

# Sewer Systems: Construction Considerations

## Introduction

Pressure sewers (effluent or grinder) and gravity sewers require different methods of construction, different installation techniques, and different degrees of accessibility to install the various products and system components. The construction impact of installing any sewer system technology falls under two main categories: on-lot and right-of-way (ROW).

Due to the use of small-diameter mainlines that follow the contour of the land, the typical ROW construction impact of pressure sewers is considerably less than that of gravity sewers. The on-lot construction impact of effluent sewers is similar to grinder sewers, but effluent sewers provide primary treatment, lower life-cycle costs,<sup>i</sup> and 24-hour reserve capacity.

Effluent sewer systems have been installed all over the country and around the world – in sparsely populated rural areas, dense downtown commercial areas, and neighborhoods with small lots, mature landscaping, and underground utilities. As a result of its low construction impact and overall affordability, this efficient technology is an ideal solution for a wide range of applications.

This document will explain various aspects of effluent sewer construction and how they compare to grinder and gravity sewer requirements in areas with small lots and existing streets, homes, and businesses.

## Right-Of-Way Construction Impact

### Pressure Sewers

The ROW components of pressure sewers consist of small-diameter, low-pressure force mains — typically 2- to 4-inch (50- to 100-mm) diameter PVC or HDPE — shallowly buried below frost depth, adjacent to the road surface, and following the contour of the land.

The force main components are typically installed via open-trench construction with trenching machines or directional boring (trenchless) construction methods. Open-trench construction methods for pressure sewers typically require a trench opening of 12 inches (305 mm) and shallowly buried pipe, as illustrated in Figure 1. Consequently, they have significantly less excavated material when compared to gravity sewers.

As illustrated in Figures 2 and 3, trenchless construction is the least-intrusive sewer construction method. Trenchless construction offers additional benefits to the public and the environment when compared to open-trench construction for pressure sewers, and especially when compared to open-trench construction methods for gravity sewers. According to the ASCE,<sup>ii</sup> trenchless construction is a less-intrusive method for installing new pipes while reducing:

- Indirect construction costs (known as “social costs to third parties”)
- Adverse environmental impacts and permitting concerns
- Problems with handling and disposing of contaminated soils and groundwater
- Costs of utility conflicts and the resulting relocations
- Costs for surface restoration, including pavement reconstruction



Figure 1. Typical open-trench construction (courtesy of InnoFlow Technologies)

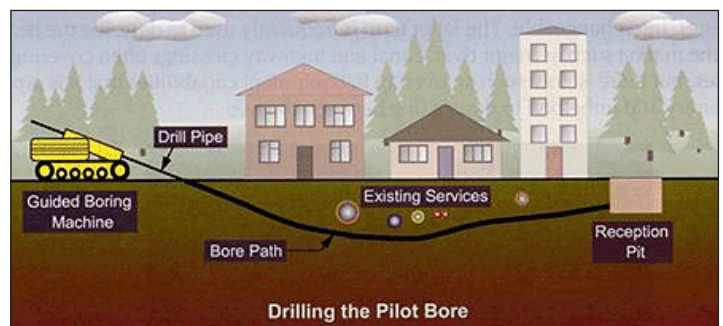


Figure 2. Drilling the pilot bore (trenchless construction)

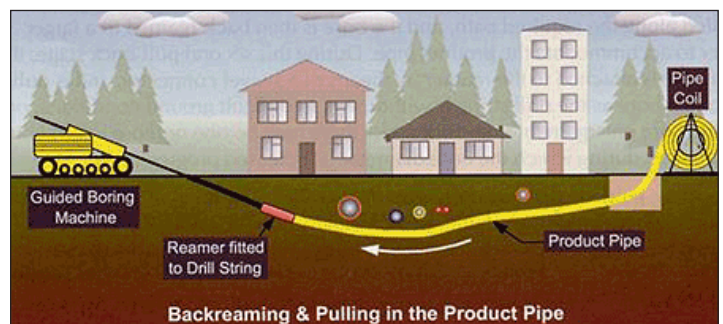


Figure 3. Backreaming and pulling the pipe (trenchless construction)

Figures 2 and 3 from the FHWA's “Manual for Controlling and Reducing the Frequency of Pavement Utility Cuts” report; used with permission. Contract number DTFH61-01-C-00024.



