Orenco Liquid Only Sewers

Design and life Cycle Costing

Our Presenter

Garry-Lee Espinosa

- Focus on Municipal Systems – East Region
  - ~ Assists engineers with the design, development, installation, and maintenance of Orenco's collection and treatment.
- Worked for Orenco since 1998 (22 years)
- Associate's of Science Degree from Umpqua Community College – Manufacturing Engineering
- Interned at the Department of Veteran's Affairs as an AutoCAD draftsman
- US Navy veteran – Desert Storm
- Retired rodeo clown
- Avid fisherman

Discussion Topics

- System Overview
- Planning
- On-lot Design
- Right of Way Design
- Life Cycle Cost Comparison

Wastewater Systems

Traditional Method

- Gravity Collection
- Treatment Plant

Wastewater Systems

Traditional Method

- Gravity collection
  - Recommended Standards for Wastewater Facilities (2004 Ed.)
    - *"…Minimum 8" dia pipe…"*
    - *"…Minimum slope of 0.4ft/100ft…"*
    - *"…Manholes at 400ft intervals, terminal ends, and changes in grade, size, or alignment…"*
    - *"…multiple pumps shall be provided…"*

Why Do We Need a Modern Technology?

- Environment

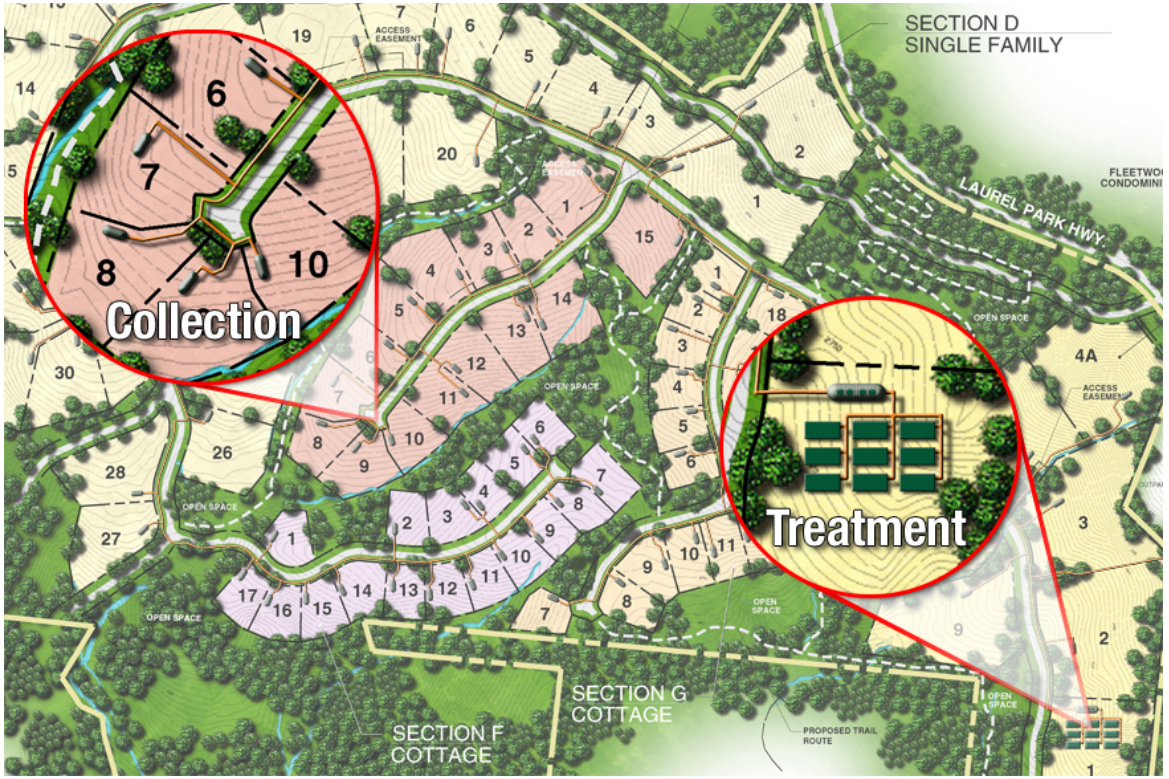
Why Do We Need a Modern Technology?

- Cost
  - USA Today *"…Government Accountability Office estimates that 41% of sewer systems charge customers less than the cost of the service…"*
  - *"…EPA projected that $388 billion will be needed from 2000 to 2019 to address the nation's clean water infrastructure problems…"*

https://usatoday30.usatoday.com/news/nation/2007-12-27-water_N.htm

Collection and Treatment

- Four integral parts to any multiple lot sewer system
  - ~ On-Lot
  - ~ Collection lines in ROW
  - ~ Treatment plant
  - ~ Final disposal



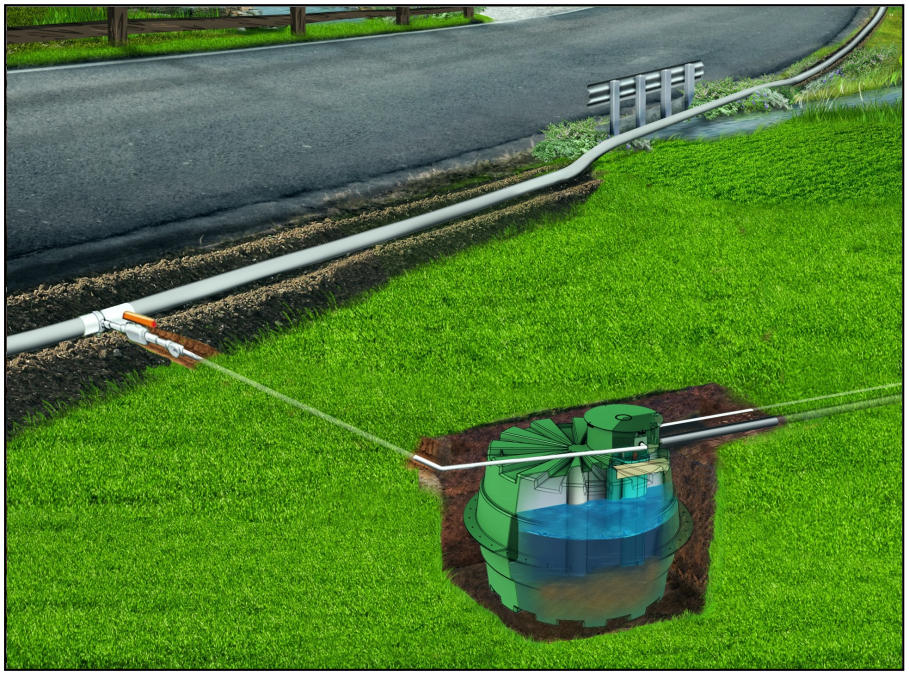
System Design

Overview

System Overview

What is a Liquid-Only Sewer?

- Pump Effluent Discharge
- Gravity Effluent Discharge



New Orenco Effluent Sewer System:

Pressurized Liquid Only Sewer = Prelos Processor

Liquid-Only Sewer: Quality of Treatment

- The ONLY collection technology that provides treatment
  - ~ 70 to 90% reduction in waste strength
- Collection and treatment technology integration
  - ~ Reduced hydraulic and biological loading to treatment facility

Data from tables 4-12 and 4-16, pgs 180 and 183, Small and Decentralized Wastewater Management, Crites and Tchobanoglous

Discussion Topics

- System Overview
- Planning
- On-lot Design
- Right of Way Design
- Life Cycle Cost Comparison

System Layout

System Layout

System Layout

Other Issues to Address

- Disruption to Residents and Traffic During Construction
- Future Extensions of Service
- Groundwater
- Odor and Corrosion Potential

Rights of Way, Access and Easements

- Collection lines built in public right of way
- Access needed for inspection and maintenance
- Easement options
  - Blanket easement
  - Deeded easement
  - Centerline easement

Discussion Topics

- System Overview
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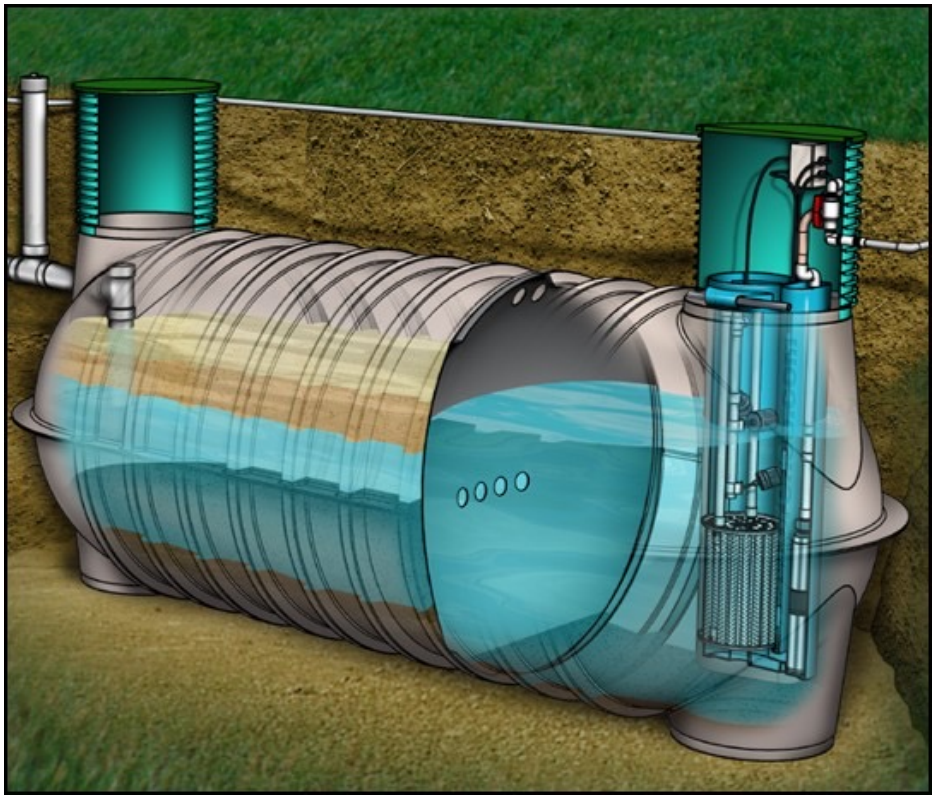
ProSTEP™ Effluent Pumping Systems

- Watertight tank
- Biotube® pump vault
- High-head effluent pump
- Control panel
- Splice box
- Float assembly
- Discharge assembly
- Risers, lids



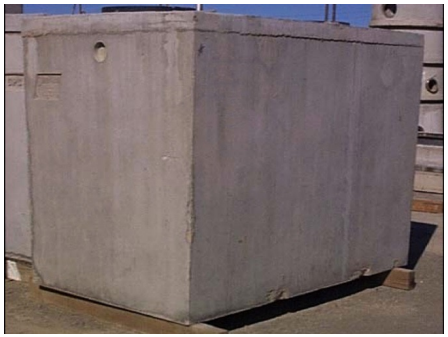
Prelos™ Liquid Only Sewer

- Watertight tank
- Biotube® pump vault
- High-head effluent pump
- Control panel
- ClickTight™ connector
- Float assembly
- Hanging discharge assembly
- Riser and lid

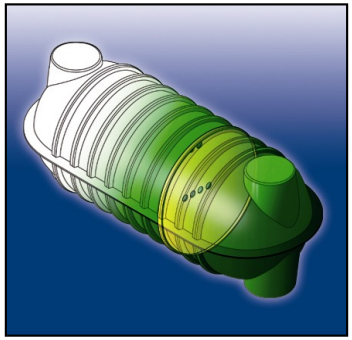
Materials of Tank Construction

Tanks must ...

- Be concrete, fiberglass, Roth poly, or DCPD
- Meet Orenco's General Specifications Guidelines



Concrete



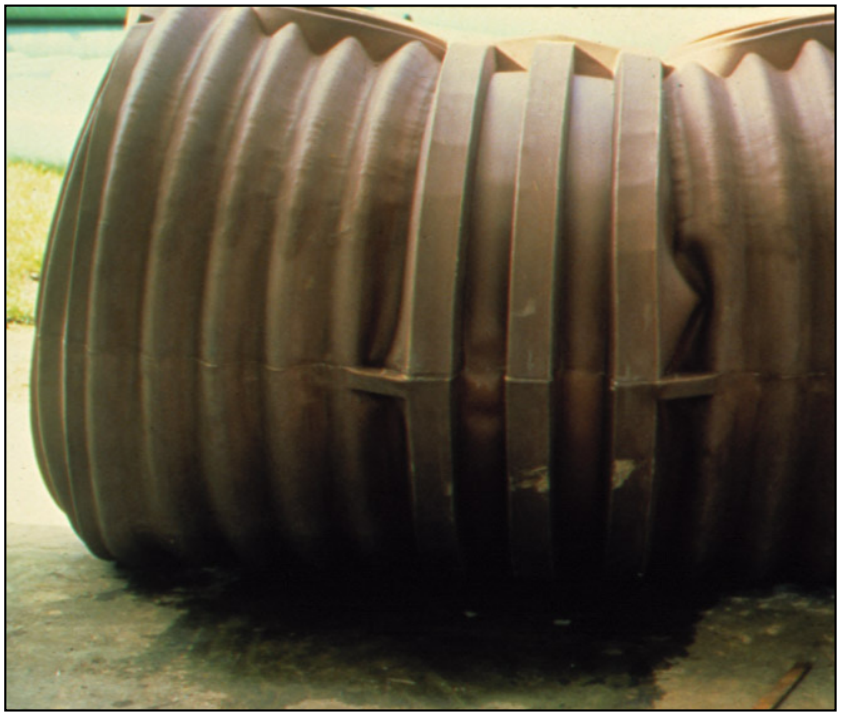
Fiberglass

Roth Poly Tank

DCPD Prelos Processor

Poor Top Seam and Wall Seam

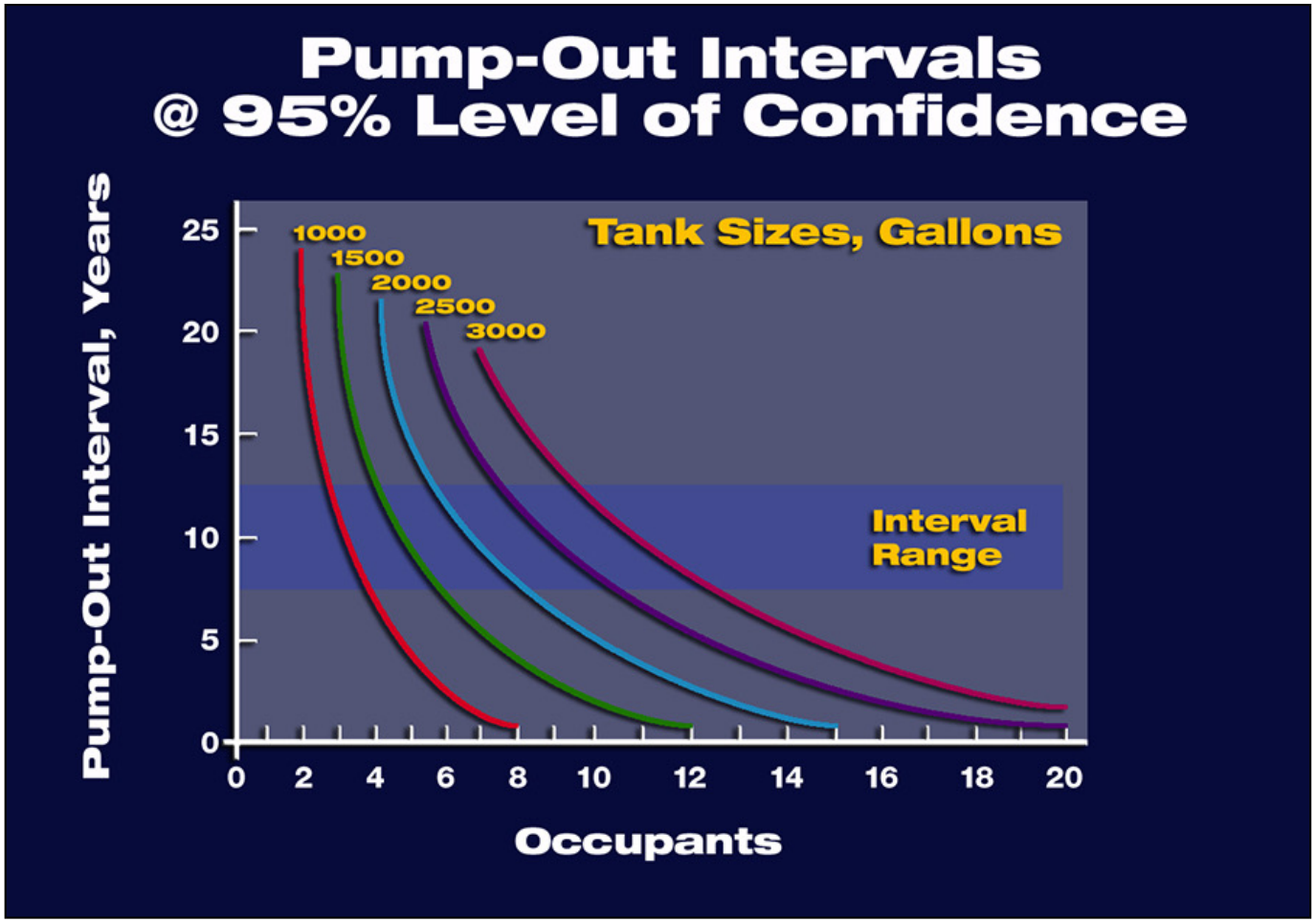
Many Polyethelyene Tanks are Unacceptable



Strength is typically 1/5 that of concrete/fiberglass tanks.

Fiberglass Tanks Require Quality Control Too

Properly Sized Tanks Reduce Pumping



The pumping interval for properly sized and managed watertight tanks is about 12 to 20 years.

