Small Community Collection Systems: Construction Costs

Background

Small rural community water and wastewater systems currently account for approximately 90% of environmental regulation violations, according to the Electric Power Research Institute (EPRI).[1]

In addition, according the EPA, "... small communities tend to be economically disadvantaged, under-served and resource-poor." Consequently, "they face significant barriers to building and maintaining effective wastewater treatment services" including ...

- Economic/financial limitations
- Inability to sustain community-wide systems (lack of economies of scale)
- Inability to attract and maintain system operators
- Lack of managerial competency and consistency
- Extreme topography and climate
- Geographic isolation/remoteness[2]

Gravity sewer costs can overtax small communities. Manholes, lift-stations, and other appurtenances essential for gravity sewers are expensive when applied to areas lacking critical density, a commonality of small communities. Slope requirements for gravity sewers often result in excessive burial depths in hilly or flat terrain, increasing the cost per foot installed. In the late 1960's, the cost of conventional gravity collection systems in rural communities was found to dwarf the cost of treatment and dispersal.[3] In the late 1970's, conventional gravity sewer estimates for the small community of Glide, Oregon, represented between 85 to 90% of the total system (collection and treatment) costs.

Lacking operational knowledge, resources, and adequate budgets, small communities rarely develop or enforce ordinances aimed at regulating sanitary sewer connections, often leading to excessive infiltration and inflow (I/I) over time. Unabated, extraneous flows from sanitary sewers increase the need for (1) larger sanitary sewer pipe, (2) lift station capacity and operation and maintenance (O&M) requirements, and (3) treatment plant capacity and O&M requirements, including energy consumption. Electrical costs associated with the processing of I/I can be expensive and costs are on the rise. Energy use consumes 30% to 40% of the O&M budgets at small WWTPs.[4] In many sanitary sewers, extraneous flow consisting of I/I is a major cause of hydraulic overloading of both the collection systems and the treatment plant (Santry, 1964; "Municipal Requirements for Sewer Infiltration," 1965; Brown and Caldwell, 1957). I/I in a sanitary sewer system in one Midwestern suburban community was found to be as high as 0.02 cfs/acre or in excess of 1,300 gpd/capita (5 m^3/d/capita). Average dry weather flows, on the other hand, were less than 70 gpd/capita (0.3 m^3/d/capita).[5]

Alternative wastewater collection systems (also known as "pressure sewers") were conceived to circumvent the challenges of gravity sewers when they are applied to small communities. These include effluent sewers and grinder sewers. Alternative sewers are particularly cost effective in …

(1) sparsely populated or suburban areas

(2) hilly or flat terrain

(3) poor soil conditions: areas with rock

(4) high groundwater

(5) small communities that require lift station(s) or include creek or river crossings

(6) small communities with minimal O&M capability

The cost savings of alternative sewers can be significant. For example, a 1998 report from the Illinois Community Action Association, titled *Alternative Wastewater Systems in Illinois*, included the results of comparative bidding for both effluent sewers and gravity sewers for the City of New Minden, IL. The cost to install an effluent sewer was $1,090,000 (1998 US Dollars), while the cost to install a comparable gravity sewer was $2,090,000, equating to a savings of $1,000,000.[6]

Orenco has collected and analyzed constructed costs from more than forty publicly funded and bid collection systems serving small communities. **On average, Orenco effluent sewers cost 41% less than gravity sewers.** The monthly debt retirement savings — per connection — equates to $28.44/month/connection (30 years, 3%), well above estimated O&M costs for Orenco effluent sewers. As reported in *"Operational Costs of Two Pressure Sewer Technologies: Effluent (STEP) Sewers and Grinder Sewers,"* the uniform equivalent monthly (O&M) costs for effluent sewers manufactured by Orenco are $7.05/month/EDU (<u>includes</u> solids management), while the uniform equivalent monthly (O&M) costs for grinder sewers are $16.91/month/EDU (excludes solids management).[7] According to Cagle et al, considering up-front capital and repair/replacement costs as well as O&M costs over the projected life of the collection systems for Lacey, Washington, the life cycle costs of Lacey's STEP sewer are lower than those of a typical gravity sewer.[8]

Table 1. 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.*

Throughout this document, costs for collection systems are separated into two main components; (1) on-lot equipment (i.e. components installed on private property with easements for construction and maintenance), and (2) Right-Of-Way (ROW) components that consist of pressure mains, gravity mains, and ancillary equipment.

Figure 1. Collection system costs include on-lot equipment and right-of-way components.

All costs contained herein are approximate, largely predicated upon publicly bid jobs with prevailing wage requirements, and require further evaluation and corroboration. Where noted, 2014 costs are adjusted according to *Engineering News Record's* Construction Cost Index (ENRCCI).