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## Gravity Sewers

In contrast, gravity sewers generally require open-trench construction (without trenching machines or directional boring methods) directly within road surfaces, large-diameter pipe (> 8-inch or 200-mm diameter), and deep excavations often in excess of 10-15 ft (3-4.6 m). The construction impact is comparatively extensive and intrusive, frequently requiring large excavation zones (Figure 4) and generous construction easements to accommodate bulky installation equipment, manholes, and lift stations. Manholes and lift stations also require dedicated public land and permanent electrical infrastructure. Because they require deeper excavations, gravity sewers are also more susceptible to dewatering requirements, complicated and time-consuming rock excavation, and more difficult designs and methods for crossing railroads and streams.<sup>iii</sup>

For example, Figures 4 and 5 show a typical gravity sewer main installation in Vero Beach, Florida. Trench dewatering and shoring was required, slowing the construction process, destroying streets, and requiring complete road restoration.

For new subdivisions, gravity sewer pipe installation is often accomplished by sloping the sides of the trenches for earth stability. This eliminates the need for trench boxes, but substantially increases the construction footprint of the installation. Existing communities, however, typically opt to restrict the trench width to reduce restoration costs and the tendency for utility conflicts, prompting the necessity for steel trench boxes (sheeting and bracing).

Indirect construction costs for gravity sewers are substantial and include the following:

- disruption to vehicular traffic
- road and pavement damage
- potential damage to adjacent utilities
- possibility of damage to adjacent structures
- heavier construction and air pollution
- risk of pedestrian safety
- higher tendency for citizen complaints
- increased environmental impact<sup>iv</sup>

When constructing a gravity sewer in an existing and active street, prolonged and inconvenient traffic delays will likely occur. Road and landscape restoration costs, due to gravity sewer's larger construction footprint, are also more expensive when compared to the restoration costs associated with pressure sewer force mains. "Depending upon soil conditions, either a portion of the roadway or the entire roadway may be removed during the (gravity sewer) trenching operation. In some cases, where only a portion of the roadway is removed for sanitary sewer installation, the remainder of the roadway is effectively destroyed due to the heavy construction traffic that must use it to complete the project."<sup>v</sup>

Backfilling of the gravity sewer trench is particularly important when considering the location of the pipe underneath road surfaces. Specific construction methods for backfilling and compaction aren't covered in this document, but vary based upon the width of the trench, excavated material characteristics, and the degree of compac-



Figure 4. Gravity sewer mainline excavation



Figure 5. Gravity sewer mainline installation



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tion required. Nonetheless, a higher degree of compaction is often required for gravity sewers, more so than for pressure sewers, because the pipe is located directly below the road surface.

Even though records of existing utilities are more accurate today than ever before, communities are still littered with unmarked and hidden electrical, gas, and telephone utilities. Gravity sewers, due to their larger construction zone and the resulting amount of excavated material, have a greater propensity for encountering existing utilities. Slope requirements of gravity sewers also make it challenging – and costly – to avoid existing utilities. The costs associated with existing utility conflicts include additional design costs, repair costs of inadvertently damaged utilities, and loss of production time (down time) while making the repairs. Conversely, pressure sewer mains can be easily re-routed to avoid existing utilities.

The time required to construct the ROW components of a gravity sewer is much longer than for a pressure sewer. This often translates to increased direct and indirect construction costs, especially the potential for citizen complaints. In Vero Beach, Florida, the engineer estimated that the time necessary to construct the pressure sewer mains was 25% of the time required for a gravity sewer.<sup>vi</sup> In Montesano, Washington, the time required to construct the pressure sewer was half that of a gravity sewer.

## On-Lot Construction Impact

### Pressure Sewers

An Orenco Sewer – also known as a STEP/STEG system or effluent sewer – is a type of pressure sewer. The on-lot components of an Orenco Sewer typically consist of a short building sewer, a 1,000-gallon (3,785-liter) tank, a pump package (0.5 hp or 3.73 kW), and a small-diameter (1-inch or 25-mm) service lateral that follows the contour of the land at a shallow burial depth. The on-lot components, specifically the watertight tank, typically constitute the largest construction impact relative to the entire effluent sewer collection system. However, installation is rarely unfeasible, even in communities with small (< 0.15 acre or < 0.06 ha) parcels. Tank excavations are typically 74-143 ft<sup>2</sup> (6.9-13.3 m<sup>2</sup>),<sup>vii</sup> whereas the usable space available to accommodate a tank generally exceeds 1,000 ft<sup>2</sup> (92.9 m<sup>2</sup>), even in existing communities or new subdivisions with small parcels and mature vegetation (see Figure 6).