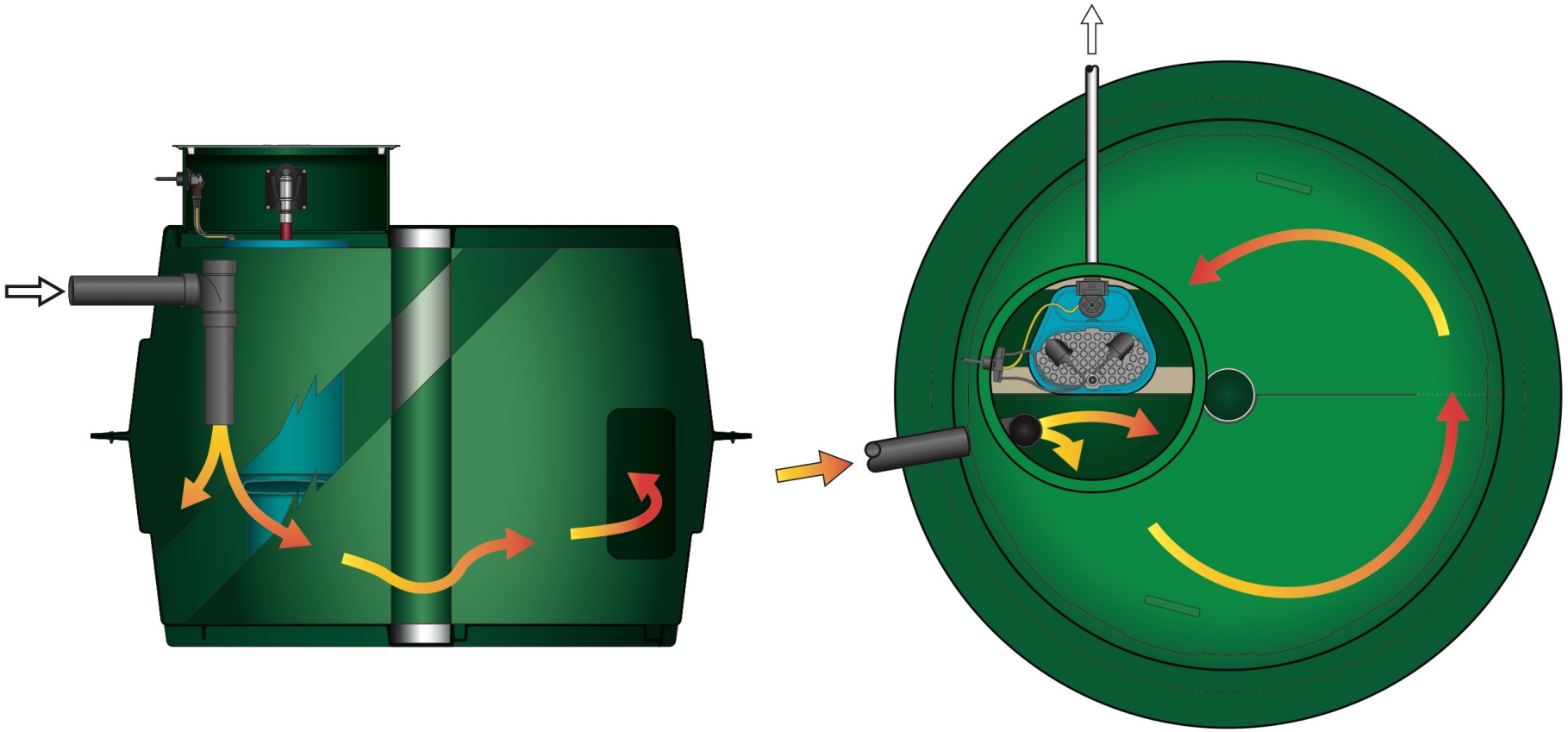
Prelos Liquid Only Sewer Components

Prelos Processor Tanks

- Primary treatment in processor tanks
- 1000-gallon tank per residence
- 70% removal of fats, oils, and greases
- 24-hour emergency storage
- 12-year pumpout with 95% confidence
- Abuses stay in interceptor tank
- Chemical sources easier to identify

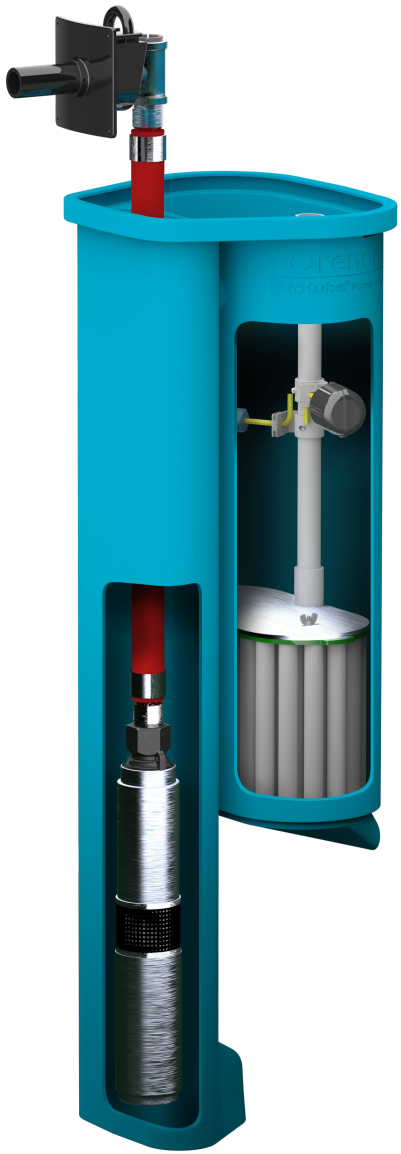
Prelos Processor Tank

Prelos™ Liquid Only Sewer

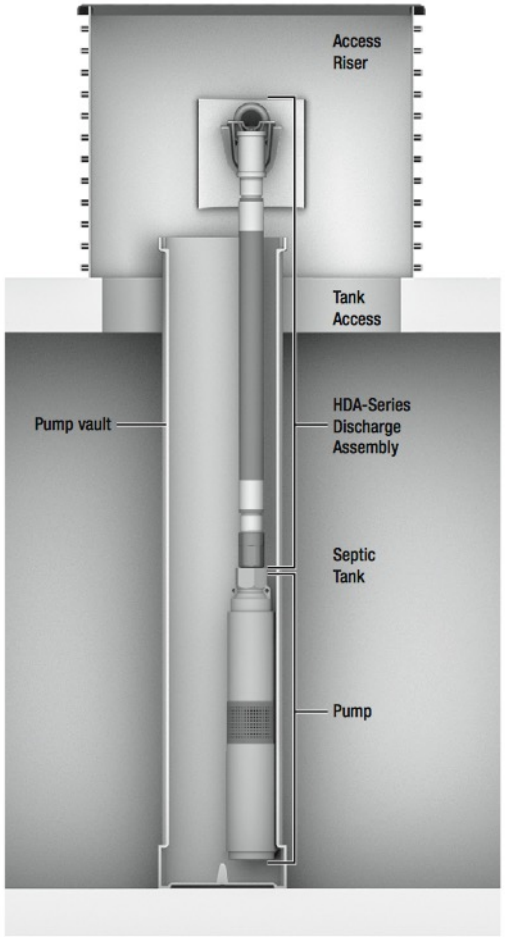


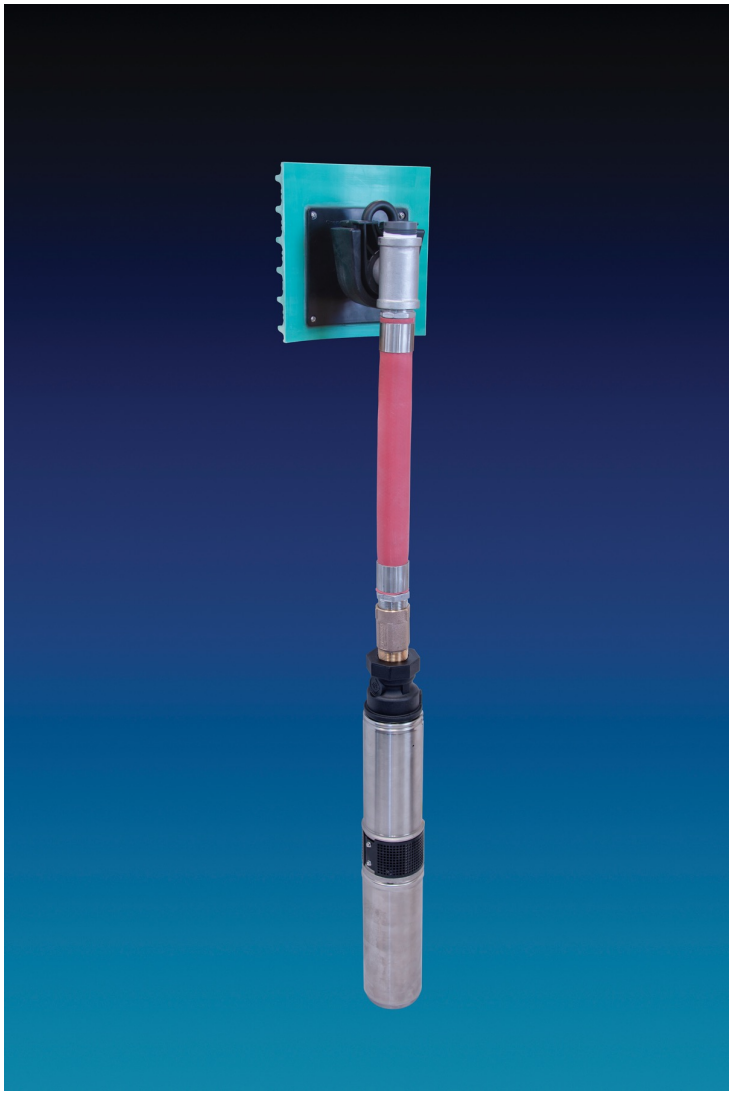
Biotube® Pump Vault

- ~13 ft^2 surface area and 4 ft^2 flow area
- “Easy access” design
- Revolutionary patented technology



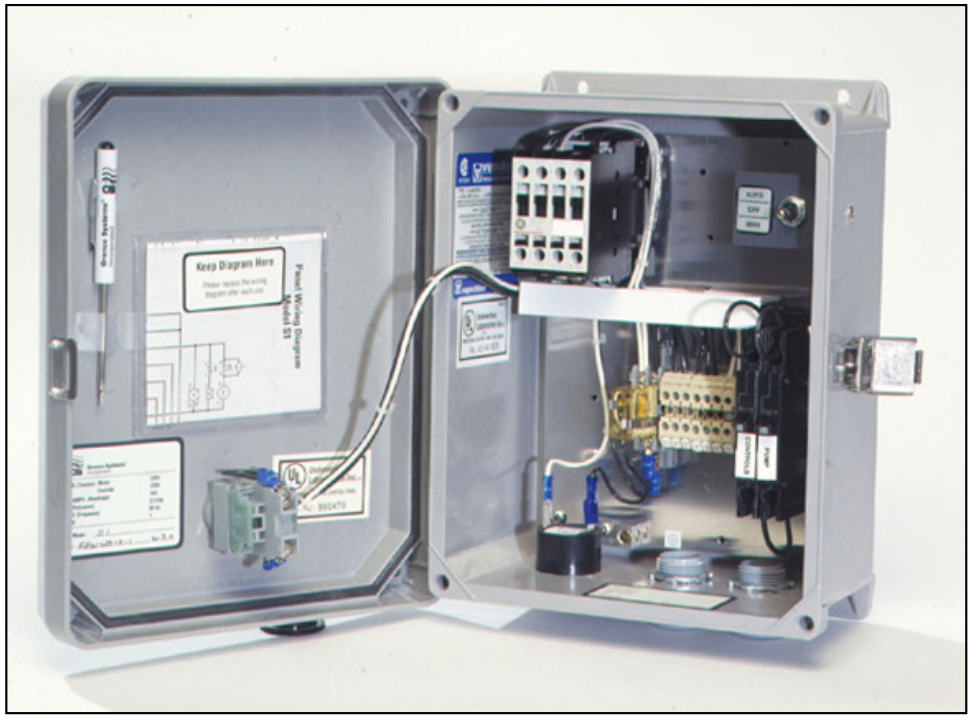
Hanging Discharge Assembly





Control Panels

- S Series
  - ~ Single pump
- DAX Series
  - ~ Duplex alternating pumps

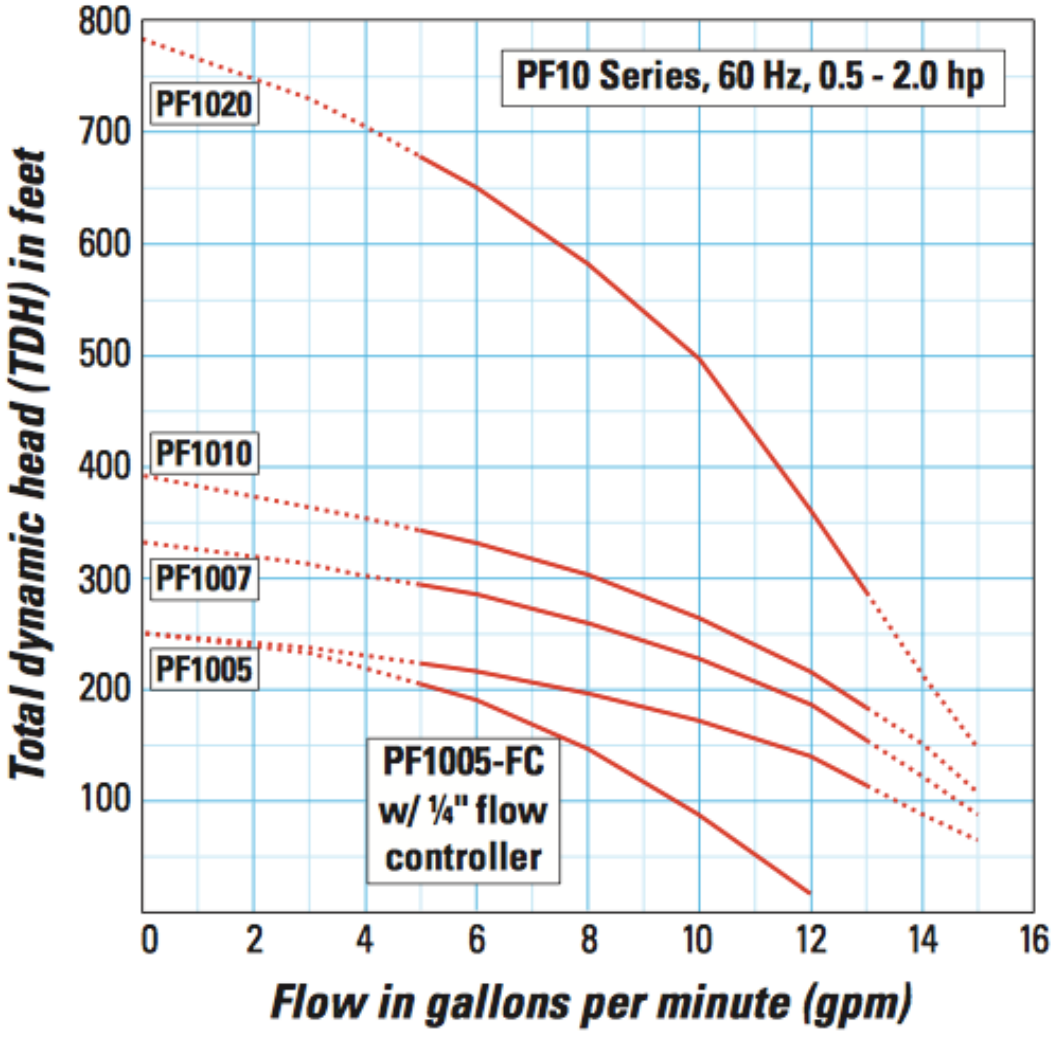


High-Head Effluent Pumps

- Lightweight
- Stainless steel/thermoplastic
- Floating stack
- UL listed/CSA certified
- Removable liquid end
- 1/2 hp, 115V, 10 to 50gpm
- Steep pump curve

Selecting Standard Pump Model

Determine the head capability of the pump model being used. This value can be used to determine the maximum allowable head loss for any particular critical point.