On-Lot Capital Costs

Costs: Effluent Sewer On-Lot Pump Package

On-lot equipment for effluent sewers consists of the following:

- 1,000- or 1,500-gal (4- or 6-m^3) interceptor tank (typically constructed of concrete or fiberglass)
- Tank access equipment (including access riser and access riser lid)
- Pump vault with 1/8-inch (3-mm) mesh screen
- Control panel
- High-head effluent pump, ½ Hp (0.25 kW), 115 VAC
- Service connection (ball valve and check valve)
- Short building sewer line
- Shallowly buried, small-diameter service lateral at constant depth (below frost depth)

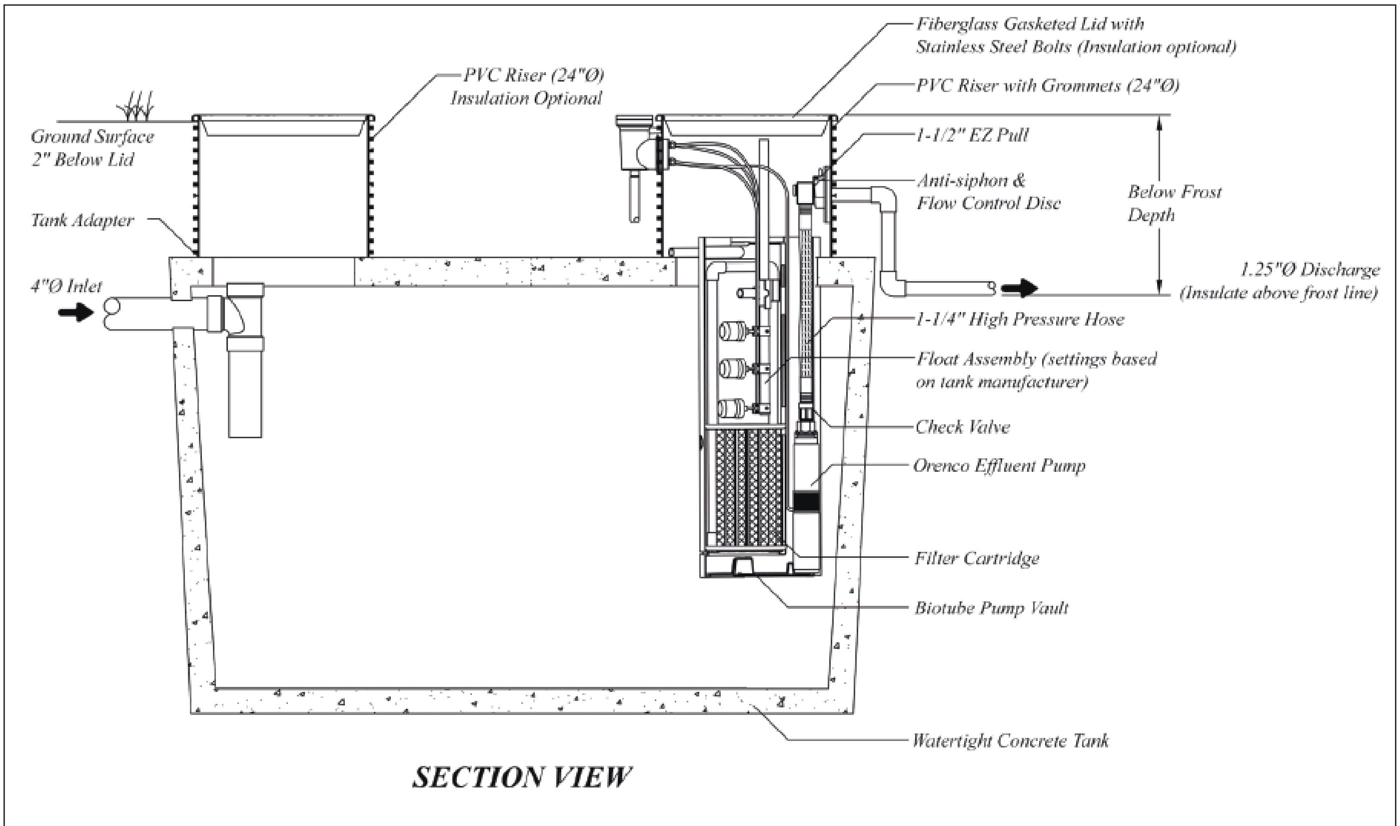

Figure 2. Typical STEP system.

Constructed costs for on-lot effluent sewer equipment — excluding the service connection, building sewer, and service lateral — are provided in Table 2. On-lot STEP package installation costs vary as a result of (1) tank volume, (2) tank material, (3) burial depth, (4) geological conditions, (5) groundwater elevation, (6) tank location and building sewer length, and (7) number of units.

Table 2. Capital Costs: On-Lot STEP Package for Orenco Effluent Sewers.

Project Name	Year	Tank Volume, gal. (m^3)	Unit	Qty	USD/Conn.	Tank Depth, ft (m)
Atoka, TN	2009	1,000 (3.8)	Each	226	$4,700	2-3 (0.6-0.9)
Lexington, IN	2010	1,500 (5.7)	Each	117	$4,532	2-3 (0.6-0.9)
Bayou La Batre, AL	2010	1,000 (3.8)	Each	26	$4,400	1.5-2 (0.4-0.6)
Bayou La Batre, AL	2010	1,500 (5.7)	Each	26	$4,950	1.5-2 (0.4-0.6)
Rathbun Lake, IA	2011	1,250 (4.7)	Each	24	$4,289	4-5 (1.2-1.5)
Superior, IA	2011	1,000 (3.8)	Each	69	$4,485	4-6 (1.2-1.8)
Fulton, AL	2012	1,000 (3.8)	Each	125	$3,400	1.5-2 (0.4-0.6)
Fulton, AL	2012	1,500 (5.7)	Each	5	$4,000	1.5-2 (0.4-0.6)
Christiansburg, OH	2013	1,000 (3.8)	Each	100	$5,095	< 3 (0.9)
Coffeeville, AL	2014	1,000 (3.8)	Each	190	$3,623	2-3 (0.6-0.9)

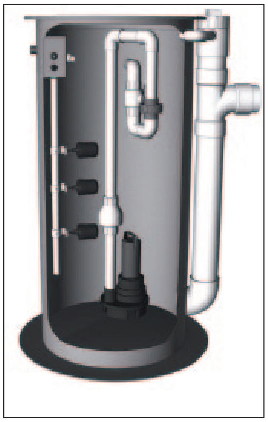

Figure 3. Typical grinder basin, pump, and assembly.