Grinder sewers, by comparison, commonly use 30- to 36-inch (762- to 914-mm) diameter basins,<sup>viii</sup> larger (1.0-5.0 hp or 0.75-3.7 kW) pumps,<sup>ix</sup> and are typically installed with a small excavator.<sup>x</sup> The construction disruption zone is for these pumps is typically 36 ft<sup>2</sup> (3.3 m<sup>2</sup>)<sup>xi</sup> or more, depending on the size of the pump, and grinder basins have a capacity of roughly 30-70 gallons (114-265 liters).<sup>xii</sup> Even though excavations for 1,000-gallon (3,785-liter) effluent sewer tanks are two to four times larger than grinder sewer excavations, these effluent sewer tanks offer nearly fifteen times more storage capacity than a grinder pump. This allows for considerably more reserve storage during high-use periods or when a problem arises.

The installation and construction impact of a small-diameter service lateral within a pressure sewer is similar to that of the force main infrastructure. Site disruption and excavated soil are minimized, especially when trenchless construction methods are employed.

### Gravity Sewers

Gravity sewer laterals, in contrast, are laid at a constant slope and often require deep excavations to tie into the deeply excavated sewer main. Gravity sewer on-lot pipe installation is typically installed by sloping the sides of the trenches for earth stability. Though this eliminates the need for trench boxes, it increases the overall construction footprint on private property. The overall on-lot construction impact of installing a gravity sewer lateral alone often exceeds that of an Orenco Sewer or grinder sewer.<sup>xiii</sup>



Figure 6. STEP system installation on 6,000 ft<sup>2</sup> (557 m<sup>2</sup>) parcel



Figure 7. Grinder sewer basin installation

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## Effluent Sewer Tank Dimensions and Excavation Estimates

At a typical home (as opposed to a commercial establishment), Orenco Sewers use a 1,000-gallon (3,785-liter) tank manufactured out of concrete or fiberglass, or the Orenco-approved polyethylene tanks manufactured by Roth Industries. Tank dimensions and approximate excavation requirements are listed in Tables 1 and 2, respectively. Concrete tank dimensions vary considerably based on the specific manufacturer. Consult a local tank manufacturer, engineer, and installer to determine necessary tank dimensions and approximate excavation requirements.

**Table 1. Typical tank dimensions for 1,000-gallon (3,785-liter) tanks**

	Concrete	Fiberglass (Orenco)	Polyethylene (Roth)
Width	63 in. (1.6 m)	72 in. (1.8 m)	62 in. (1.6 m)
Length	99 in. (2.5 m)	123 in. (3.1 m)	133 in. (3.4 m)
Height	64 in. (1.6 m)	65 in. (1.7 m)	51 in. (1.3 m)

*Table based on manufacturers' data from Willamette Graystone, Orenco Systems, and Roth Industries*

**Table 2. Estimated tank excavation requirements for 1,000-gallon (3,785-liter) tanks**

	Concrete	Fiberglass (Orenco)	Polyethylene (Roth)
Width	87 in. (2.2 m)	120 in. (3.0 m)	110 in. (2.8 m)
Length	123 in. (3.1 m)	171 in. (4.3 m)	181 in. (4.6 m)
Total Excavated Footprint	74 ft <sup>2</sup> (6.9 m <sup>2</sup> )	143 ft <sup>2</sup> (13.3 m <sup>2</sup> )	138 ft <sup>2</sup> (12.8 m <sup>2</sup> )

*Table based on manufacturers' data from Willamette Graystone, Orenco Systems, and Roth Industries*

The excavation requirements listed in Table 2 assume an 18- to 36-inch (457- to 914-mm) burial cover over the tank in stable soils. Tanks buried deeper typically require larger excavations to ensure personnel safety and proper tank installation. Sloping excavation faces, shielding, and shoring methods should be considered and implemented based upon workplace safety regulations, along with the engineer's and contractor's evaluation of the specific site and installation risks.

In comparison, grinder systems use a 30- or 36-inch (762- or 914-mm) diameter basin with a typical depth of 7-8 ft (2.1-2.4 m). Depending on construction techniques, soil type, and ballast requirements, actual excavations are generally 36 ft<sup>2</sup> (3.3 m<sup>2</sup>) or more.<sup>xiv</sup>

## Effluent Sewer Systems: Parcel Statistics

Though Orenco Sewers are ideal for low-density communities and new subdivisions, they are also suitable for communities with high-density residential or commercial areas. Many have been installed in communities with small parcels, large commercial districts, mature landscaping, and limited space. For example, in Montesano, Washington, 25% of all the installations are on lots that are smaller than 6,500 ft<sup>2</sup> (604 m<sup>2</sup>). For new construction, it is even easier to plan for tank location. Knolls Estates in Sutherlin, Oregon, has over two hundred new homes on lots smaller than 10,000 ft<sup>2</sup> (929 m<sup>2</sup>), many of which also have considerable slopes across the lot. Figure 8 illustrates a finished STEP package installed in Vero Beach, Florida.

