

CHAPTER 5. COLLECTION SYSTEM ALTERNATIVES

This chapter evaluates alternative wastewater collection system technologies. Each technology is described along with the relative advantages and drawbacks for each as they would apply to the Pt. Hadlock sewer service area.

A technical evaluation comparing the alternative collection systems is presented in this chapter along with a technical recommendation for a preferred collection system technology.

WASTEWATER COLLECTION ALTERNATIVES

Alternatives Considered

Five wastewater collection system technologies were considered for evaluation. These are described below:

- Conventional gravity collection – Wastewater flows through a series of sloped pipes to pump stations where it is pumped to the wastewater treatment plant.
- Septic tank effluent pump (STEP) collection – Wastewater flows from the building drain to a septic tank on the property. Most of the wastewater solids remain in the septic tank. The clarified effluent from the tank is pumped into a pressurized sewer main using a high-pressure pump. The pressurized main conveys the clarified effluent to the wastewater treatment plant.
- Grinder pumps – Wastewater flows from the building drain into a sump on the property. When the sump fills a float activates a grinder pump within the sump. A grinding mechanism on the pump grinds solids down and pumps the ground solids and wastewater into a pressurized sewer main. The pressurized main conveys the wastewater to the wastewater treatment plant.
- Small diameter gravity – A small diameter gravity collection system is a cross between a conventional gravity collection system and a STEP system. Like a STEP system, there is a septic tank on the private property. Most of the wastewater solids remain in the septic tank. The clarified effluent from the tank flows by gravity through a series of sloped small diameter pipes to pump stations where it is pumped to the wastewater treatment plant.
- Vacuum sewers – Vacuum sewers convey wastewater by use of vacuum stations and vacuum collection lines located in each neighborhood. Wastewater flows from the building drain into a sump (or vacuum pit) located on the property. When the sump fills, a valve opens and the wastewater is sucked into the vacuum main. Once the pit is empty, the valve closes. The wastewater is conveyed via small diameter vacuum pipes to the vacuum station where it is pumped to the wastewater treatment plant.

Rejected Alternatives

Two alternatives were rejected early in the evaluation process. The rationale for their rejection is as follows:

Small Diameter Gravity Sewers

Small diameter gravity sewers were not recommended for further consideration. Small diameter gravity was rejected because it did not provide enough advantage given the local terrain, would require deep pipe excavations, and would not provide significant benefit over conventional gravity sewers principally because septic tanks would be required on private properties.

Vacuum Sewers

Vacuum sewers were rejected because they are not suitable for the varied terrain found in the sewer service area, they provide limited lift capability thereby requiring additional local pump stations, would require vacuum pits at each property, and additional odor control facilities would be required at the vacuum stations.

ALTERNATIVES CONSIDERED FOR FURTHER EVALUATION

After review of the service area and the key features of each evaluated technology; gravity collection, STEP, and grinder pump systems were recommended for further evaluation.

Conventional Gravity Sewers

Description

Conventional gravity sewers use a series of sloped pipes between manholes to collect and convey raw wastewater from the sewer connection to the wastewater treatment plant. The pipelines are a minimum of 8-inch diameter, are sloped at a minimum slope of 0.004 feet/foot, and are typically laid between 8 feet and 20 feet deep. Wastewater is collected within sewer mains and slope towards the wastewater treatment plant or to a local pump station.

Each service connection to the wastewater treatment plant is achieved through a sloped pipe (service lateral) from the building's drain to the gravity sewer main in the street. The construction of the service lateral is typically the responsibility of the property owner from the property line to the building drain. Within the street right-of-way, construction of the service connection from the sewer main to the property line is the responsibility of the sewer agency. This type of collection system does not require any access and maintenance easements since maintenance of the service lateral on private property is the responsibility of the property owner.

Figure 5-1 shows a typical service connection to a gravity sewer system.

In some instances, parts of the service area are located in basins requiring the construction of a pump station to locally collect the wastewater and pump it out of the basin towards to the wastewater treatment plant. It is through a series of gravity collection lines and pump stations that wastewater within the service area is collected and conveyed to the wastewater treatment plant.

A key strategy in the design of a gravity collection system is to use the contours of the existing terrain to maximize efficiency in the construction of pipelines towards the wastewater treatment plant. An efficient design strategy involves sewers excavated as shallow as possible while minimizing the number of pump stations.