Capital Costs: Grinder Sewer On-Lot Pump Package

On-lot equipment for grinder systems consists of the following:

- 1-2 Hp (0.75-1.5 kW), 230 VAC grinder pump
- 80- to 100-gallon (0.3- to 0.4-m^3) basin, typically polyethylene or fiberglass
- Control panel and level controls
- Service connection (ball valve and check valve)
- Short building sewer,
- Shallowly buried, small-diameter service lateral at constant depth (below frost depth).

Constructed costs for on-lot grinder packages, excluding the service connection, building sewer, and service lateral, are provided in Table 3. On-lot grinder package installation costs vary as a result of basin volume, basin material, burial depth, geological conditions, groundwater elevation, basin location and building sewer length, number of units, reserve storage requirements, and existing home electrical upgrades for 230 VAC power.

Table 3. On-Lot Grinder Package Capital Costs for Grinder Sewers.

Project Name	Yr	Unit	Qty	USD/Connection
Carlisle, IA	2008	Each	152	$4,035
Leisure Lake, IA	2012	Each	339	$5,207

Costs: Pressure Sewer (Grinder and Effluent Sewer) Service Laterals

In addition to the pump packages that are required for grinder and effluent sewers, pressure sewers also require a 1-inch to 1.25-inch diameter (25-mm to 30-mm) service lateral installed at a constant depth. Service laterals include a service connection (Figure 4) that consists of a ball valve, check valve, and access riser.

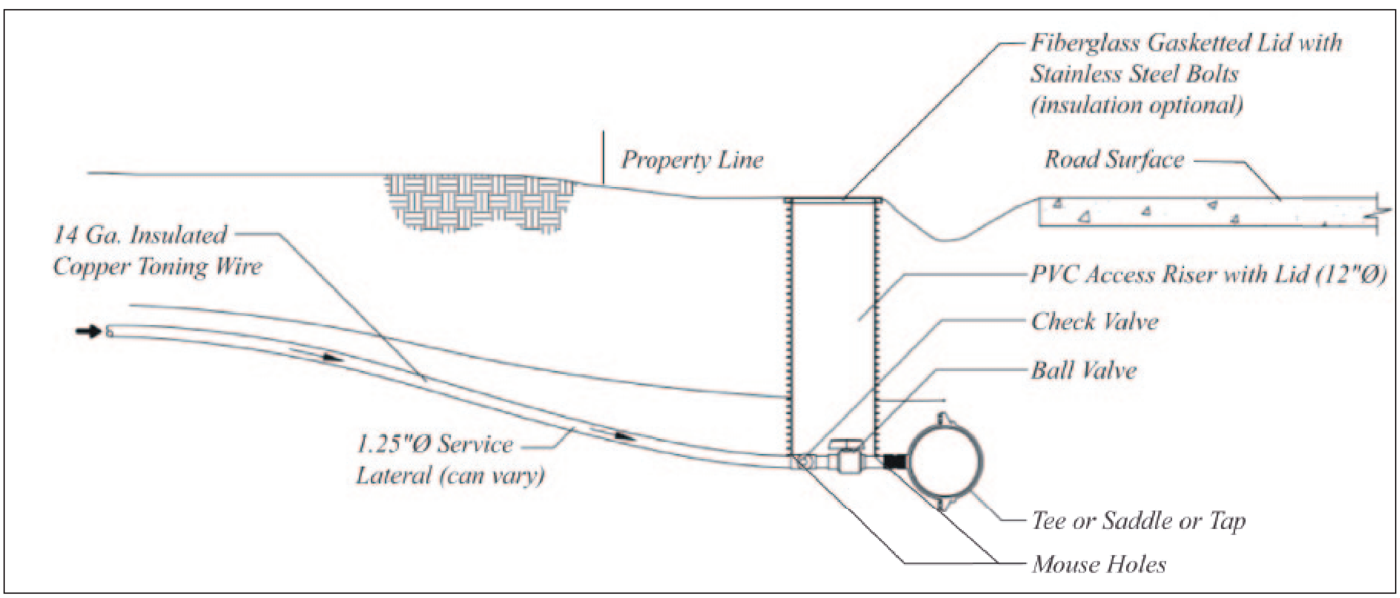

Figure 4. Pressure sewer service lateral.

Table 4 lists constructed costs for several service laterals. Service lateral costs vary based upon (1) main line depth, (2) geological conditions, (3) groundwater elevation, (4) pipe material, and (5) service lateral length.

Table 4. Constructed Costs: Service Laterals for Grinder and Effluent Sewers.

Project Name	Yr	Connections	USD/Linear Ft	USD/Meter	USD/Connection
Carlisle, IA	2008	152	$8.00	$26.24	$816
Lexington, IN	2010	117	(not available)	(not available)	$290
Fulton, AL	2012	130	$2.75	$9.02	$275
Coffeeville, AL	2014	200	$2.83 to $6.40	$9.28 to $20.99	$401

On-Lot Costs: Gravity Sewers

On-lot equipment for gravity sewers consists of a 4-inch to 6-inch (100- to 150-mm) diameter service lateral installed at a 2% slope to provide gravity flow to the mainline. If, depending on the depth of the gravity main, gravity service cannot be provided, a pumping system is required to lift the sewage up to the gravity main.