The usable area available to install the tank depends on the overall parcel area minus the area associated with impervious surfaces, set-



*Figure 8. On-lot Orenco STEP package installed in Vero Beach, Florida*



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backs from wells and waterways, proximity to sensitive vegetation (trees, shrubs, etc.), and permanent or immovable structures. The inability to properly maneuver installation equipment to certain areas of a site may also reduce the area available to install the tank. Table 3 summarizes the parcel data for several communities and demonstrates the ability to install tanks on small lots. Due to the availability and format of county GIS data, the parcel data summarized may not include all of the parcels that the sewer system serves or include empty parcels within the service area that have yet to be built out.

**Table 3. Parcel statistics for existing Orenco Sewer systems<sup>A</sup>**

Size Acres (1 acre = 0.4 hectare)	# Parcels						
	Montesano, Washington	Missoula, Montana	Coburg, Oregon	Elkton, Oregon	Diamond Lake, Washington	Christiansburg, Ohio	Vero Beach, Florida <sup>B</sup>
0 - 0.15	369	68	55	42	19	5	4
0.16 - 0.2	158	14	74	10	5	1	3
0.2 - 0.3	468	15	156	36	15	12	82
0.3 - 0.4	183	3	72	8	5	5	38
0.4 - 0.5	111	8	32	8	6	9	18
> 0.5	127	2	31	19	206	42	12

<sup>A</sup> Orenco site documentation based on county GIS data.

<sup>B</sup> Denotes STEP system under construction.

## Aerial Photos



Figure 9. Montesano, WA

### Montesano, Washington

Installed in 1991, Montesano’s Orenco Sewer system has over 1,500 connections. It replaced an antiquated gravity sewer that suffered extreme infiltration and inflow. Initially, the city’s engineer proposed a new gravity sewer system. However, because of tight lot constraints, the 1.5-year expected installation time, and the physical disruption a gravity sewer installation would cause, the city council and public works department requested that other options be presented. Montesano’s Orenco Sewer system was installed in half the time and at a lower cost than the proposed gravity sewer, and allowed the town to convert the existing gravity sewer to a storm sewer.

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Figure 10. Missoula, MT

## Missoula, Montana

Beginning in 1995, Missoula installed an Orenco Sewer with 1,300 Septic Tank Effluent Pump (“STEP”) packages to replace existing onsite septic systems that were failing. The city continues to replace failing systems as needed with STEP packages and now has over 1,700 total packages installed. In the older parts of the city, the average lot size is less than 6,000 ft<sup>2</sup> (557.4 m<sup>2</sup>), and the tank burial depth is typically greater than 6 ft (1.83 m).



Figure 11. Coburg, OR

## Coburg, Oregon

Installed in 2013, Coburg's Orenco Sewer system consists of 420 connections, including a large contingent of commercial businesses and mobile home parks. The older part of the city is comprised of small lots, established trees, and limited usable area for tank installation.



Figure 12. Elkton, OR

## Elkton, Oregon

Elkton's Orenco Sewer system serves 113 connections (79 of these are STEP packages; 34 are Septic Tank Effluent Gravity or “STEG” packages). The system also serves a commercial downtown core area and an older, densely populated residential area. (See Orenco's Elkton case study, NCS-22, for more details.)





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## Conclusion

Construction impact, indirect construction costs, ease of installation, and the time required to complete the installation are major considerations for homeowners and communities when evaluating wastewater collection system options. Gravity, grinder, and effluent sewers require different methods of construction and different accessibility requirements to install the various products and system components. Effluent sewer systems are routinely installed in communities with low- and high-density residential neighborhoods, downtown commercial districts, and areas with mature and established landscapes. The overall construction impact associated with effluent sewers is similar to grinder sewers, but often considerably less than gravity sewers. Gravity sewers, because of their deeply excavated mains and service laterals and their need for manholes and lift-stations, require significant construction disruption zones. The time required to construct a gravity sewer is frequently two to three times longer than a pressure sewer. Compared to gravity and grinder sewers, effluent sewers also offer the benefit of providing primary treatment, low life-cycle costs, and 24 hours of emergency storage. In short, their minimal impact, ease of installation, and high value make Orenco Sewers a logical choice for wastewater collection.

## References:

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