Tanks for High Flow Installations

- Tanks should be sized for a minimum of two (2) days detention, based on maximum day design flow
- Pump tanks should be sized for a minimum of 25% of maximum day design flow
- Filters should be sized based upon:

Equation 11 $$A_F = (0.0044)(P_C * Q_C)(MTBC)$$

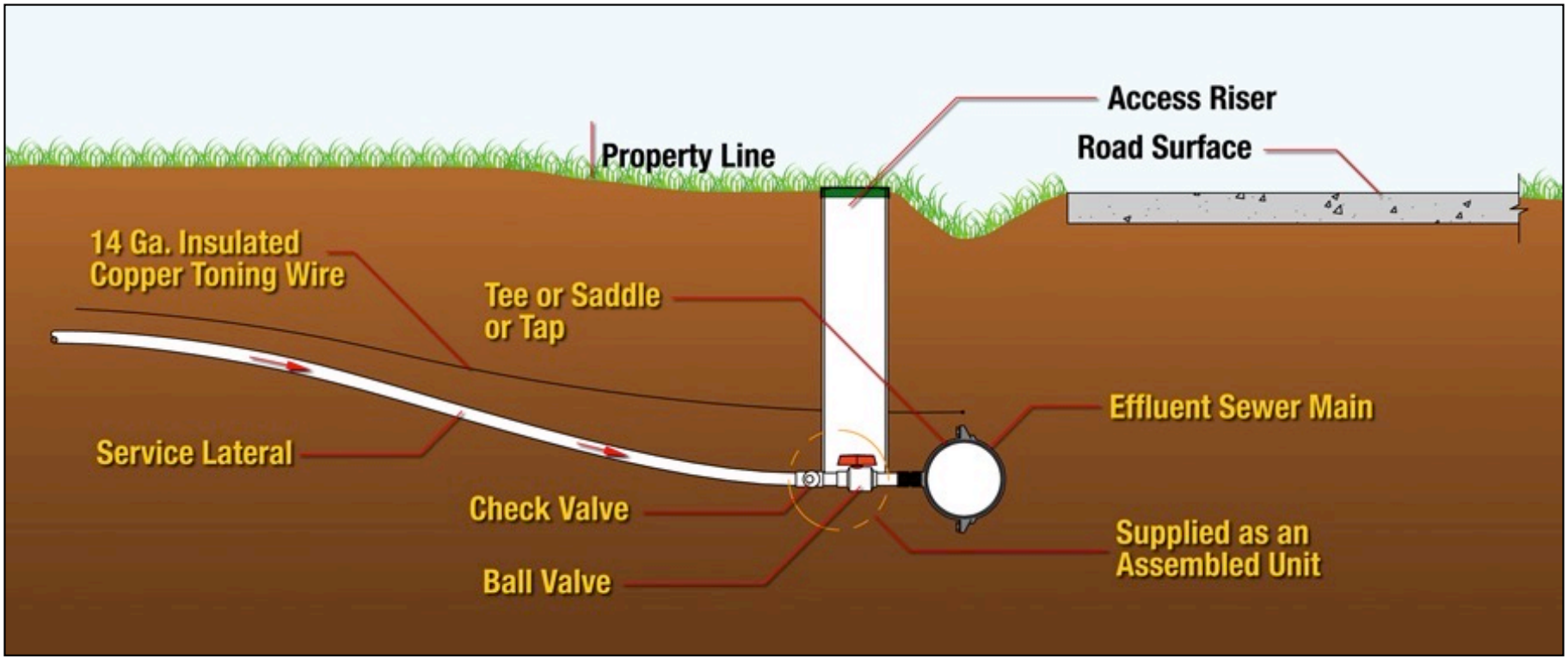
where: A_F = *Filter Area, ft²*
P_c = *Population density, capita/EDU*
Q_c = *Daily per capita flow value, gpcd*
MTBC = Mean time between filter cleaning, years

Table 5. Filter and Flow Area Chart

Series	Filter Area, ft² (m2)	Flow Area, ft² m²
FT15-36	50.5 (4.7)	15.2 (1.4)
FT12-36	30.0 (2.8)	9.0 (0.84)
FT08-36	14.6 (1.4)	4.4 (0.41)
FT04-36	5.1 (0.5)	1.5 (0.14)

Service Connections

- Comprised of check valves and ball valves
- Access to the surface required
- Allows for isolation of on-lot components



Discussion Topics

- System Overview
- Planning
- On-lot Design
- Right of Way Design
- Life Cycle Cost Comparison

Physical Separation from Other Utilities

- Bury depth, 30+ inches (0.75+ m)
- Horizontal separation
- Vertical separation

Water Body, Railroad, and Highway Crossings

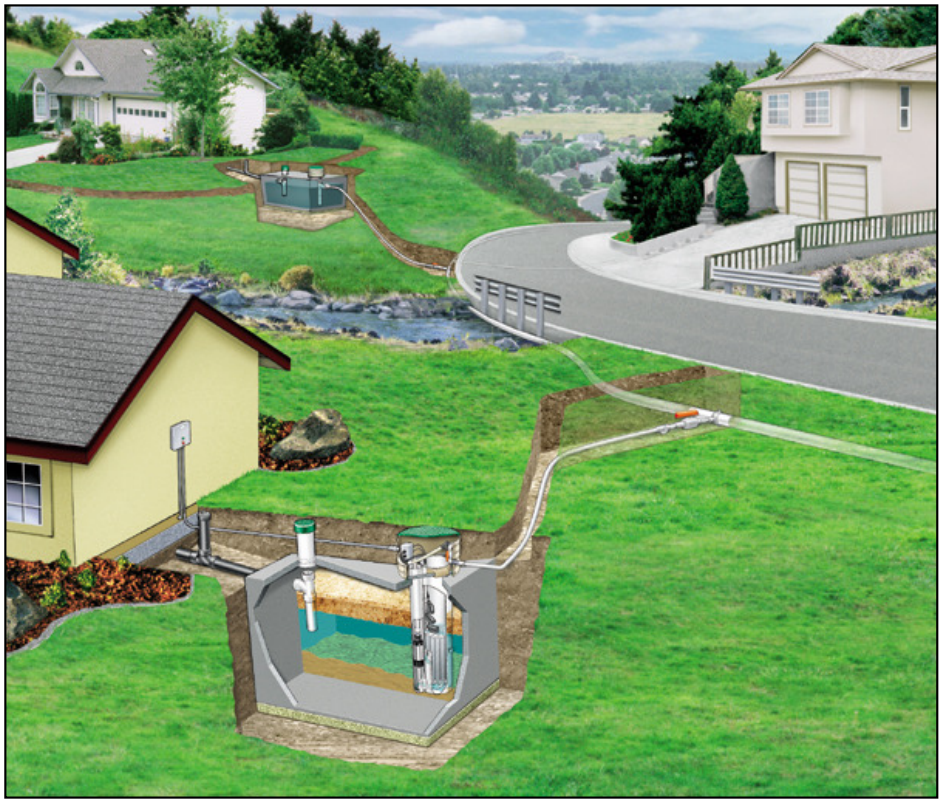
- Avoid whenever possible
- Extended permit processes

Configuration and Valving for Piping Networks

- Uni-directional flow, branch configuration
- Isolation valves on upstream sections of submains

Daily Design Flows

- Calculate EDUs
  - A single-family residence is defined as 1 equivalent dwelling unit (EDU)
  - Per capita flows range from 40-60 gpd (150-230 lpd)



Daily Design Flows

Commercial

- Calculate Equivalent Dwelling Units
  - With a population density of 3 people per home, An EDU is equivalent to 150 gpd
  - A commercial site that has a flow of 450 gpd would be the equivalent to 3 EDUs
  - Tank sizing chart

Calculating Peak Flows

Flow Equation

Qgpm = (EDUs) (PC/ 6) + 15

Simplified Equation

Qgpm = (EDUs/ 2) + 15

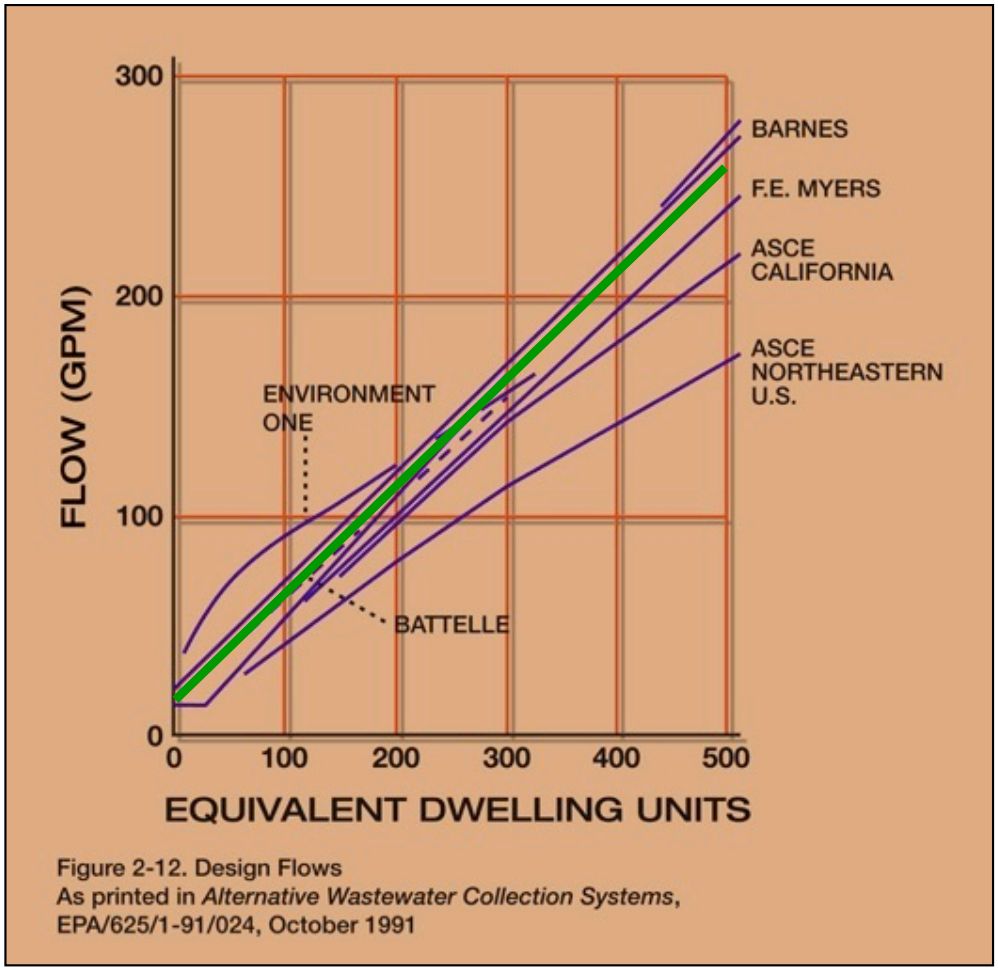
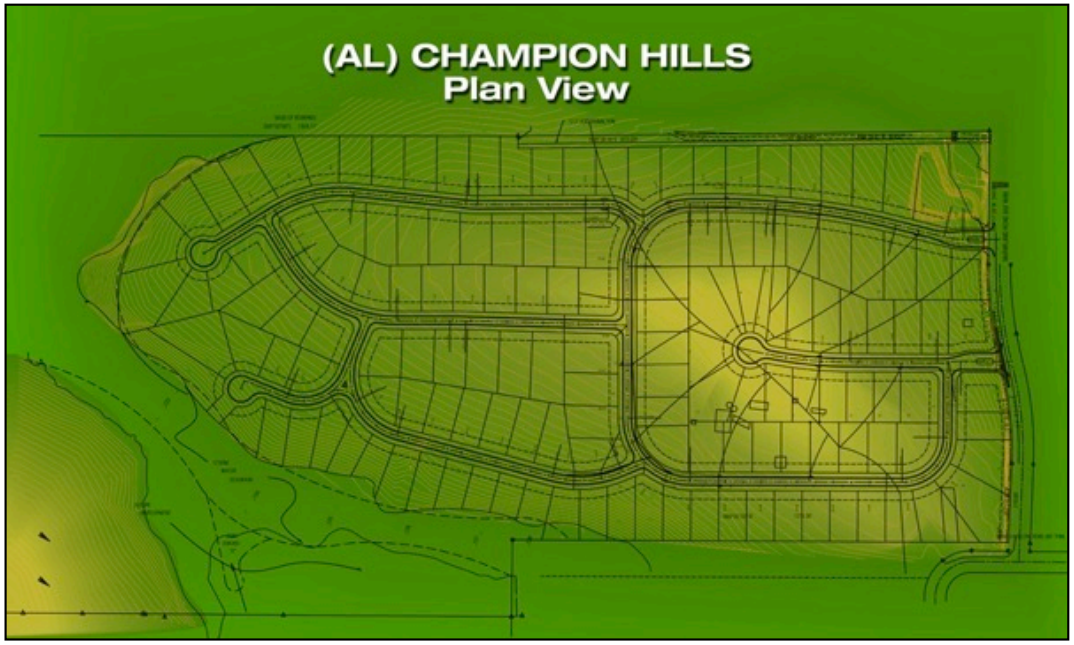


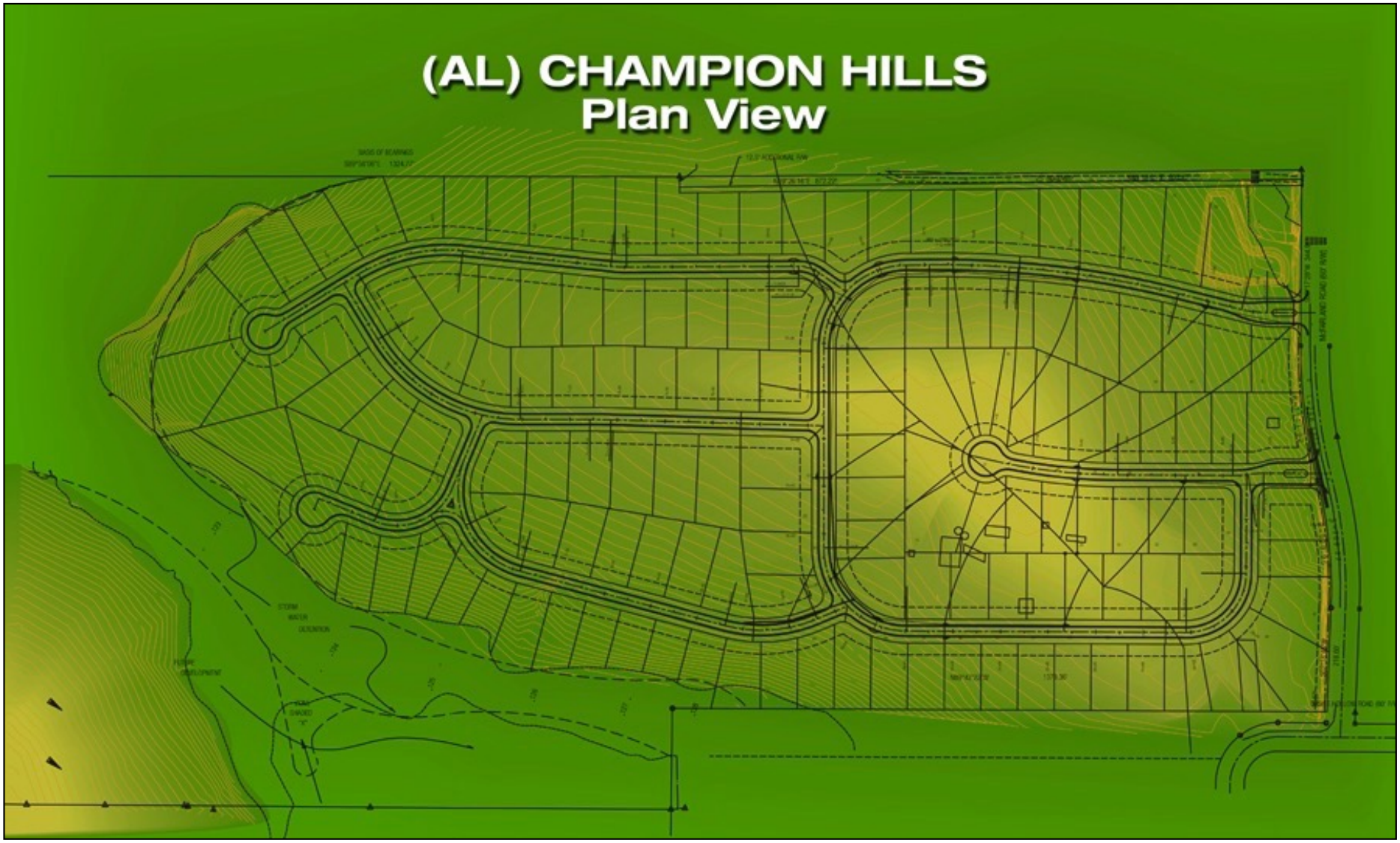
Figure 2-12. Design Flows
As printed in *Alternative Wastewater Collection Systems*, EPA/625/1-91/024, October 1991

Plan View

- The plan view outlines ...
  - ~ Site characteristics
  - ~ Lot locations
  - ~ Road locations
  - ~ Contours

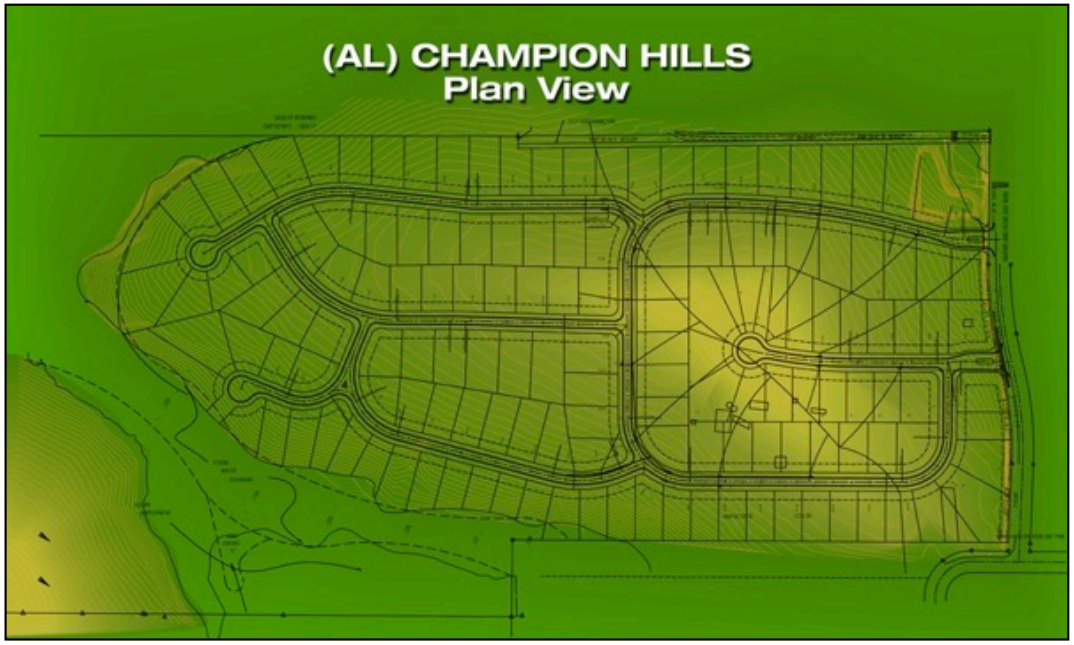


Plan View

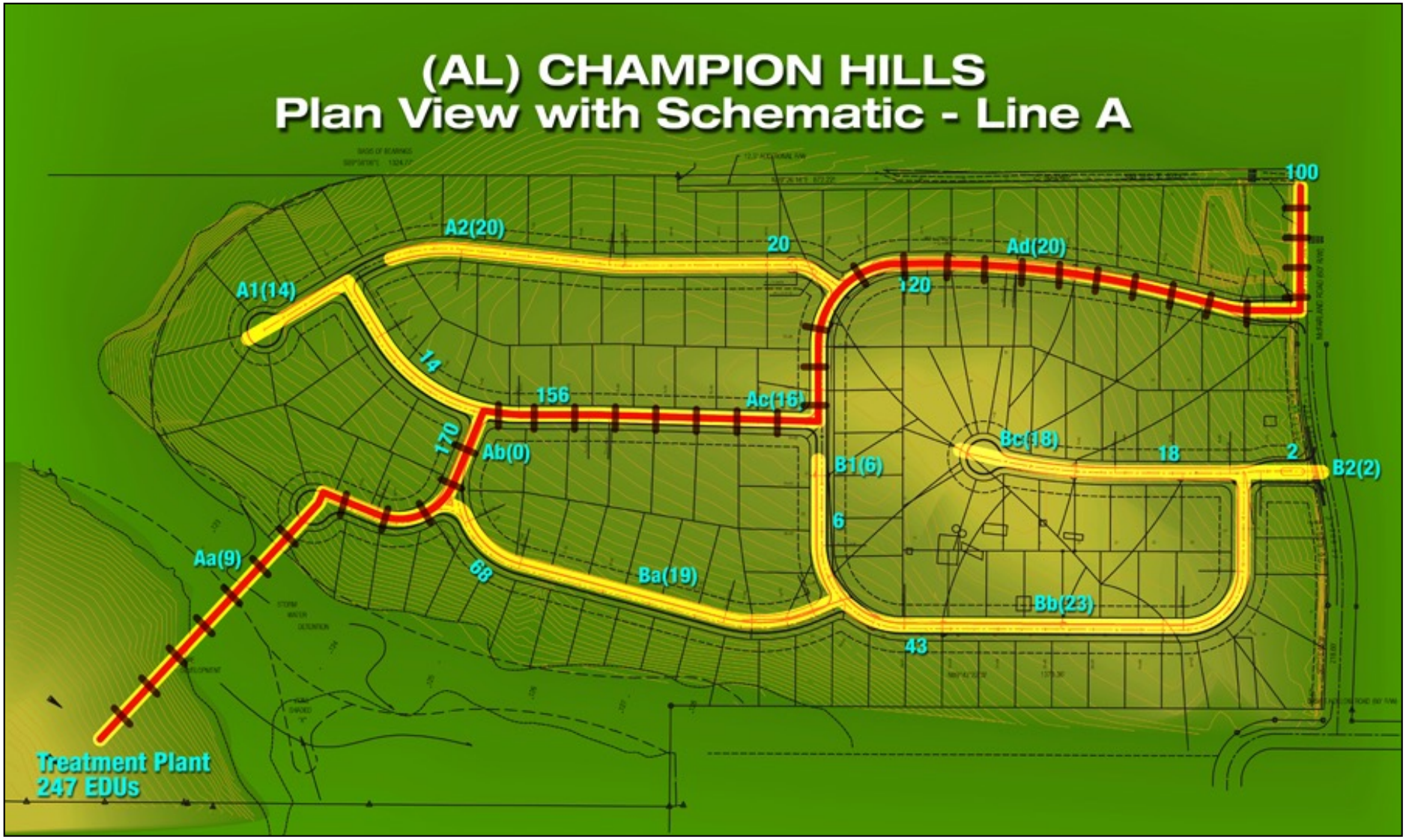


Main and Branch Line Layout

- Identify discharge point
- Identify mainline
- Label line segments
- Label station points
- Determine number of connections