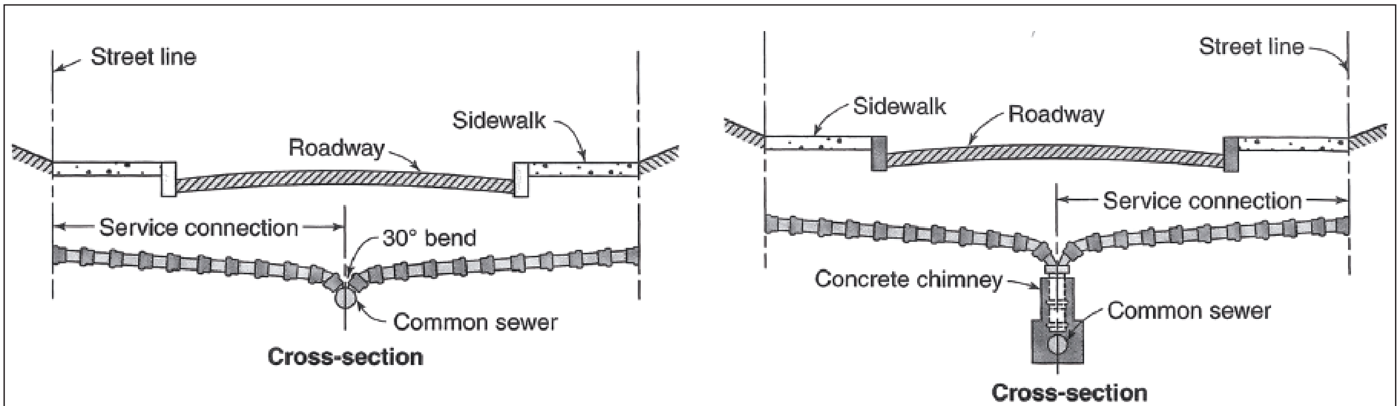

Figure 5. Typical gravity sewer service lateral (*Water Supply and Wastewater Removal*, 2011).

Table 5 lists constructed costs for service laterals from a number of gravity sewer projects. Constructed costs for gravity sewer service laterals vary based upon main line depth, geological conditions, groundwater elevation, pipe material, and service lateral length.

Table 5. Constructed Costs: Building Service Laterals for Gravity Sewers.

Project Name	Yr	Connections	USD/Linear Ft	USD/Meter	USD/Connection
Lore City, OH	2013	129	$55 to $115	$180 to $377	$2,387
Coolville, OH	2013	196	$27	$88	$700
Harrisville, OH	2013	97	$31	$101	$571
Glenford, OH	2014	64	$40 to $74	$131 to $242	$1,686

Right-Of-Way Capital Costs

ROW Costs: Pressure Sewers

Mainline and appurtenances for pressure sewers (grinder and effluent) typically consist of the following:

- Small diameter mainlines — 2- to 4-inch (50- to 100-mm) typical — that follow the contour of the land (see Figure 6)
- Service saddles

- Air release valves
- Clean-outs
- Pigging ports
- Mainline isolation valves. Mainline material is generally polyvinyl chloride (PVC) or polyethylene (PE or HDPE), with pipe buried at shallow depths and with fewer joints compared to gravity sewers due to their increased individual pipe lengths.

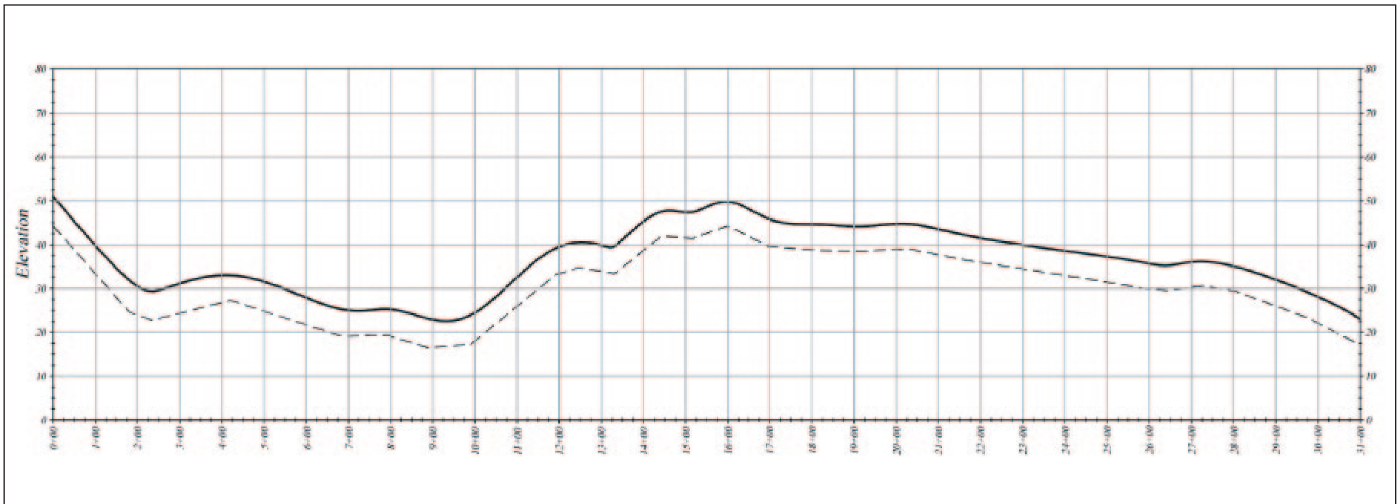

Figure 6. Typical pressure sewer profile, following the contour of the land.