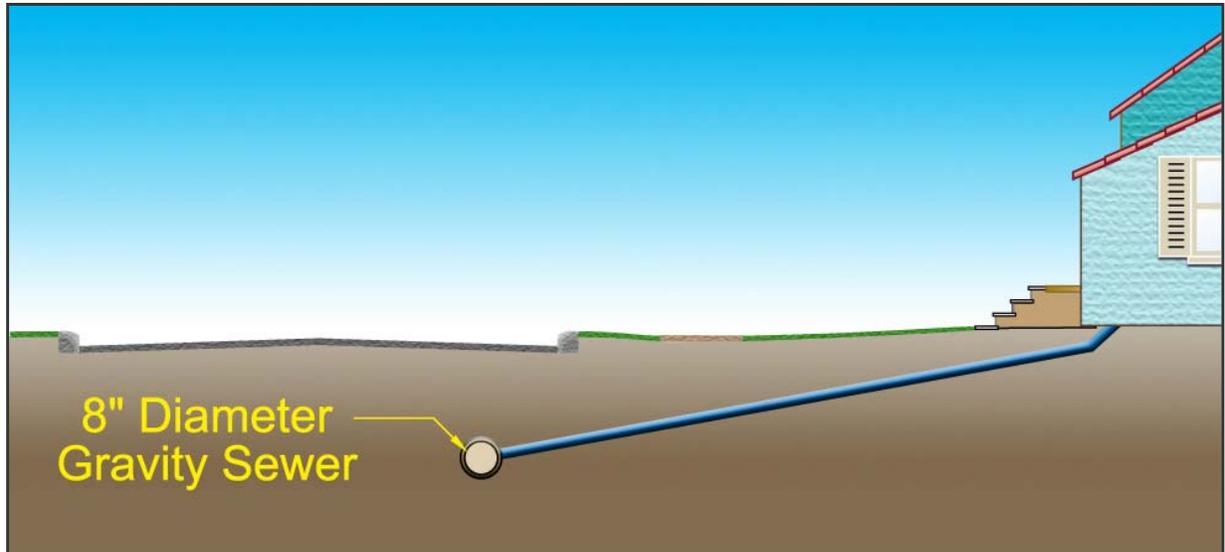


Figure 5-1. Conventional Gravity Sewer System and Service Connection

Maintenance for a gravity collection system involves pump station checks, routine maintenance of the pump station equipment, and flushing of the gravity collection lines. Operational costs for a typical gravity collection system involve electricity to operate the pump stations.

Design Criteria

The gravity collection system was developed using design criteria prescribed in the *Washington State Department of Ecology Criteria for Sewage Works Design, Water Quality Program, December 1998* (“Orange Book”) and flow generation criteria developed in Chapter 4 – Population, Flow and Loads.

The key design criteria used in the development of the gravity collection system are as follows:

- Average Daily Flow(Q) = 75 gallons/capita/day (for base flow of 60 gpcd and I/I allowances of 250 gpad based upon flow assumptions in Chapter 4 – Population, Flow and Loads.
- Peak Flow – Ratio of Peak Hour flow to Average Daily flow based upon peaking factor equation in Section C1-3.3.2 of the Orange Book. The equation is as follows:

$$\frac{Q \text{ peak hourly}}{Q \text{ design average}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$$

- Minimum pipeline diameter = 8-inch.
- Minimum Pipeline Depth = 8 feet.
- Maximum Pipeline Depth = 20 feet.
- Minimum Slope = 0.40 feet/100 feet. This is the minimum slope prescribed in DOE Criteria for Sewage Works Design for an 8-inch diameter sewer. Shallower slopes are allowed for larger diameter sewers. However, all pipes were laid out using the 0.40 slope to be conservative and to account for inaccuracies in the base map contours (10-foot contour intervals).

Proposed Layout

The preliminary design for a gravity collection system was developed throughout the service area boundary. The sewer laterals were developed along existing right-of-way to serve the land area within the service area boundary. A 20-foot contour map was used to develop an overall collection system strategy which included planned flow direction, pipeline diameters, pump station locations, and a central collection point from which to send flow to a wastewater treatment plant through an influent pump station. The proposed gravity collection system layout is shown in Figure 5-2.

Advantages and Drawbacks

Several advantages and drawbacks of gravity collection systems were identified during the evaluation of collection system alternatives. Below is a summary of the advantages and drawbacks of gravity collection systems.