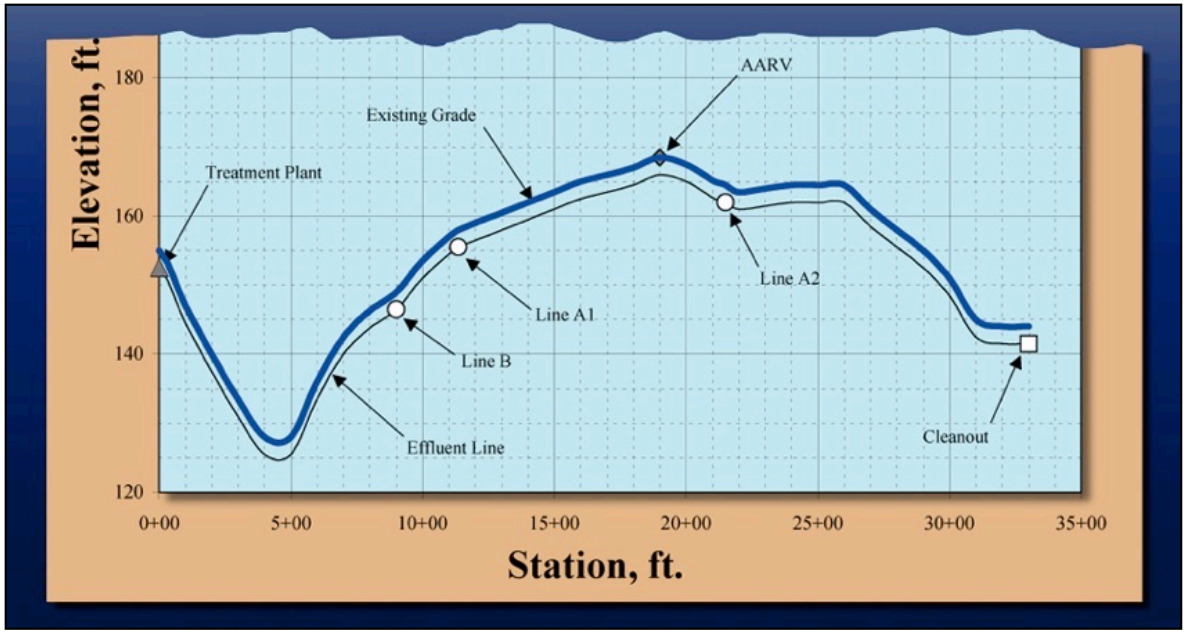
Mainline Layout



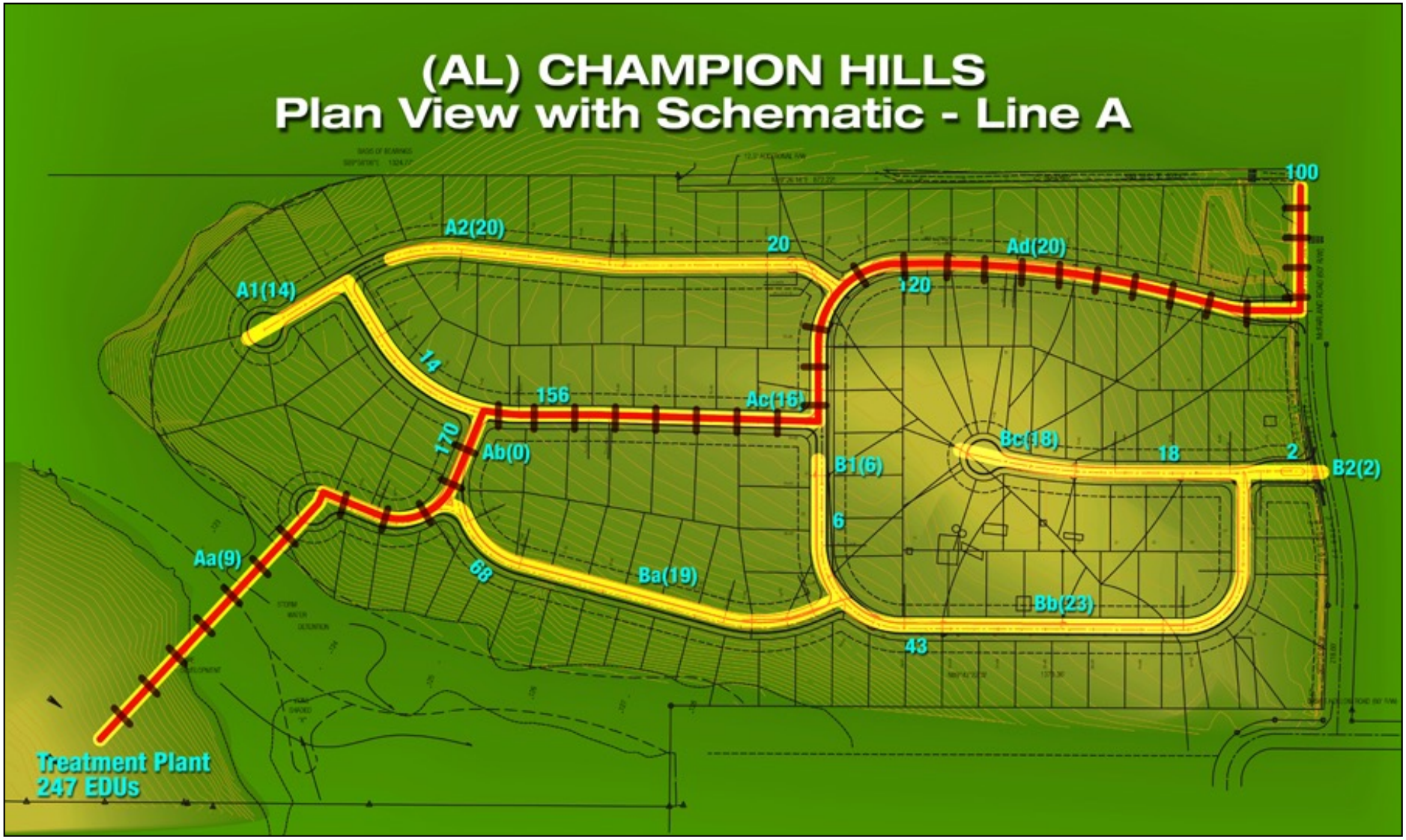
Mainline Profile

Hydraulic Analysis Sheet
Champion Hills

Pipe Class/Sch.:		Cl. 200								
Depth Of Burial (ft.):		2.5								
	Station	Grade Elev. (ft.)	Line Elev. (ft.)	EDUs	Nominal Pipe Diameter, Headloss ft., (Velocity, ft/s)	Flow Rate (gpm)	HGL Points	Ends and Intersections	AARV	Static
Line A	0+00	155.0	152.5	247	4",11.4 ft, 3.9 ft/s	159.1	152.5	152.5		152.5
	0+35	153.0	150.5							152.5
	1+00	147.0	144.5							152.5
	2+00	140.0	137.5							152.5
	3+00	133.5	131.0							152.5
	4+00	128.0	125.5							152.5
	5+00	128.0	125.5							152.5
	6+00	136.0	133.5							



Mainline Layout



Calculating the Flow for Segment Aa

- Flow Equation

Qgpm = (EDUs) (PC/ 2) + 15

= (247 EDUs) (3.5 / 6) + 15

= (864.5 / 6) + 15

= 144.0 + 15

= 159.0 gpm

Calculating Friction Losses

- From the Hazen-Williams Equation

$$h_f = (0.000995\ L\ Q^{1.85}) / D^{4.87}$$

$$= (0.000995 * 900\ 159^{1.85}) / 4.072^{4.87}$$

$$= 11.4$$

Where ...
h_f = head loss due to friction, feet
L = length, feet
Q = flow rate, gpm
D = line diameter, inches

Hydraulic Grade Line Analysis

Hydraulic Analysis Sheet
Champion Hills

Pipe Class/Sch.:		Cl. 200								
Depth Of Burial (ft.):		2.5								
	Station	Grade Elev. (ft.)	Line Elev. (ft.)	EDUs	Nominal Pipe Diameter, Headloss ft., (Velocity, ft/s)	Flow Rate (gpm)	HGL Points	Ends and Intersections	AARV	Static
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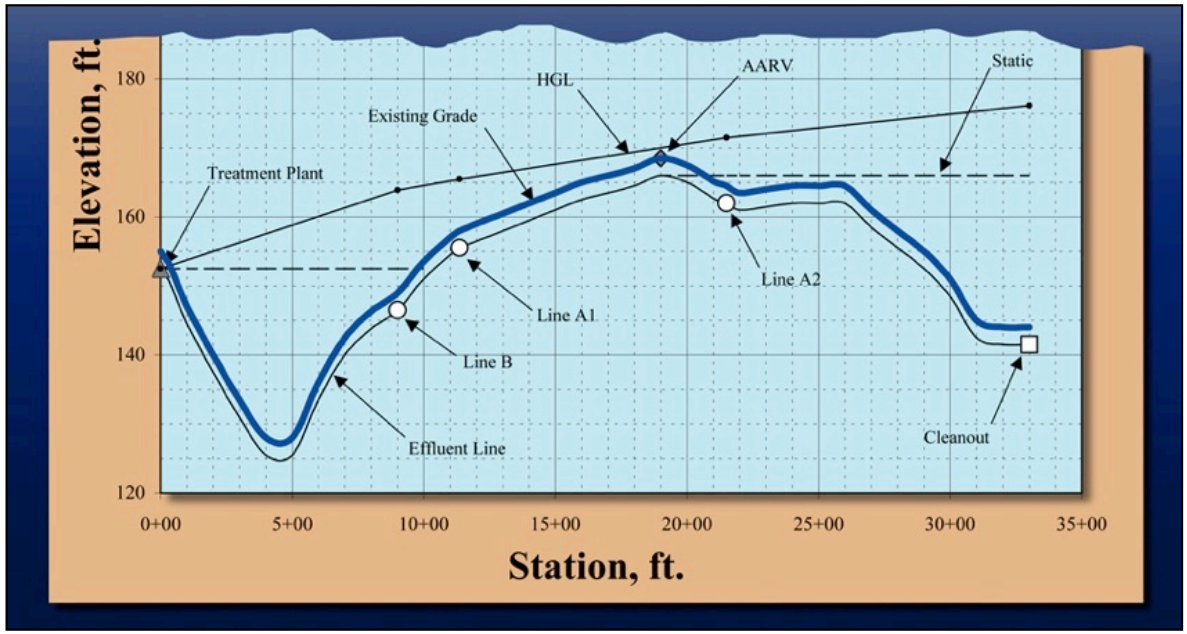
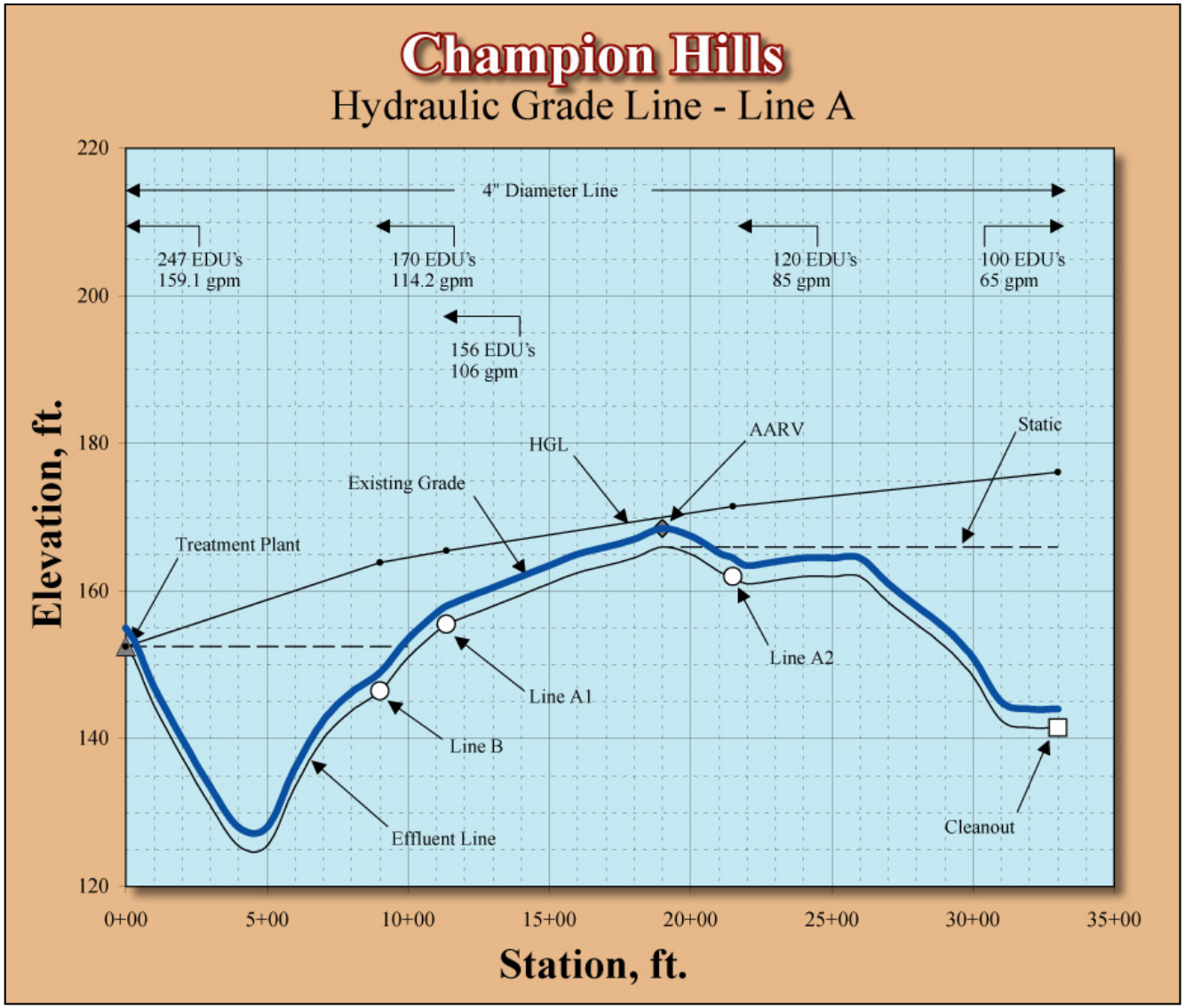
	0+35	153.0	150.5							152.5
	1+00	147.0	144.5							152.5
	2+00	140.0	137.5							152.5
	3+00	133.5	131.0							152.5
	4+00	128.0	125.5							152.5
	5+00	128.0	125.5							152.5
	6+00	136.0	133.5							



Calculating the Hydraulic Grade Line (HGL)