Table 6, adapted from *Water Supply and Wastewater Removal* (2011), lists approximate costs for pressure sewer mains and appurtenances. Construction costs fluctuate due to (1) geological conditions, (2) burial depth, (3) pipe material, (4) groundwater depth, and (5) surface restoration requirements.

Table 6. Installed Unit Costs: Pressure Sewer Mains (Effluent and Grinder) and Appurtenances.*

Item	Unit	Cost per Unit, in 2008 USD
2-inch (50-mm) diameter mainline	Linear ft (meter)	$10.70 ($35.10)
3-inch (80-mm) diameter mainline	Linear ft (meter)	$11.40 ($37.40)
4-inch (100-mm) diameter mainline	Linear ft (meter)	$12.90 ($42.32)
6-inch (150-mm) diameter mainline	Linear ft (meter)	$18.00 ($59.05)
8-inch (200-mm) diameter mainline	Linear ft (meter)	$20.00 ($65.61)
2-inch (50-mm) diameter isolation valve	Each	$360
3-inch (80-mm) diameter isolation valve	Each	$390
4-inch (100-mm) diameter isolation valve	Each	$500
6-inch (150-mm) diameter isolation valve	Each	$570
8-inch (200-mm) diameter isolation valve	Each	$820
Automatic air release station	Each	$1,430

** Table 18.8, Water Supply and Wastewater Removal, 2011.*

ROW Costs: Gravity Sewer

ROW equipment for gravity sewers consists of the following:

- Large diameter mainline laid at a constant slope (see Figure 7)
- Manholes
- Lift stations (if required)
- Air release valves (if required)

Costs fluctuate based upon bedding material, location (rural versus urban), clearing costs, topography, geological conditions, depth, and surface restoration costs. Table 7 lists constructed costs for PVC gravity sewer pipe, excluding manholes, lift-stations, service wye's, and terminal clean-outs. It assumes ideal soil conditions, no dewatering, and an 8-ft (2.4-meter) mean burial depth.

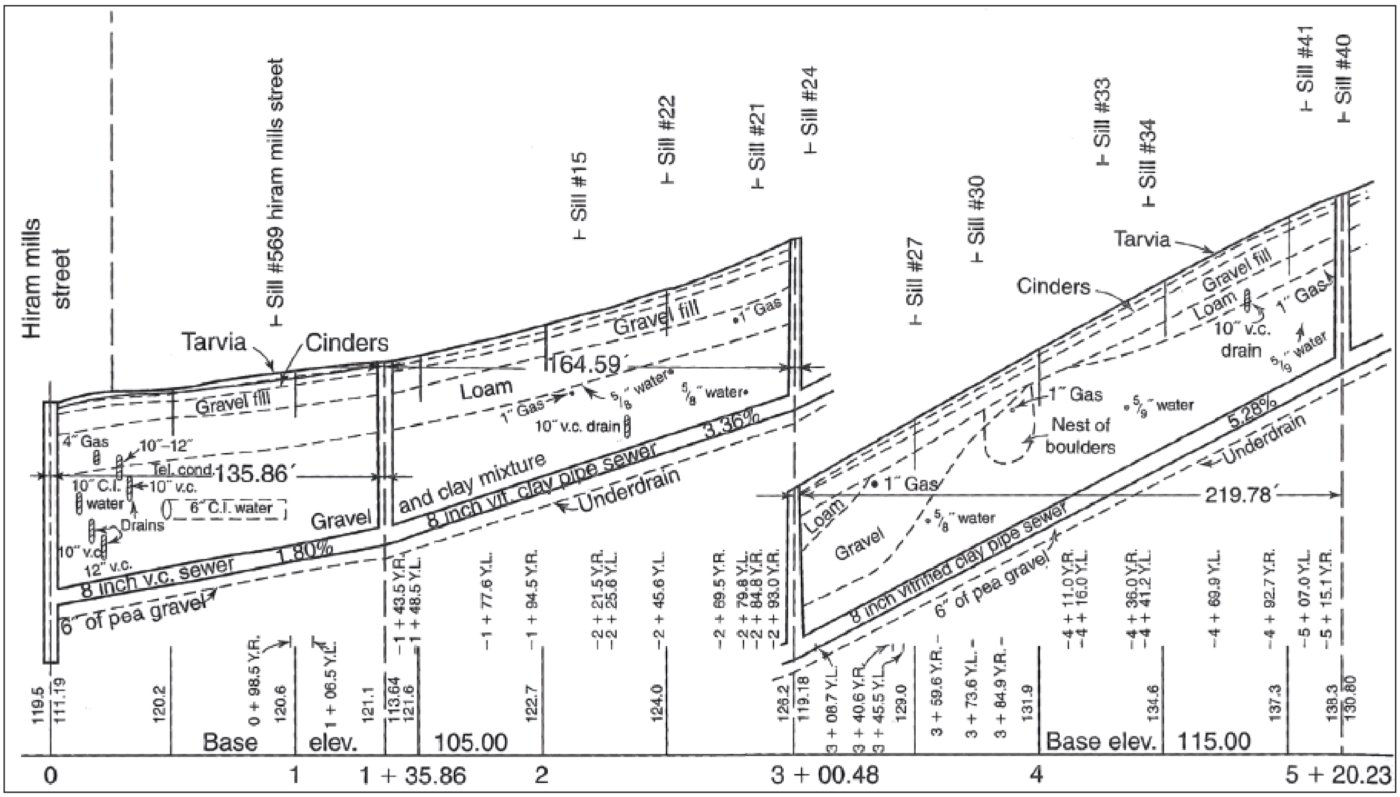

Figure 7. Profile of gravity sewer (*Water Supply and Wastewater Removal*, 2011).

