 years, of funding studies and reports, only to be told that conventional technologies and pressure sewer technologies are cost-prohibitive. Decentralized wastewater experts can cite dozens of examples of small communities paying hundreds of thousands – even millions – of dollars in studies, with nothing to show for them. Meanwhile, construction costs continue to rise, while grant funds for studies continue to be depleted.

Now, with more than 30 years of operational history for pressure sewers, accurate, long-term cost data is available and easily replicable. For example, Lacey, Washington has a hybrid collection system consisting of 12,000 gravity sewer connections (with 47 lift stations and 245 km [152 miles] of mainlines), 3,000 effluent sewer connections, and 102 grinder pump connections. In a paper presented at WEFTEC 2013, Orenco's Bill Cagle et al concluded that, "With substantially lower up-front capital and repair/replacement costs, and with O&M costs that are virtually the same as those of gravity sewers, the life cycle costs of Lacey's STEP sewer are clearly lower than those of a typical gravity sewer."[19]

While it is true that every sewering option has its place, it is also true that pressure sewers are an even more affordable and sustainable solution than has been generally acknowledged. Communities and their consultants can now use long-term data to evaluate pressure sewer technologies and ultimately apply the solution with the lowest life cycle cost.

This kind of accurate, long-term cost data is critical when communities are evaluating and selecting sewer technologies for purchase and when they are establishing post-selection rate structures that cover true life cycle costs: capital costs, operational costs, and reserve funds for repair/replacement.

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