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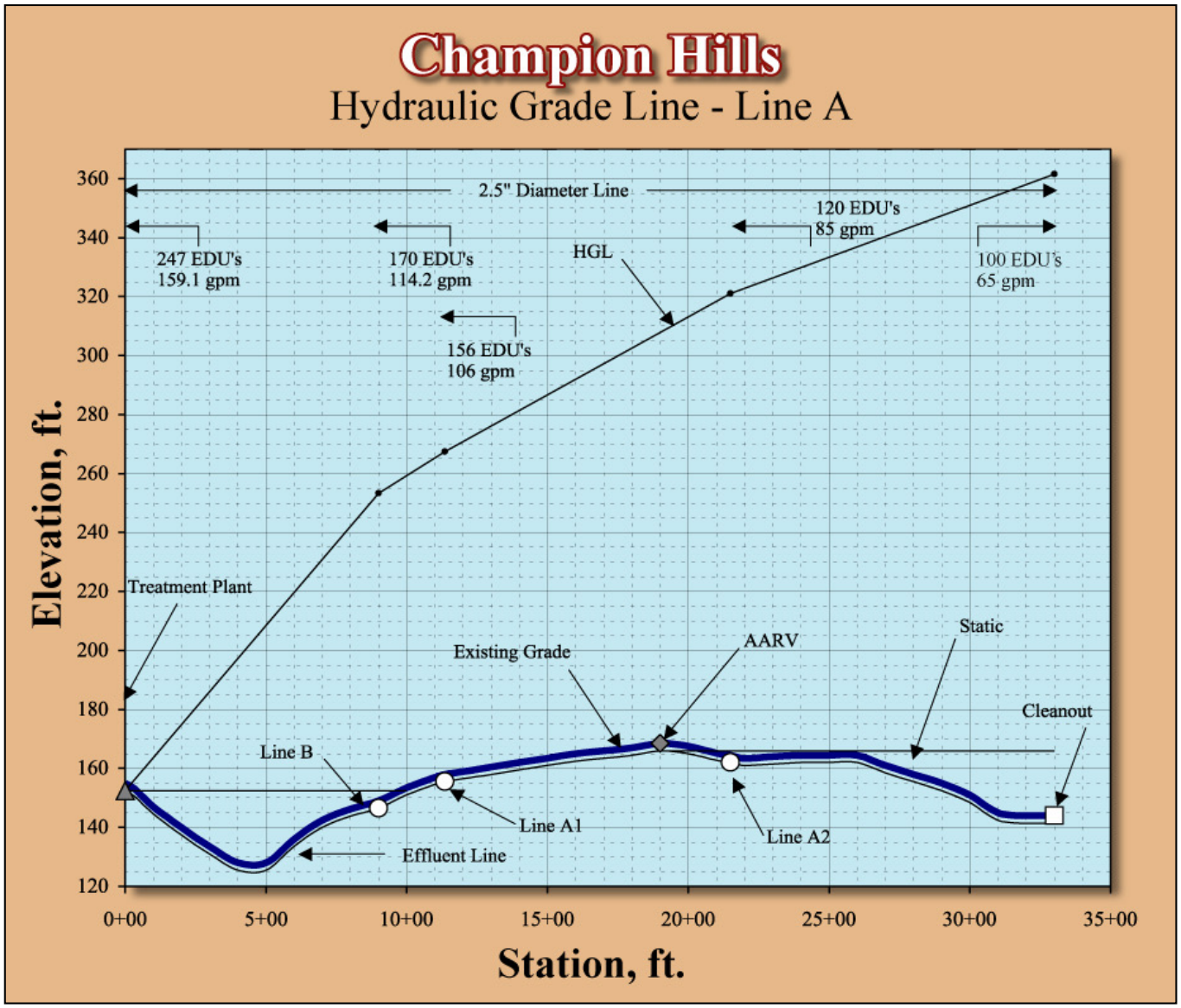


Piping

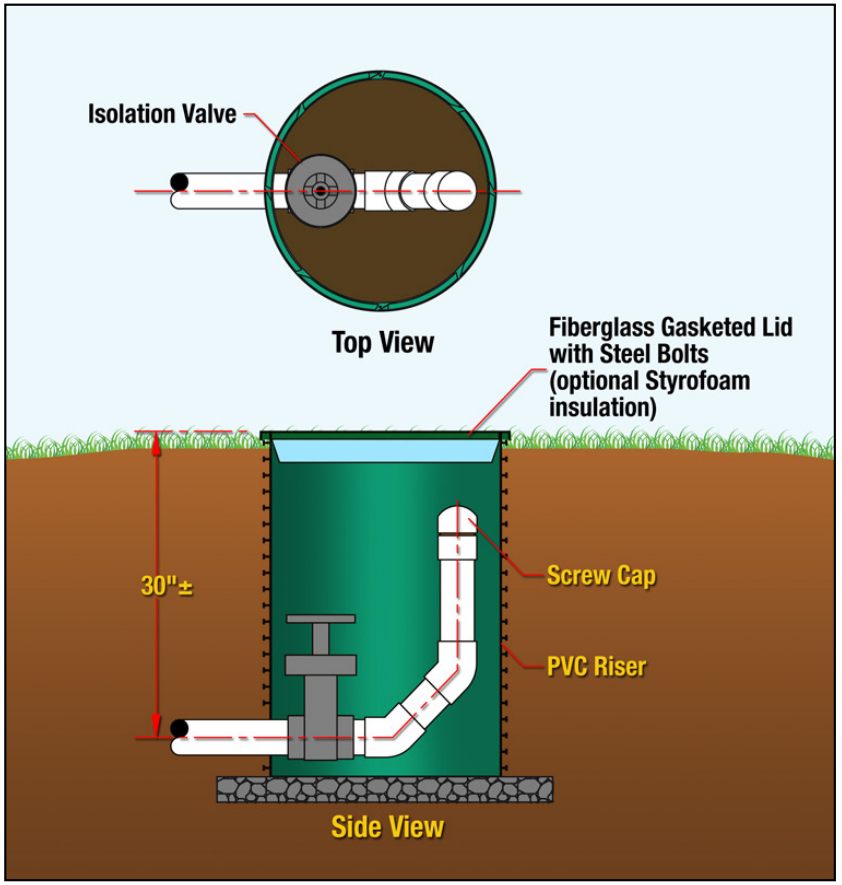
- Piping materials
  - PVC
    - Fairly rigid
    - Thin, smooth walls with low frictional losses
    - Most common type for open trench construction
  - HDPE
    - Flexible
    - Thicker walls, higher frictional loss than PVC
    - Most common type for directional bore construction

Piping and Fittings, cont.

- PVC fittings
  - 6” (150 mm) and smaller, socket-type PVC
  - Larger fittings typically PVC, epoxy coated ductile iron, stainless steel, or bronze/brass
- HDPE fittings
  - Fittings typically PVC body, HDPE body, stainless steel, or bronze/brass

Terminal Clean-Outs

- Located at terminal ends
- Provides an entry point for cleaning “pigs” if necessary



Mainline Testing and Inspection

The line is filled and pressurized and the pressure held for a period of two hours. Allowable leakage is calculated using the following equation (see AWWA C 600 Section 4):

Equation 10

$$L = \frac{S\,D\,\sqrt{P}}{133200}$$

where: L = *Allowable leakage for push-on or mechanical joints, GPH**
S = *Length of pipe tested, feet*
D = *Nominal pipe diameter, inches*
P = *Average test pressure, PSI, at lowest location on test section*

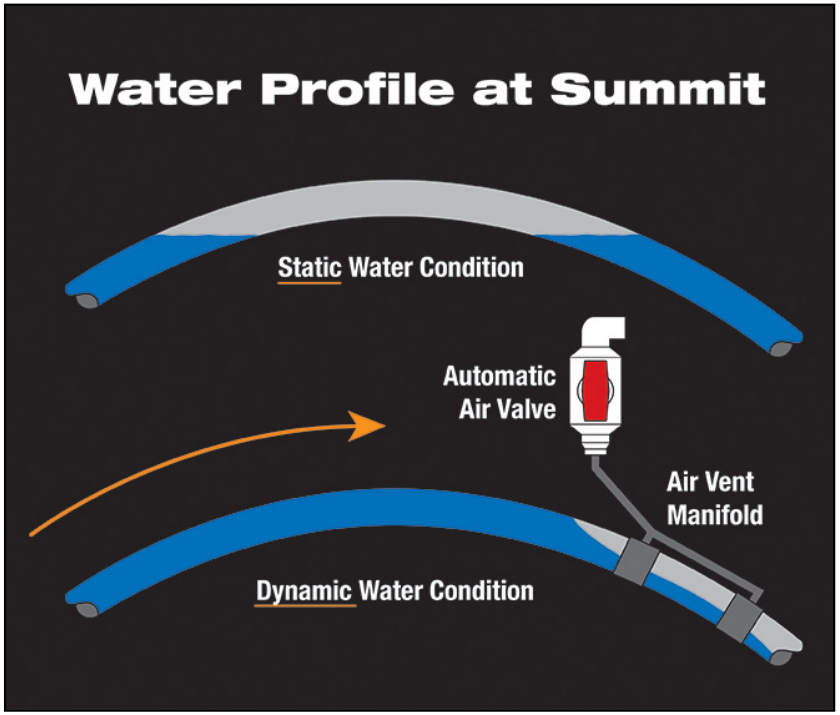
**Add 0.0078 gal/hr/in of nominal valve size for each metal-seated gate valve pumped against.*

Isolation Valves

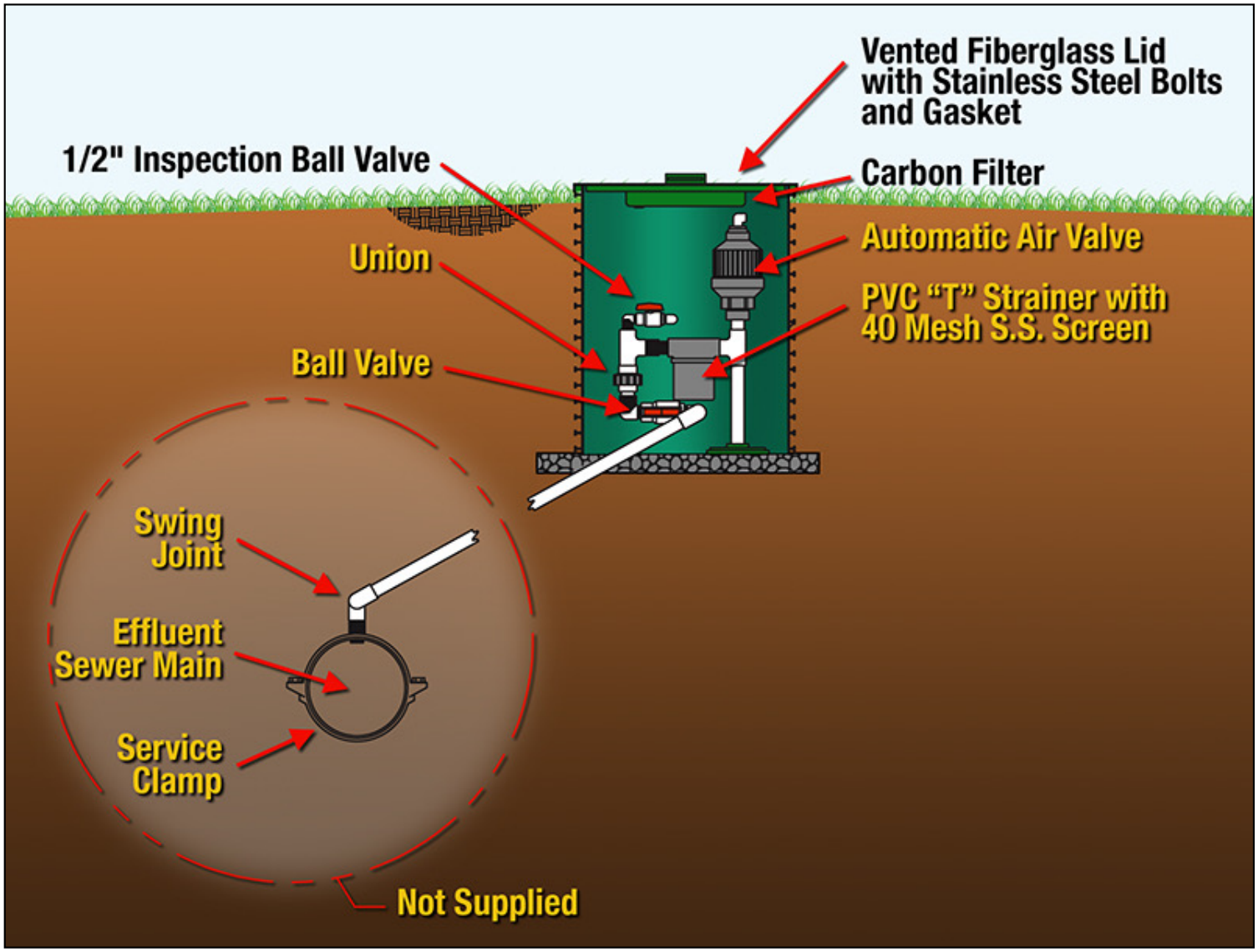
- Typically located upstream of the branch intersection and mainline
- Allows for O&M and leak repair
- Must be exercised annually
- The number of valves used should be minimized
- PVC valving
  - Ball valves up to 3”; Gate valves for larger diameters
- HDPE valving
  - Reduced valving, as the line can be “pinched” to close
  - May require pipe stiffeners when using iron valves

Automatic Air Valves

- Considerations
  - ~ Manual vs. automatic
  - ~ Air release vs. combination valve
  - ~ Proper sizing
  - ~ Open base enclosure for drainage
  - ~ Filter on enclosure for venting



Automatic Air Valves



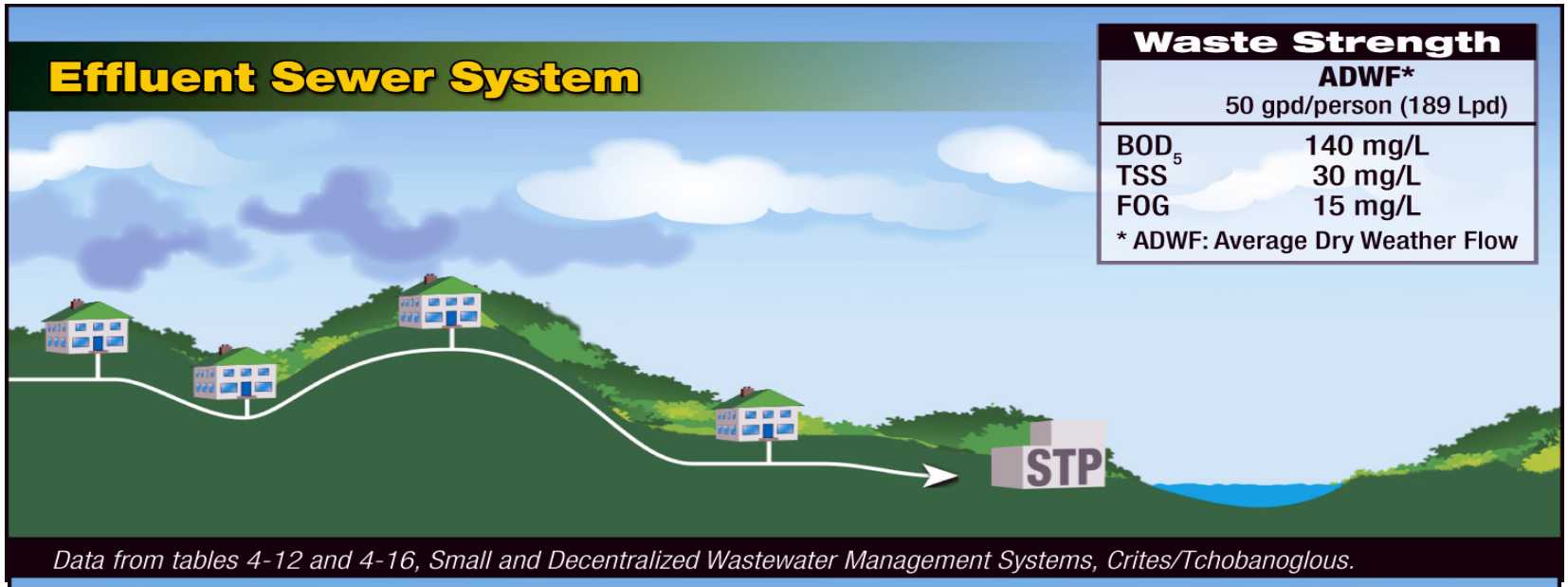
Freeze and Damage Prevention

- Underground components should be buried below the frost line or protected by insulation or heating tape
- Components in the right of way should be located to allow access for O&M activities, but also to reduce the likelihood of accidental damage

Discussion Topics

- System Overview
- Planning
- On-lot Design
- Right of Way Design
- Life Cycle Cost Comparison

System Comparison



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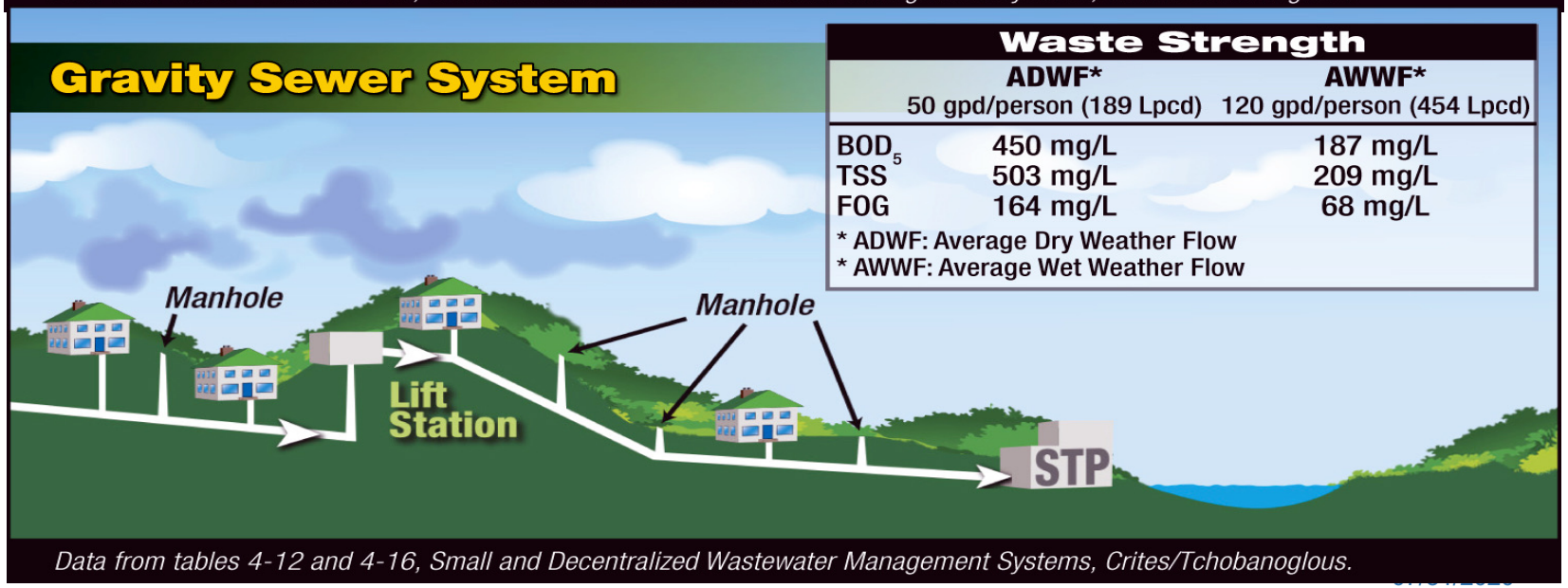