Table 7. Installed Unit Costs: Gravity Sewer Pipe USD/Linear Ft (PVC)*

Item	Unit	Cost per Unit, in 2008 USD
6-inch (150-mm) diameter mainline	Linear ft (meter)	$27 ($88)
8-inch (200-mm) diameter mainline	Linear ft (meter)	$30 ($98)
12-inch (300-mm) diameter mainline	Linear ft (meter)	$35 ($114)

** Table 16.3, Water Supply and Wastewater Removal, 2011.*

Manholes are generally required at the end of each line, at all changes in grade, size, or alignment, at all intersections, and at distances not to exceed 400 ft (121 m) for sewers with diameters of 15 inches (375 mm) or less.[9] With small gravity sewers, a minimum manhole diameter (bottom) of 4 ft (1.2 m) is widely accepted. Table 8 lists constructed costs for sanitary sewer manholes.

Small Community Collection Systems: Construction Costs

Table 8. Constructed Costs: Gravity Sewer Manholes (USD).

Project Name	Yr	Connections	Unit	USD
Lore City, OH	2013	129	Each	$3,500 to $5,500
Coolville, OH	2013	196	Each	$2,800 to $6,000
Harrisville, OH	2013	97	Each	$2,345 to $4,650
Glenford, OH	2014	64	Each	$2,700 to $4,500

When gravity sewers are installed in trenches deeper than 10 ft (3 m), the cost of sewer line installation increases significantly because of the more complex and costly excavation equipment and trench shoring techniques required. Lift stations are used to reduce mainline installation depth and, in some cases, reduce the capital cost of sewer system construction. Lift station construction has a significant economy of scale, and is generally expensive and difficult to apply to small communities. For example, if the capacity of a lift station is increased by 100%, the construction cost would increase only by 50 to 55%. Table 9 lists constructed costs for lift stations that were constructed for small communities.

Table 9. Constructed Costs:* Gravity Sewer Lift Stations (USD).

Project Name	Yr	Unit	Qty	USD
Coolville, OH (Pump Station #1)	2013	Each	1	$50,000
Coolville, OH (Pump Station #2)	2013	Each	1	$45,000
Coolville, OH (Pump Station #3)	2013	Each	1	$45,000
Coolville, OH (Pump Station #4)	2013	Each	1	$50,000
Coolville, OH (Pump Station #5)	2013	Each	1	$90,000
Harrisville, OH (Pump Station #1)	2013	Each	1	$97,250
Harrisville, OH (Pump Station #2)	2013	Each	1	$97,125
Glenford, OH	2014	Each	2	$90,000

** Coolville, OH (235 connections), Harrisville, OH (97 connections), and Glenford, OH (64 connections).*

Tank Decommissioning and Abandonment Costs

Providing sewer service to communities that currently manage wastewater with individual onsite systems typically requires abandonment of the existing septic tanks. Wastewater from existing septic tanks is first pumped, and then the tank is typically crushed and backfilled with appropriate fill material. Table 10 lists septic tank abandonment costs from various septic tank abatement projects. Construction costs will vary based upon (1) tank depths and locations, (2) geological conditions, (3) backfill costs, and (4) septic tank pumping and hauling costs.

Table 10. Costs: Decommissioning and Abandonment of Existing Septic Tank.

Project Name	Year	Unit	Qty	USD/Connection
Atoka, TN	2009	Each	226	$400
Bayou La Batre, AL	2010	Each	26	$550
Lexington, IN	2010	Each	117	$373
El Dorado, AR	2011	Each	440	$495
Rathbun Lake, IA	2011	Each	27	$475
Fulton, AL	2012	Each	125	$200
Bixby, MN	2012	Each	28	$280

Total Collection System Costs

Constructed costs for various small community grinder, gravity, and Orenco Effluent Sewer projects are tabulated in Table 11. Costs are highly dependent on local site conditions (soil conditions, groundwater depth, surface restoration requirements, topography, and material choices) and therefore are only provided for general comparison purposes. 2014 USD costs are adjusted using Engineer News Record Construction Cost Index (ENRCCI).

Table 11. Total Collection System Costs:* Orenco Effluent Sewers.

Project Name	Year	Connections	Bid	USD/Connection	USD/Connection (2014)
Atoka, TN	2009	226	$1,816,115	$8,036	$9,113
Ewing, VA	2010	25	$150,884	$6,035	$6,666
Morefield Bottom, VA	2010	53	$610,979	$11,528	$12,733
Tishomingo, MO	2010	238	$2,213,656	$9,301	$10,274
Lexington, IN	2010	117	$1,117,792	$9,554	$10,553
Perks, IL	2011	58	$544,715	$9,392	$10,064
El Dorado, AR	2011	402	$3,085,873	$7,676	$8,226
Hillsdale, NY	2011	130	$922,750	$7,098	$7,606
Fulton Phase I, AL	2012	130	$1,037,545	$7,981	$8,334
Christiansburg, OH	2013	242	$2,042,550	$8,440	$8,592
Cleveland, MS (Isaac Daniels)	2013	36	$401,890	$11,163	$11,365
Cleveland, MS (Stanton)	2013	43	$453,816	$10,553	$10,744
Cleveland, MS (Noblin)	2013	76	$692,995	$9,118	$9,283
McIntosh, AL	2013	409	$3,205,307	$7,836	$7,978
Eagleville, TN	2014	150	$1,429,317	$9,528	$9,529
Woden, IA*	2014	147	$2,306,052	$15,687	$15,687
Coffeeville, AL	2014	200	$1,638,943	$8,194	$8,195

** The tanks in Woden, IA, were between five and ten feet deep. USD 2014 costs adjusted per ENRCCI.*

Table 12. Total Collection System Costs:* Grinder Sewers.

Project Name	Year	Connections	Bid	USD/Connection	USD/Connection (2014)
Carlisle (Avon Lake), IA	2008	152	$1,409,456	$9,272	$10,845
Ellston, IA	2010	31	$440,423	$14,207	$15,693
Fenton, IA	2011	185	$2,014,830	$10,890	$11,670
Leisure Lake, IA	2012	339	$3,294,798	$9,719	$10,148
Ringgold, IA	2012	104	$1,390,888	$13,373	$13,964
Lampton, MS	2013	516	$3,288,329	$6,372	$6,488

** USD 2014 costs adjusted per ENRCCI.*

Small Community Collection Systems: Construction Costs

Table 13. Total Collection System Costs:* Gravity Sewers.

Project Name	Year	Connections	Bid	USD/Connection	USD/Connection (2014)
Village of Alma, IL	2005	165	$1,509,737	$9,150	$11,943
Village Manor, OH	2007	49	$596,995	$12,183	$14,865
Amesville, OH	2007	82	$688,670	$8,398	$10,247
Lawr Chester, OH	2008	170	$2,631,776	$15,481	$18,106
Marion Township, OH	2009	189	$2,040,240	$10,794	$12,242
Village of Yorkshire, OH	2010	52	$991,816	$19,073	$21,068
Pleasant Plain, IA	2010	68	$1,082,393	$15,917	$17,582
Promise City, IA	2010	63	$585,982	$9,301	$10,274
Knox County - Bladensburg, OH	2011	77	$964,767	$12,529	$13,426
Knox County - Millwood, OH	2011	48	$1,124,892	$23,435	$25,112
Town of Appalacia / Exeter, VA	2011	125	$1,218,820	$9,750	$10,448
Harrisville, OH	2011	93	$1,976,503	$21,252	$22,773
Town of Morristown, NY	2011	108	$2,497,065.00	$23,120	$24,775
Fairview, IA	2011	30	$411,001.50	$13,700	$14,680
Los Osos, CA (Area B and C)	2012	1757	$29,425,000.00	$16,747	$17,487
Hastings, IA	2012	72	$777,650.35	$10,800	$11,278
Coolville, OH	2013	235	$3,634,005.00	$15,463	$15,742
Harrisville, OH	2013	97	$1,277,721.80	$13,172	$13,410
Lore City, OH	2013	160	$3,262,767.25	$20,392	$20,760
Glenford, OH (Re-Bid)	2014	64	$1,386,718.00	$21,667	$21,667

** USD 2014 costs adjusted per ENRCCI.*

Table 14 summarizes the data tabulated in Tables 11-13. Based upon the above data set, on average, Orenco Effluent Sewers have construction costs that are 41% less than gravity sewers.

Table 14. Constructed Collection System Costs:* Three 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.*

Note that STEP systems integrate primary treatment into the collection system, thereby eliminating influent screening, primary clarification, and other primary treatment processes common in secondary wastewater treatment facilities. Pressure sewers (STEP and grinder) are low pressure and watertight, therefore nearly eliminating I/I, which enables smaller secondary and advanced treatment processes.

Phasing Considerations

Developments or communities that anticipate slow growth are often well suited for Orenco Effluent Sewers. The front-end infrastructure (mainlines) represent less than 20% of the overall cost of the collection system; the majority of the costs (on-lot equipment) are deferred until the home is constructed or connected, and they are generally financed with the home.

For example, there is a $73,500 difference in present worth cost associated with a 100-unit development that installs all of the collection system equipment up-front (Figure 8, Option 2) compared to installing ten (10) systems per year over the next ten (10) years (Figure 8, Option 1). This assumes on-lot equipment at $5,000/connection and 3% interest. The user rate savings are $3.12/month/connection less than if the system were constructed entirely at the outset, assuming 3% interest and a 30-year term.