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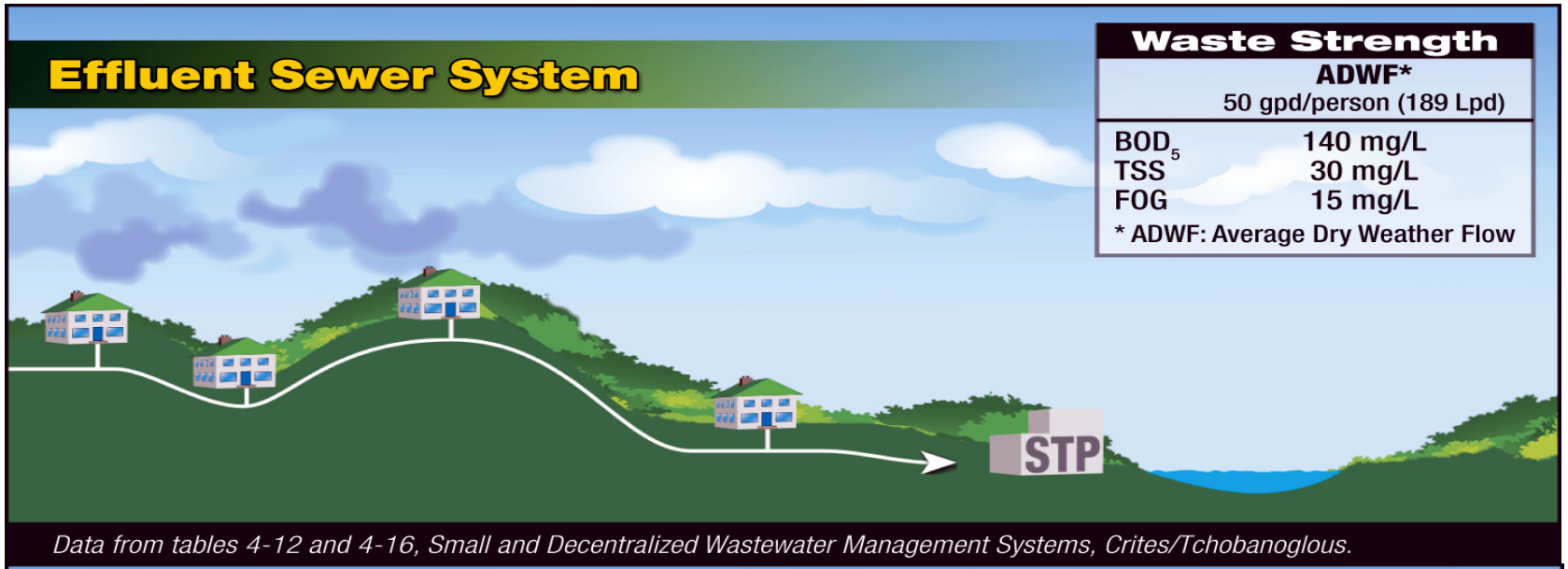
System Comparison



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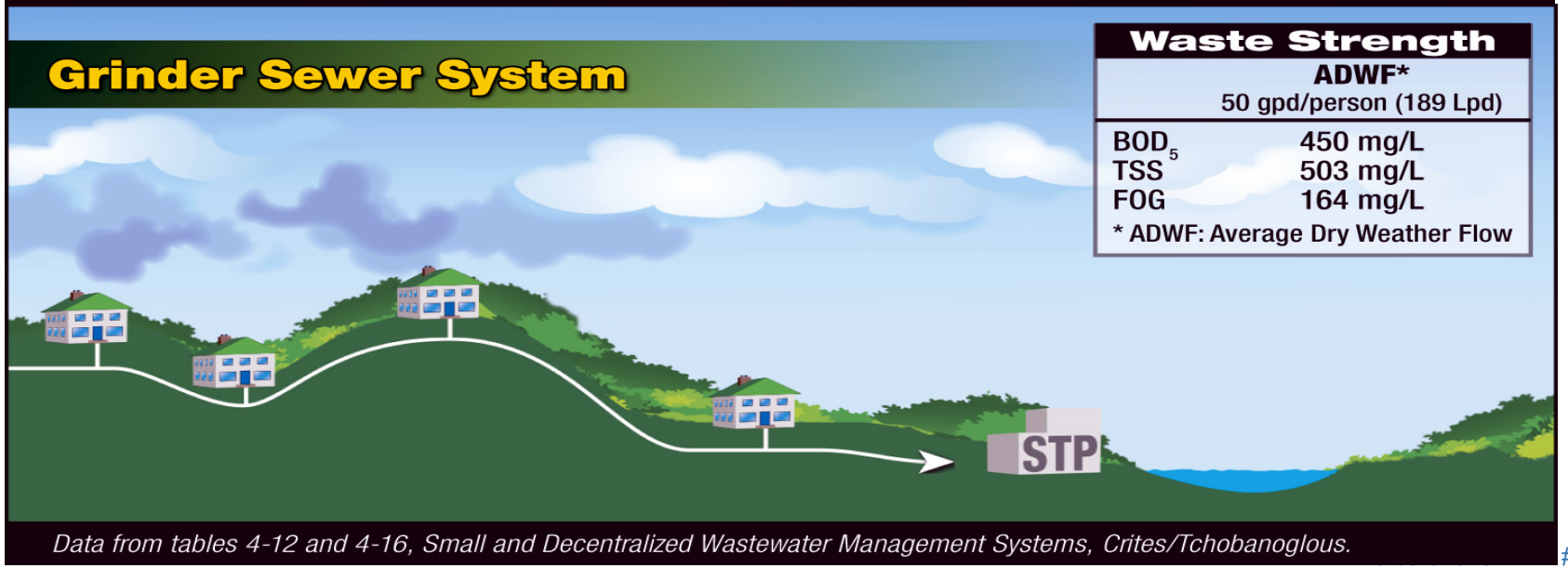
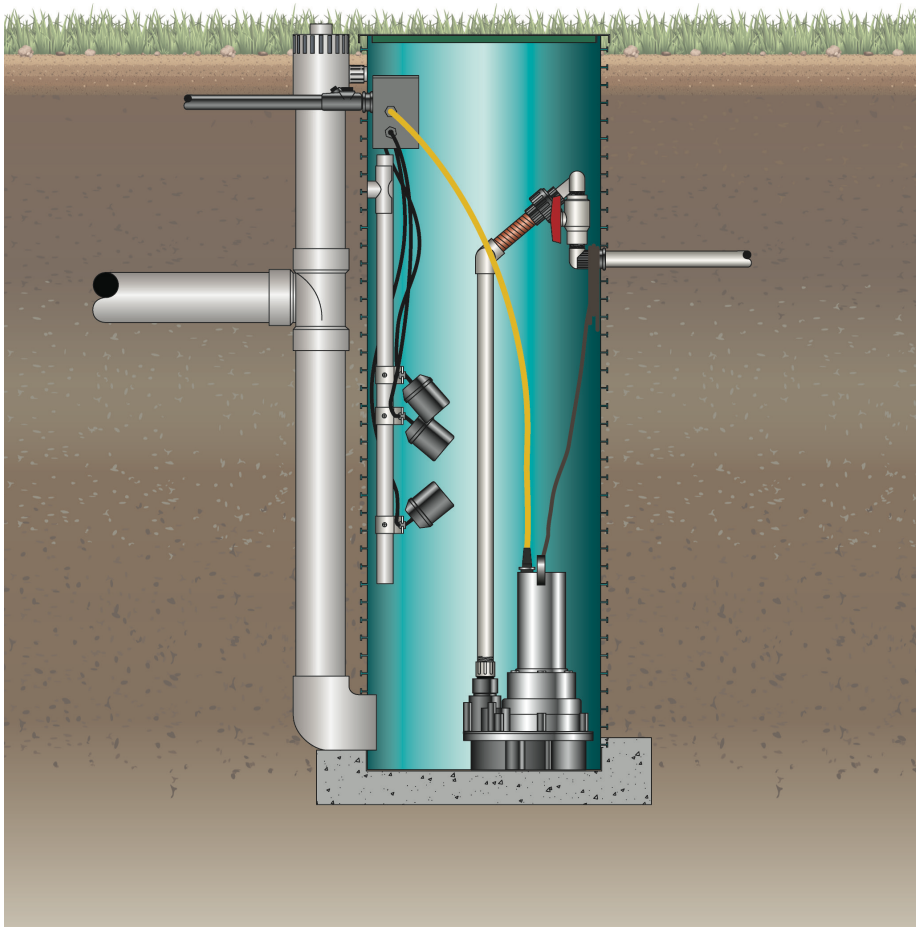


Data from tables 4-12 and 4-16, Small and Decentralized Wastewater Management Systems, Crites/Tchobanoglous.

Grinder Sewer

- Pump basin at each home
- Solids are ground to a “slurry”
- Mains must carry solids
- Must maintain minimum or scouring velocity in the mains
- Solids are processed at the treatment facility



Grinder Sewer *(Continued)*

- Mains must be small diameter
- Remember that the minimum velocity is a consideration - the mains carry solids
- Lines cannot be sized for future growth
- Solids are blended with fats, oil, and grease. This may be a settling concern
- Grinder pumps are heavy
- Pumps grind and pump
- Cutters require maintenance

Comparison of Collection Technologies

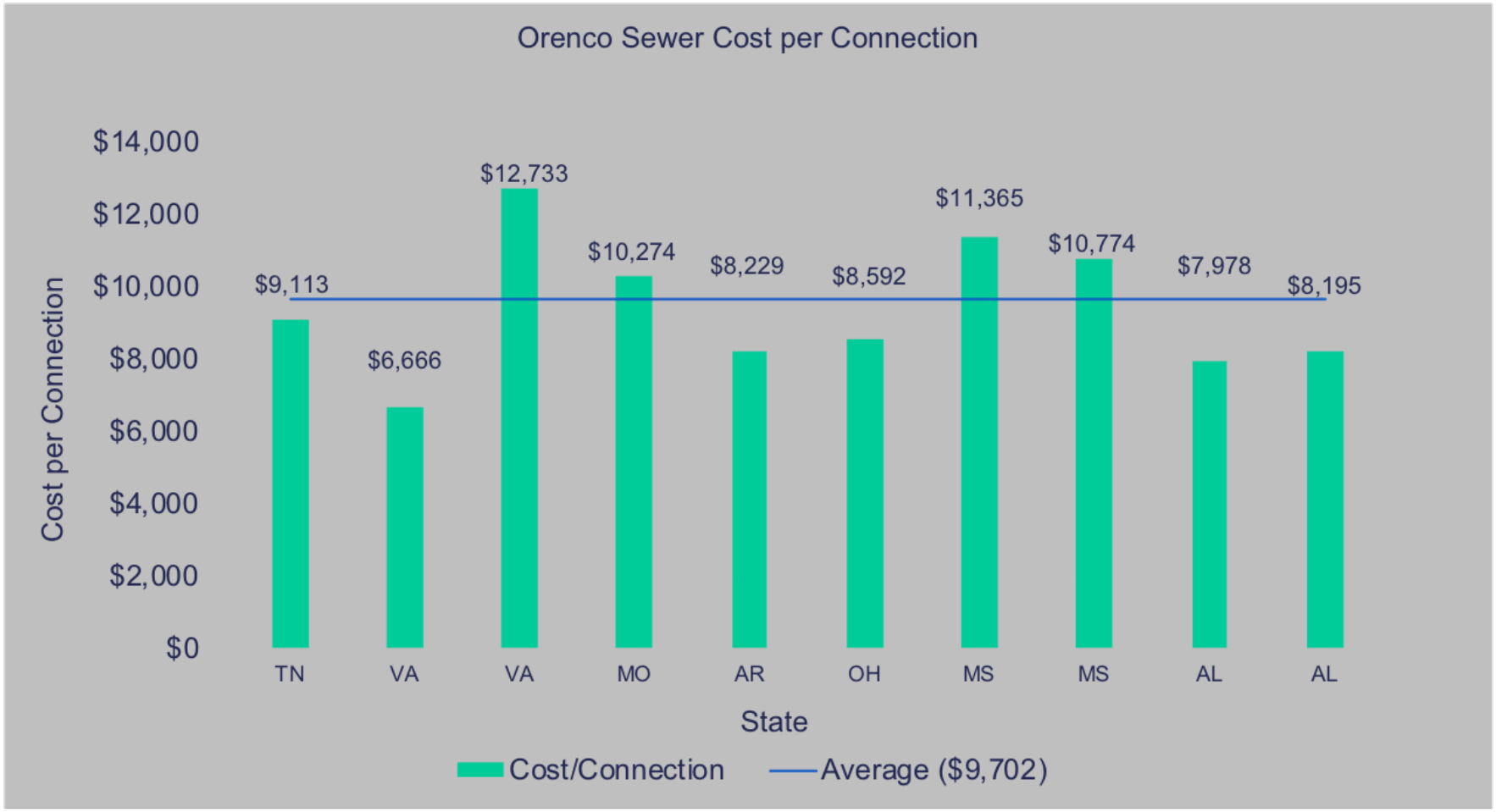
	Effluent Sewer	Conventional Gravity Sewer	Grinder Pressure Sewer
Excavation	Minimal disturbance	Significant disturbance	Minimal disturbance
Waste Stream	Liquid stream only	Full stream plus I&I	Macerated stream
Community Vision and Growth	Expandable	Future capacity built in and costs borne by current users	Expandable, but oversizing lines may cause maintenance impacts*

Source: WERF Performance & Cost of Decentralized Unit Processes Fact Sheets C1, C2, & C3
*added by author

Evaluating Wastewater Systems
Up-Front and Life-Cycle Costs

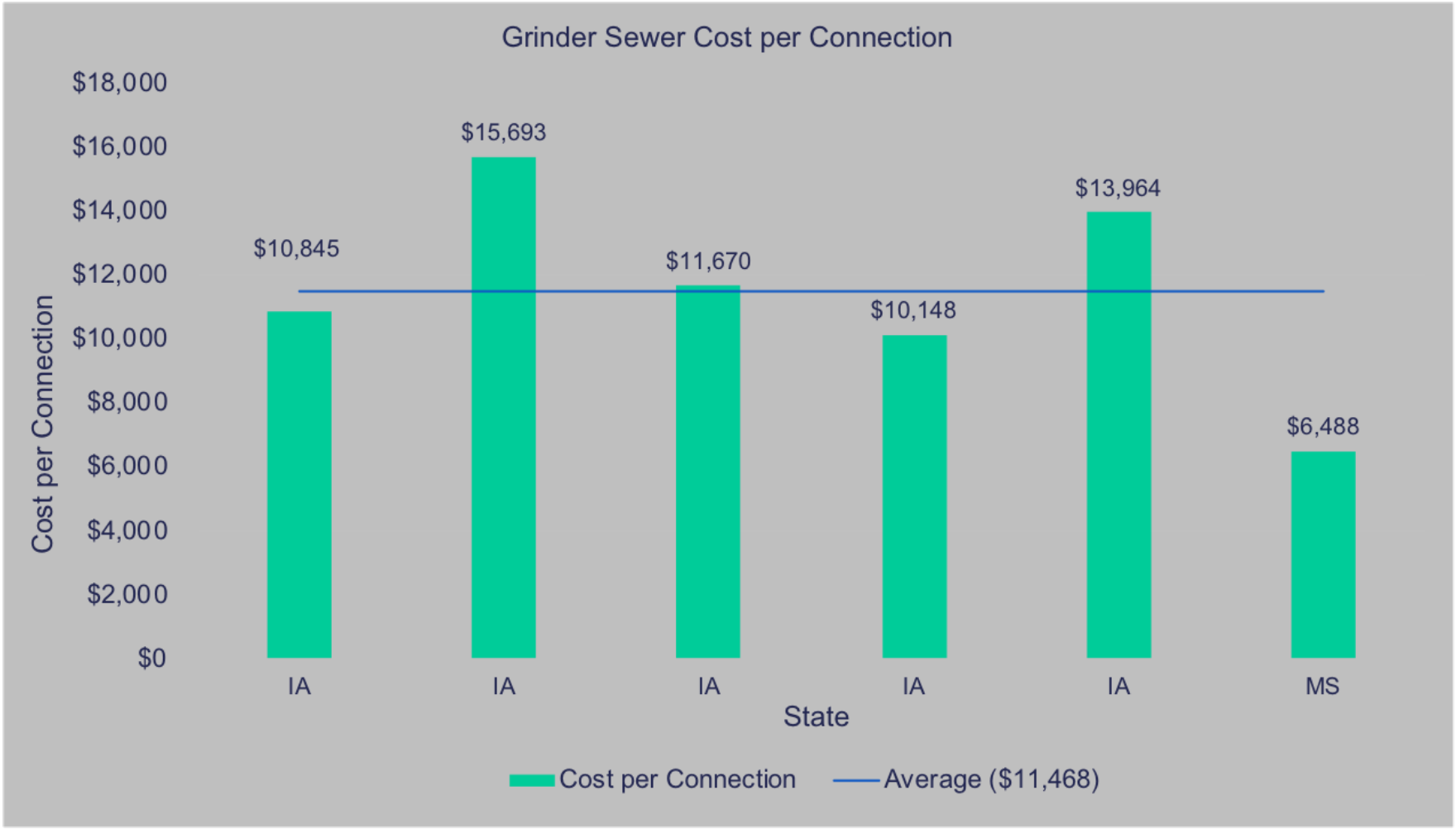
- Up-front capital costs
  - ~ Includes engineering, construction (including land costs), startup/commissioning
  - ~ Generally *similar* for pressure sewer technologies
- Life-cycle costs
  - ~ Represent the ***total*** cost of owning infrastructure
  - ~ Includes engineering, construction, R&R, and O&M
  - ~ *Varies* significantly for decentralized technologies