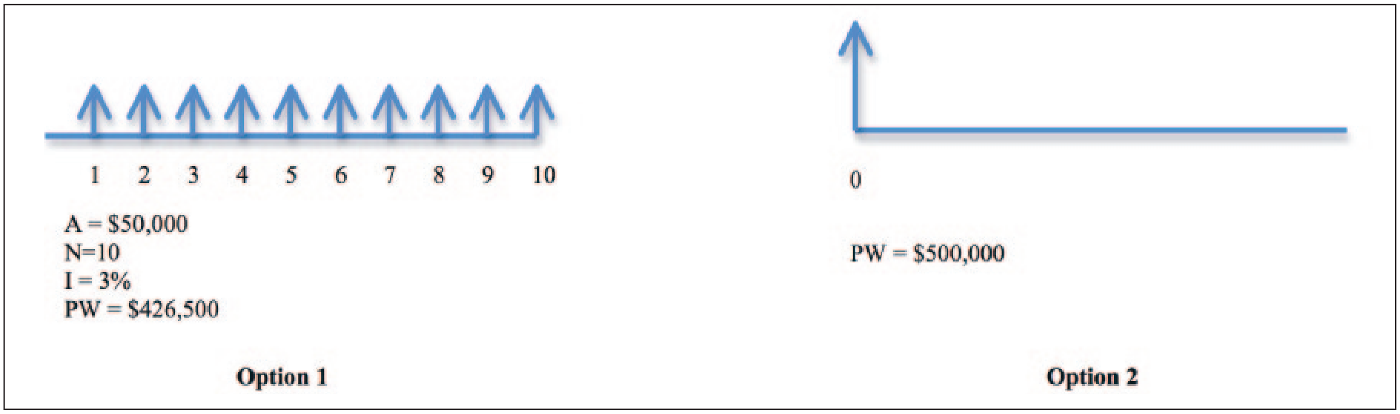

Figure 8. Economics of phasing in an Orenco Effluent Sewer system.

Life Cycle Costs

Virtually all wastewater collection and treatment system owners will spend more on operation and maintenance than on the initial capital cost of the system. Consequently, when evaluating collection system options or establishing user rates, a thorough understanding of operation and maintenance costs is critical.

Until recently, operation and maintenance costs of alternative collection systems weren't substantiated with long-term data. As reported in "*Operational Costs of Two Pressure Sewer Technologies: Effluent (STEP) Sewers and Grinder Sewers*," the uniform equivalent monthly costs for effluent sewers (Orenco) and grinder sewers are $7.05/month/EDU and $16.91/month/EDU, respectively (Molatore, p.12). Moreover, the effluent sewer cost includes solids management and the grinder system cost does not.

Lacey, Washington has a hybrid collection system consisting of 12,000 gravity sewer connections — with 47 lift stations and 152 miles (244 km) 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 [effluent] sewer are clearly lower than those of a typical gravity sewer" (Cagle et al, p.1).

Based on data listed in Table 14, the average difference in cost between an Orenco Effluent Sewer ($9,702/connection) and a 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 the perceived lower operation and maintenance costs of gravity sewers.

Additional Resources

In 2010 the Water Environment Research Foundation (WERF) developed fact sheets for gravity sewers, effluent sewers, grinder sewers, and vacuum sewers. The fact sheets include design characteristics, performance, and costs for each collection system technology. A *Wastewater Planning Model* (cost estimating tool) is also available that allows users to compare capital and life cycle costs of effluent sewers to those of grinder, vacuum, and gravity sewers.[10] An example for a 200-unit subdivision is shown in the following tables. WERF's results generally show that effluent sewers are the lowest cost alternative, with respect to up-front and life cycle costs.

Table 15. WERF Wastewater Planning Model: Effluent and Grinder Sewers (200 EDU).

Cost Description	Effluent Sewer			Grinder Sewer		
Cost of collection network	$516,179	to	$774,268	$525,950	to	$788,925
Installation cost of on-lot	$2,625	to	$3,938	$4,291	to	$6,436
Total installation cost	$1,041,232	to	$1,561,848	$1,384,090	to	$2,076,135
Total system cost/connection	$5,206	to	$7,809	$6,920	to	$10,381
Annual on-lot O&M	$63	to	$78	$224	to	$336

Table 16. WERF Wastewater Planning Model: Vacuum and Gravity Sewers (200 EDU).

Cost Description	Vacuum Sewer			Gravity Sewer		
Cost of collection network	$2,120,188	to	$3,180,283	$3,092,330	to	$4,638,494
Installation cost of on-lot	$3,761	to	$5,641	$726	to	$1,088
Total installation cost	$2,120,188	to	$3,180,283	$4,638,494	to	$5,001,322
Total system cost/connection	$10,601	to	$15,901	$23,192	to	$25,007
Annual on-lot O&M	Maintained by utility			$16	to	$24

Conclusion

Small communities face enormous challenges when constructing and maintaining wastewater infrastructure. Conventional collection system technologies — when applied to small, rural communities — typically result in costs that exceed affordability thresholds and ultimately require grant subsidies to attain reasonable user rates. Without economies of scale, operational budgets are often underfunded, ultimately jeopardizing system sustainability and threatening permit non-compliance.

Alternative collection systems were developed and designed to avoid the shortcomings associated with applying gravity sewers to small communities. Historically, effluent sewers ($9,702/connection) have resulted in an average cost savings of $6,692 (41%), when compared to gravity sewers ($16,394/connection). The monthly debt retirement savings — per connection — equates to $28.44/month/connection (30 years, 3%), well above the estimated uniform equivalent monthly O&M costs for effluent (Orenco) sewers of $7.05/month/EDU.

With increasing energy costs, uncertainties about future fossil fuel supplies, and increasing awareness of the impacts of greenhouse gas emissions, the efficient management of energy is now of greater concern among both private and public entities.[11] Orenco effluent sewer systems are largely immune to extraneous flows, resulting in a major cost savings, both capital and electrical, at the WWTP. Orenco effluent sewer systems, by design, also enable simpler operations, less expensive operational equipment, and less reactive maintenance with respect to immediate response time relative to individual onsite problems versus gravity or lift station problems.

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