Total Collection System Cost:
Effluent Sewers

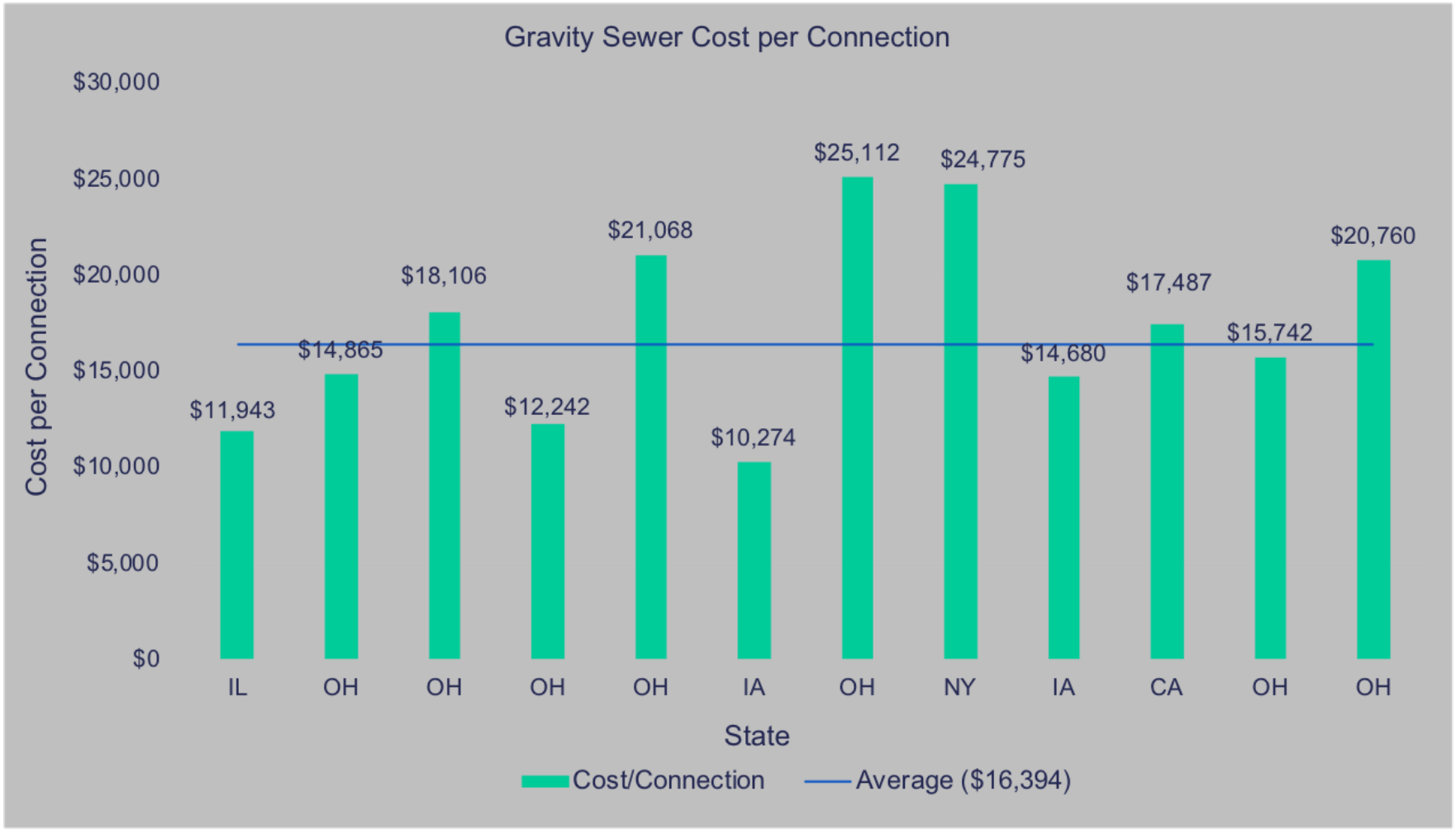


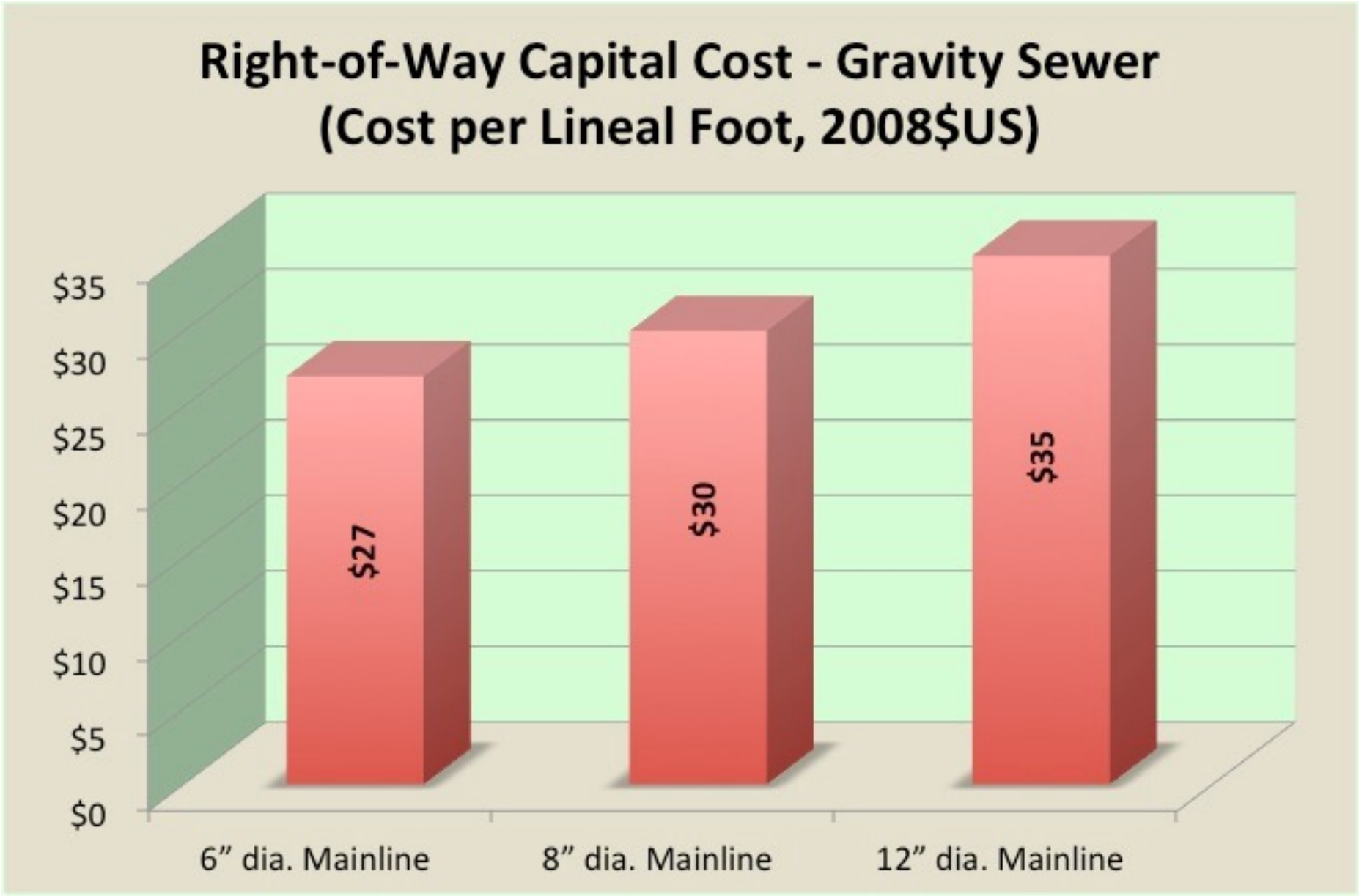
Note: All costs shown are for Orenco Sewers

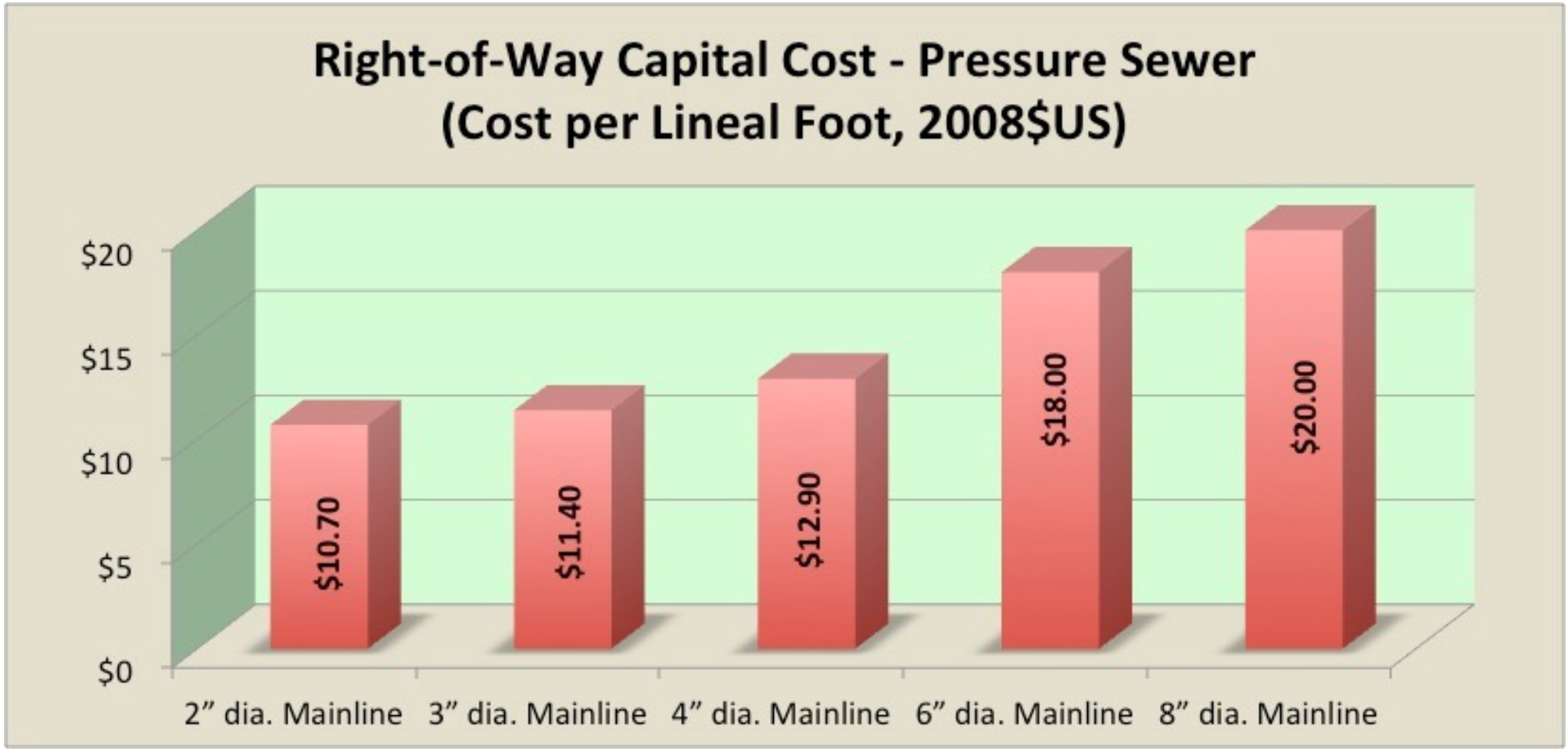
Total Collection System Cost:
Grinder Sewers



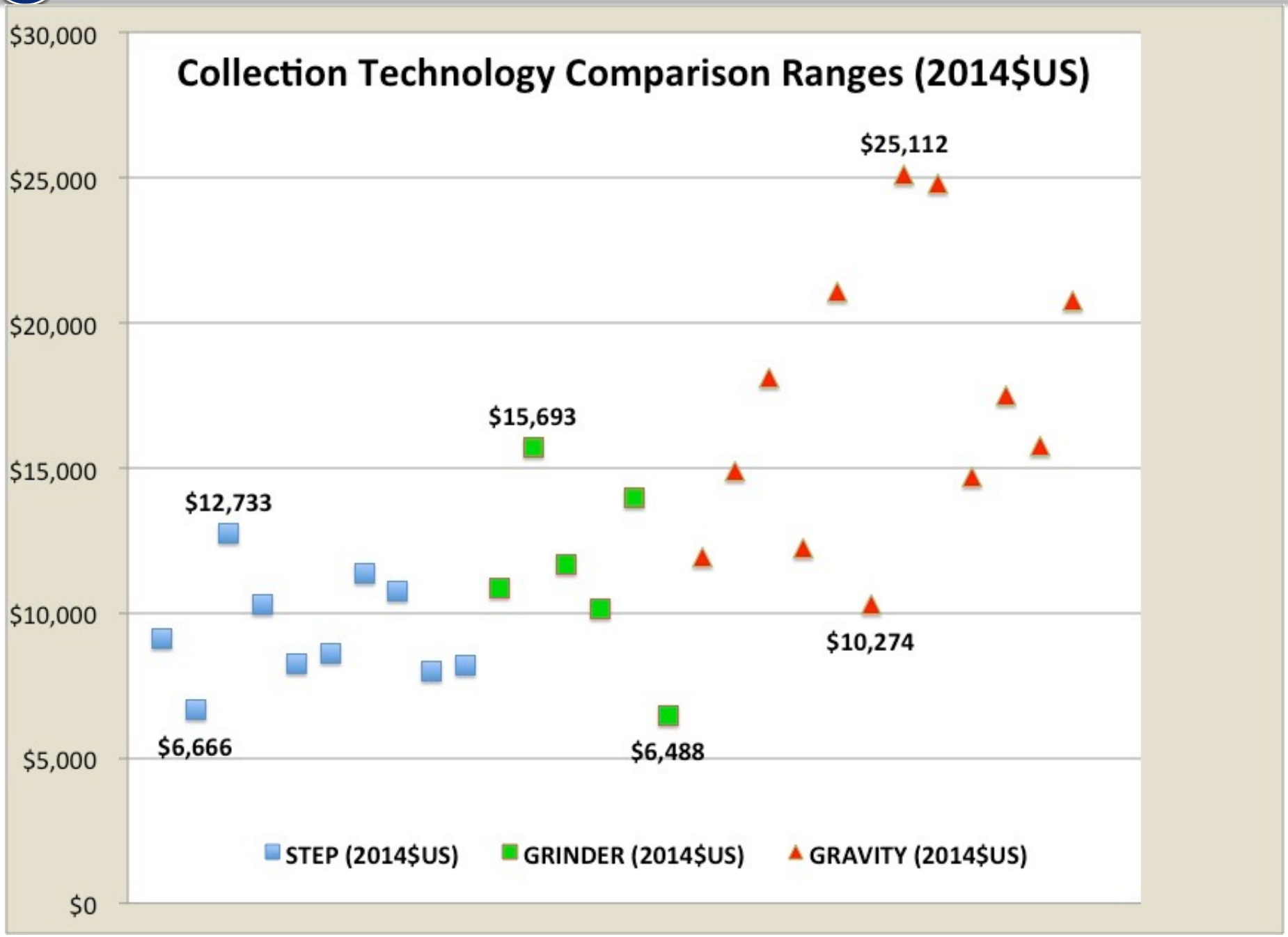
Total Collection System Cost:
Gravity Sewers

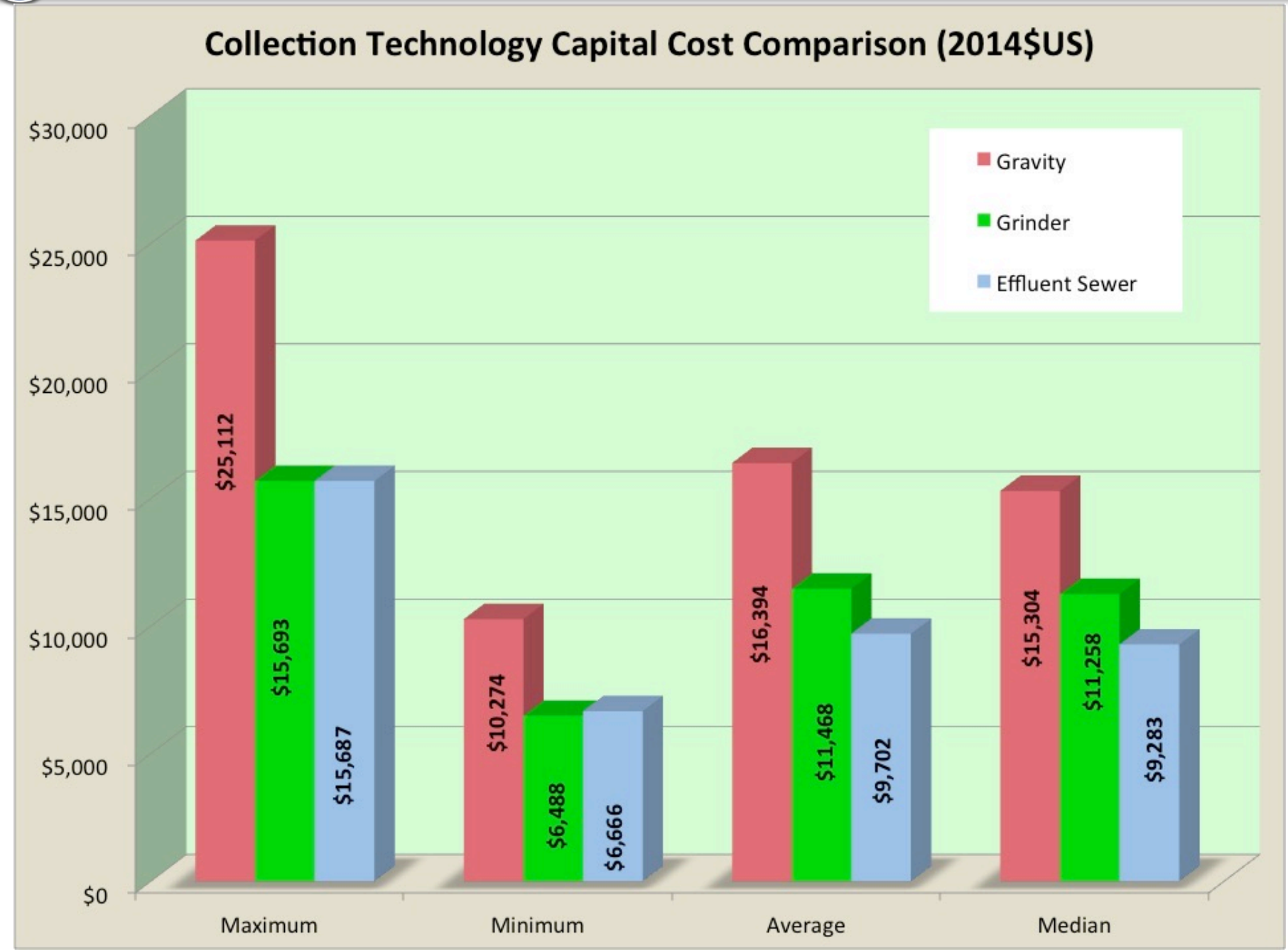



Right-of-Way Capital Cost - Gravity Sewer
(Cost per Lineal Foot, 2008$US)
$35
$30
$25
$20
$15
$10
$5
$0
$27
$30
$35
6” dia. Mainline
8” dia. Mainline
12” dia. Mainline



Source: Water Supply and Wastewater Removal, Third Edition 2012


Collection Technology Comparison Ranges (2014$US)
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
$25,112
$15,693
$12,733
$10,274
$6,666
$6,488
STEP (2014$US)
GRINDER (2014$US)
GRAVITY (2014$US)


Collection Technology Capital Cost Comparison (2014$US)
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
Gravity
Grinder
Effluent Sewer
$25,112
$15,693
$15,687
$10,274
$6,488
$6,666
$16,394
$11,468
$9,702
$15,304
$11,258
$9,283
Maximum
Minimum
Average
Median

Water Research Foundation

- Independent scientific research organization
  - Wastewater and stormwater issues
- Focused on results for the next generation of science and Technology
  - Research Costs
  - Developed excel cost estimating tool
    - Capital and O&M Costs
- WRF fact sheets
  - Gravity Sewer Systems
  - Pressure Sewers [Grinder]
  - Effluent Sewers
  - "*Performance & Cost of Decentralized Unit Processes," 2010*
  - http://www.werf.org/i/c/DecentralizedCost/Decentralized_Cost.aspx

WRF Agrees:

O&M Costs Are Equal for Effluent Sewer & Gravity

	Effluent Sewer	Conventional Gravity Sewer	Grinder Pressure Sewer
Materials/Install	$0.90-1.35 M	$2.43-3.64 M	$1.34-2.01 M
Annual O&M	$60,000-90,000	$65,000-97,000	$106,000-159,000
60 Year Life Cycle Cost – Present Value (2009 Dollars)	$2.45-3.68 M	$4.47-6.71 M	$4.71-6.11 M

Source: WRF Fact Sheets C1, C2, & C3
"Performance & Cost of Decentralized Unit Processes," 2010

Data based on 50,000 gpd or 200 homes

Capital Cost Summary

- Small communities face enormous challenges when constructing and maintaining wastewater infrastructure
- Gravity collection systems for small communities typically result in a cost that exceeds affordability thresholds (1.5 to 3% of MHI)
- Effluent sewers ($9,702/connection) have resulted in an average savings of $1,762 (15%) when compared to grinder sewers ($11,468/connection) and $6,692 (41%) when compared to gravity sewers ($16,394/connection)

Gravity Sewer I&I Considerations

- Gravity sewer I&I identification and correction programs are typically costly and often times ineffective

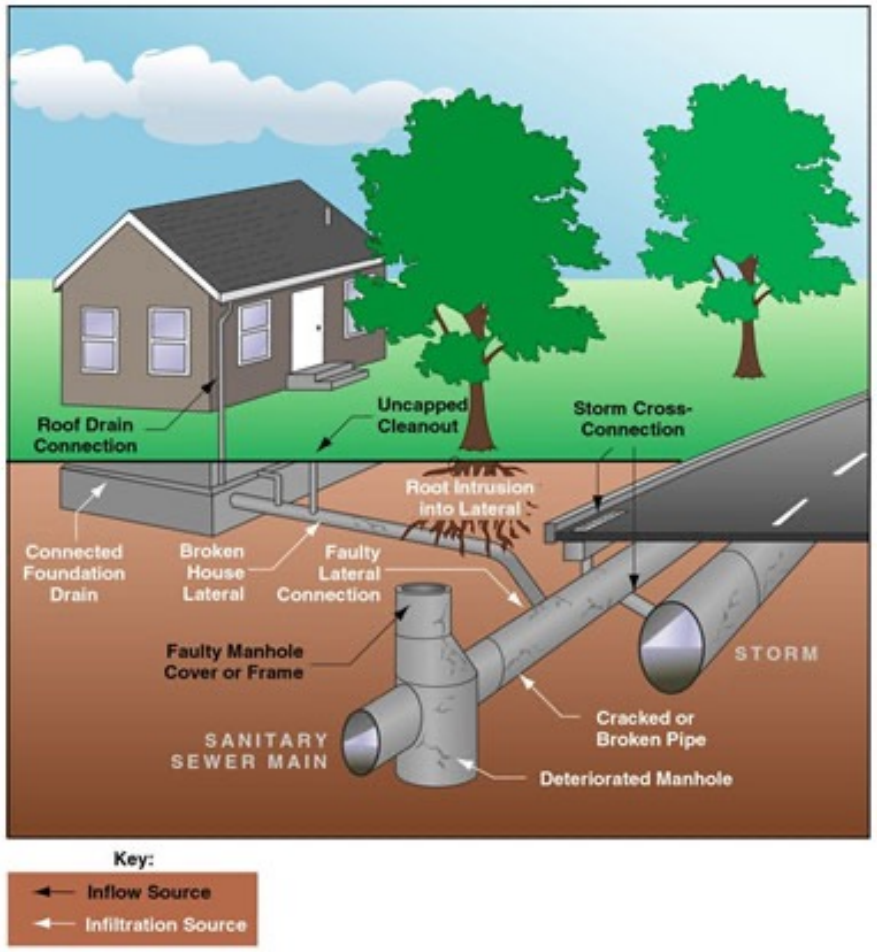


Image from City of Lakeport, CA. https://www.cityoflakeport.com/public_works/sewer/inflow_and_infiltration_iandi_summary.php

Pressure Sewer I&I Considerations

- Pressure sewer systems virtually eliminate I&I when structurally sound, watertight tanks are used.

Collection System Impact on Treatment

- Pressure Sewers provide a significant reduction in plant flow due to the elimination of infiltration (50 gpcd vs. 120+ gpcd)
- Liquid-only Sewer provides for flow modulation and a reduction of peak flow at the treatment facility
- Liquid-only Sewer reduces organic treatment needs
- Liquid-only Sewer greatly reduces overall biosolids management
- Liquid-only Sewer greatly reduce the energy use

Proactive Maintenance (PM)

- Liquid-only sewer system PM
  - Measure sludge/scum, inspect and clean effluent and pump screen, verify panel and float operation.
- Grinder sewer system PM
  - Inspect pump basin, sharpen cutters/blades, verify panel and liquid sensor operation.

Liquid-Only Sewers		Grinder Sewers	
Frequency	3 years	Frequency	3 years
Time	1.5 hours/visit	Time	1.5 hours/visit
Cost	$40.00/hr	Cost	$40.00/hr
UEM PM Cost	**$1.60/month/EDU**	**UEM PM Cost**	**$1.60/month/EDU**

Reactive Maintenance (RM):
PED and Grinder

Liquid-Only Sewers		Grinder Sewers	
Uniform Equivalent Monthly RM	1.5 hours/month/100 EDUs	Uniform Equivalent Monthly RM	1 service call per (8) years – 3 hour service call
Cost	$40.00/hr	Cost	$60.00/hr – (some immediate response)
UEM RM Cost	**$0.60/month/EDU**	**UEM RM Cost**	**$1.90/month/EDU**

Equipment Repair and Replacement (R&R)

	Liquid-Only Sewers			Grinder Sewers		
Component	**Freq.**	**Cost/ Event**	**4% Amortized**	**Freq.**	**Cost/ Event**	**4% Amortized**
Pump Replacement	20 yrs	$600	$1.62/mo/EDU	20 yrs	$2,500	$7.00/mo/EDU
Pump Repair	N/A	N/A	N/A	10 yrs	$800	$5.22/mo/EDU
Float Replacement	10 yrs	$100	$0.68/mo/EDU	10 yrs	$100	$0.68/mo/EDU
Misc. Components	10 yrs	$75	$0.51/mo/EDU	10 yrs	$75	$0.51/mo/EDU
		Total:	**$2.81/mo/EDU**		**Total:**	**$13.41/mo/EDU**

* Cost shown associated with Liquid-Only Sewer pump systems. Costs for gravity Liquid-Only Sewer systems are a fraction of this value

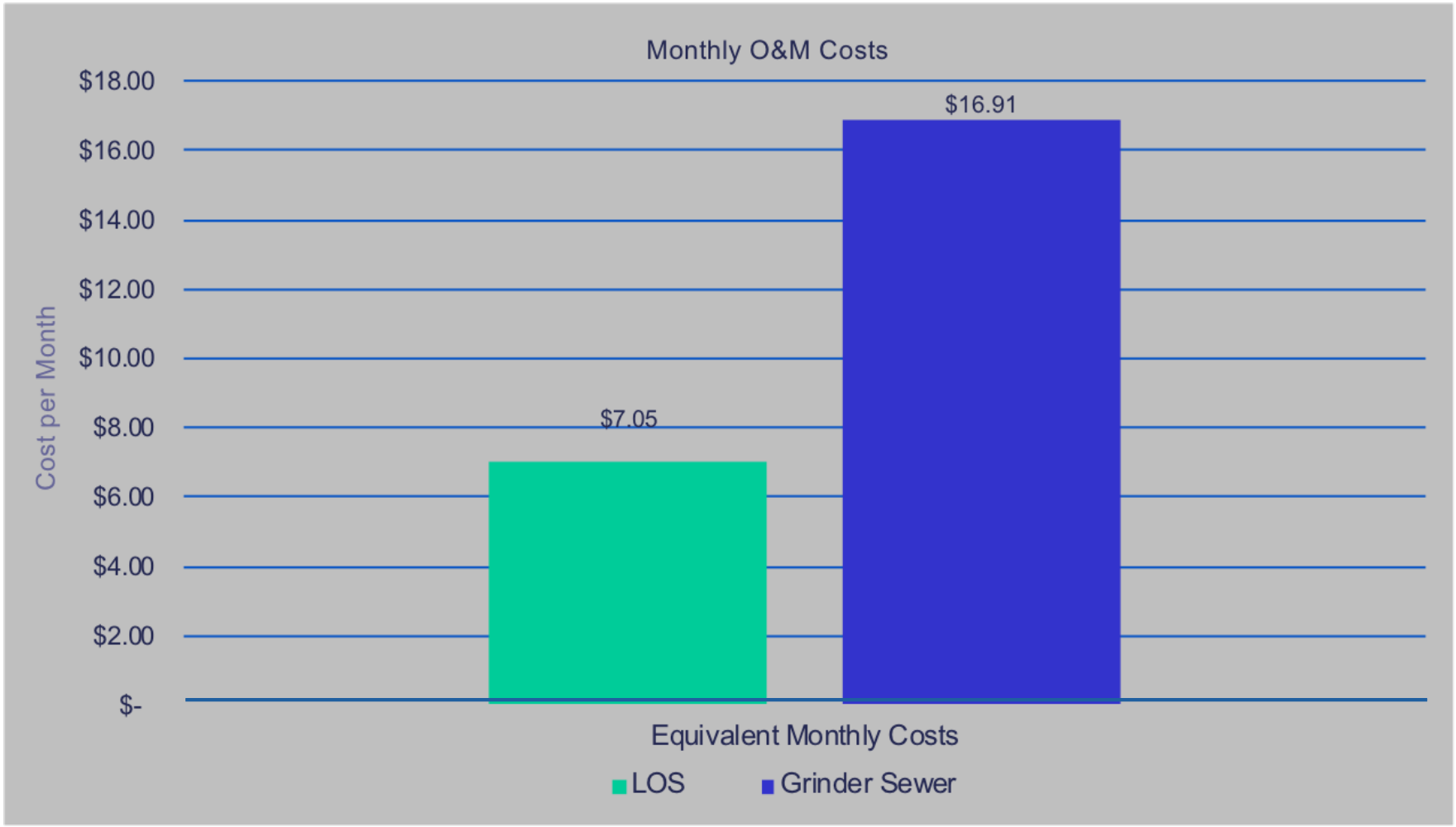
Solids Management: LOS Systems

LOS Systems				
Component	**Freq.**	**Tank Size**	**Cost/Event**	**4% Amortized**
Tank Pump-out	10 yrs	1,000 gal	$300	$2.04/mo/EDU
			Total:	**$2.04/mo/EDU**

Grinder systems manage solids at the wastewater treatment plant.

O&M Cost Estimate

LOS & Grinder Sewer



NOTE: All costs $/month/EDU

Electrical Usage: PED and Grinder

- All costs typically funded by homeowner

	Pump	Pump Run Time	Power Cost	Equivalent Monthly Costs ($/month/EDU)
Grinder Sewer	1.5 Hp, 230 VAC, 16 amps	20 mins/day	$0.10/kWh	**$3.70**
Effluent Sewer (STEP)	0.5 Hp, 115 VAC, 12 amps	20 mins/day	$0.10/kWh	**$1.38**

Water Research Foundation

O&M Costs Are Equal for STEP & Gravity

	Effluent Sewer	Conventional Gravity Sewer	Grinder Pressure Sewer
Materials/Install	$0.90-1.35 M	$2.43-3.64 M	$1.34-2.01 M
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Source: WRF Fact Sheets C1, C2, & C3
"Performance & Cost of Decentralized Unit Processes," 2010

Data based on 50,000 gpd or 200 homes

Lacey, WA

- Traditional sewer expansion too costly
- Alternative system looked at in mid-1980's
- 1986 first STEP connection installed
- High growth rate; up to 31,000 in 2000
- Primarily driven by small developers

Lacey, WA

- Relatively new technology
- Engineering standards incomplete
- Minimal construction oversight
- No preventive maintenance
- High amounts of callouts, lower level of service

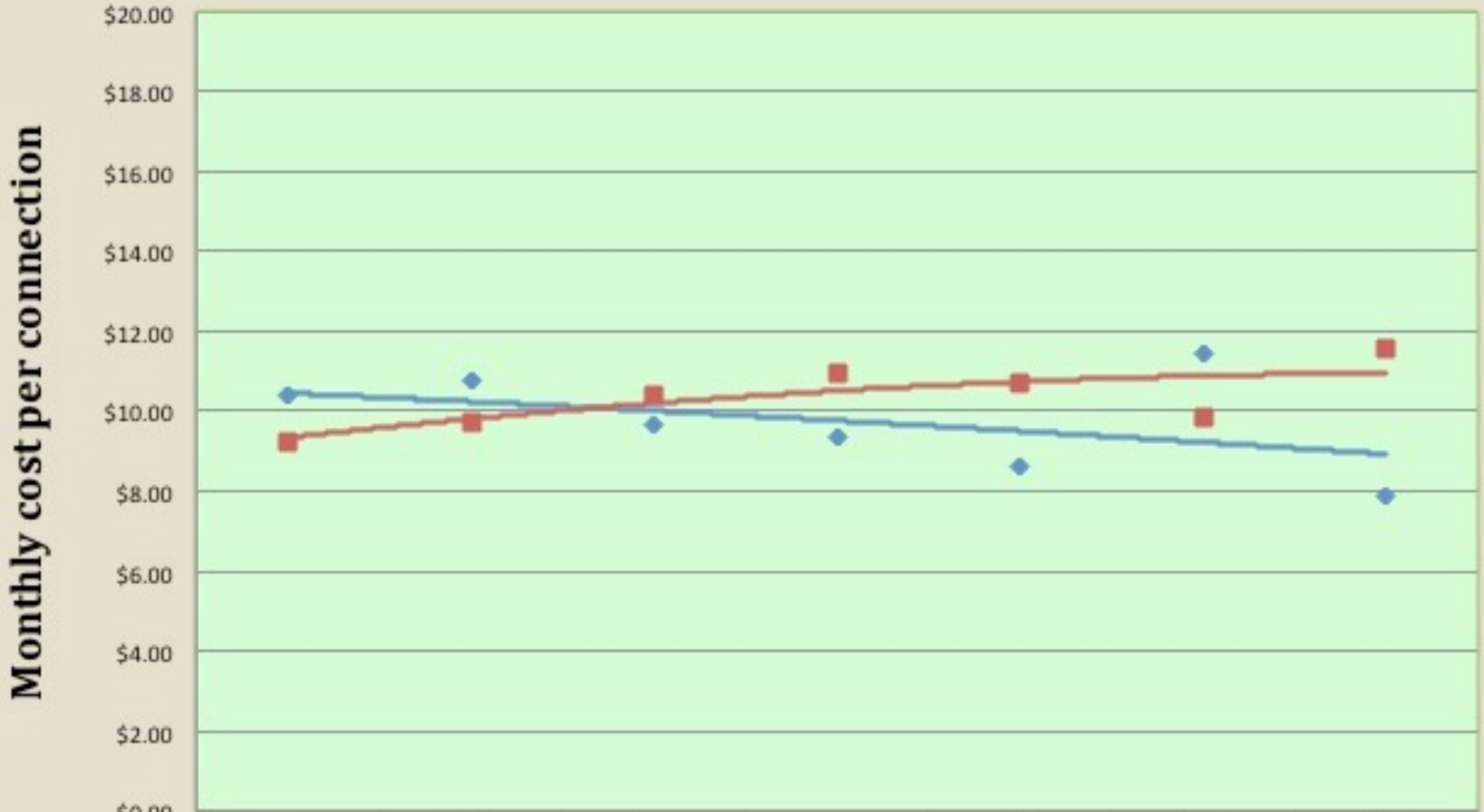
Aggressive Maintenance Approach

- Full Service Maintenance (FSM)
- All new systems inspected
- Bioxide injection at all STEP discharge points
- Tanks pumped and cleaned on a 3-year cycle

The Right Balance

- In 2007 a team was formed to evaluate STEP
- Modern equipment decreases cost associated with FSM
- Alternatives to Bioxide (Aeration); better design principles
- Tanks pumped on an as-needed basis

City of Lacey, WA O&M Costs 2008-2014



	2008	2009	2010	2011	2012	2013	2014
Effluent Sewer	$10.38	$10.79	$9.63	$9.35	$8.61	$11.46	$7.90
Gravity Sewer	$9.21	$9.75	$10.40	$10.96	$10.73	$9.83	$11.56

Additional Services

- Design support
  - ~ Plan review
  - ~ Specifications
  - ~ Case studies
  - ~ Bid tabulations
- Installation support
  - ~ Installer training
- O&M support
  - ~ Operator training
  - ~ Asset management

Summary

Orenco Liquid-Only Sewers:

- Are easier to design then gravity sewers
- Don’t require manholes or lift stations
- Cost less then traditional gravity collection system
- Are the ONLY collection technology to provide primary treatment
- Are equal in O&M costs to gravity sewer and less then grinder collection.

Protect ...

North Umpqua River, Steamboat, Oregon.

Solutions for Modern Wastewater Treatment

Garry-Lee Espinosa

gespinosa@orenco.com

www.orenco.com