Advantages

- **Proven Reliability**—This is the most common type of wastewater collection system. This type of technology has been in service longer than any other type of technology.
- **Length of Service**—This type of collection system will provide the longest reliable service life compared to other types of collection system technologies. There are no individual on-site mechanical installations required. The gravity collection lines can have a 50-year service life provided they can convey the anticipated future design flows.
- **Lowest Operation and Maintenance Costs**—This type of collection system has the lowest operation and maintenance costs compared to pressurized collection systems. This is because there are no on-site pumps or equipment at each service connection.
- **On-Site Equipment**—This type of system does not require on-site equipment. A gravity service lateral is required on the private property between the building drain and the service connection in the right-of-way. On site connection costs are less than for other technologies
- **No Maintenance Easements**—Since the property owner is responsible for maintenance of the service connection to the sewer, no maintenance easement is required.
- **Lower Life Cycle Costs**—Cost of gravity conveyance is less over the life cycle of a project since the cost for on-site connections, operations, and maintenance are less than for pressurized sewers. Cost savings become significant as the population density increases and the on-site connection, operations, and maintenance costs per connection become a larger part of the total life cycle cost.

Drawbacks

- **Requires Constant Downward Slope** – Deep sewers may have to be dug for flat terrain, intermediate pump stations may be required for hilly areas.
- **Higher Initial Costs** – Construction of the sewer mains may be more expensive due to deeper trench excavation.
- **Infiltration & Inflow** – Gravity collection systems are more susceptible to infiltration and inflow through manholes and some joints in the pipeline system. Unlike a pressurized collection system, there is no back pressure within the pipes to prevent water from entering the collection system.

Pressurized Wastewater Collection Systems (STEP & Grinder Pumps)

STEP (Septic Tank Effluent Pump) Description

A STEP system uses pressurized sewer mains to collect and convey wastewater to the wastewater treatment plant. Typically, each service connection has an individual septic tank with pump which pumps into the pressurized main.

For a STEP collection system, wastewater flows from the building drain to the septic tank where solids settle. Inside the tank is a pump chamber which houses a high head pump and control floats. The clarified effluent is pumped from the septic tank into the pressurized main. The effluent flows through the pressurized mains to the wastewater treatment plant.

Figure 5-3 shows a typical service connection in a STEP collection system.

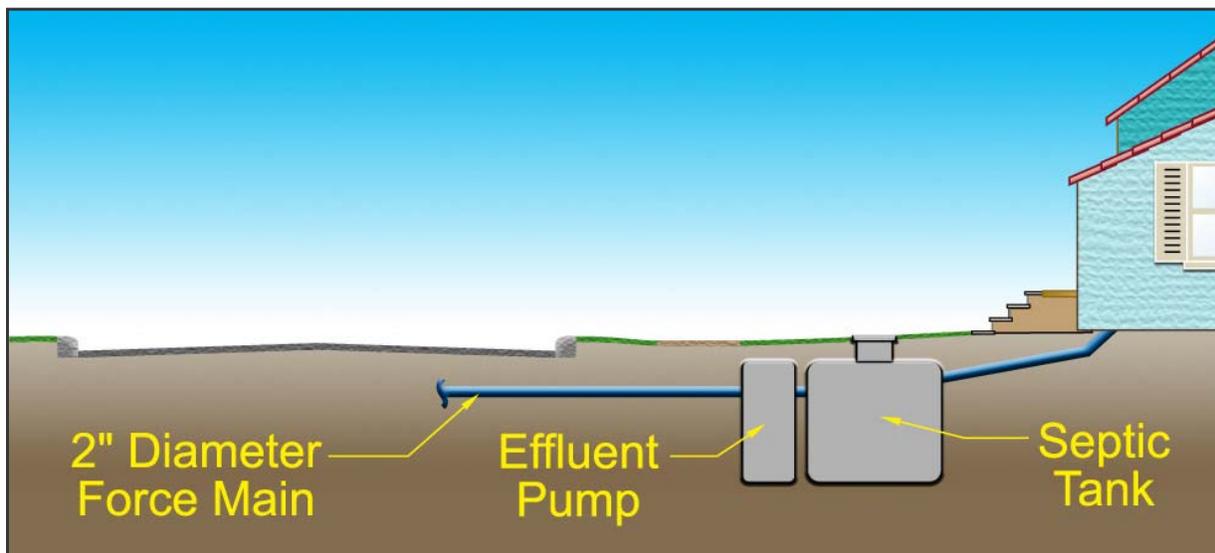


Figure 5-3. Septic Tank Effluent Pump (STEP) System Service Connection

Since the solids stay behind in the septic tanks, screening and/or primary treatment facilities are not required at the wastewater treatment plant. This benefit, however, is off-set by the requirement for routine and emergency maintenance and repair of each septic tank and pumping system in the service area. This maintenance is generally provided by the wastewater authority since the septic tanks and pumps are considered to be components of the wastewater infrastructure. This arrangement can be quite costly, cumbersome and labor intensive. Service calls for pumping septic tanks, pump maintenance, pump and/or control equipment malfunction and electrical supply malfunctions must be provided in a timely fashion, often during off-hours, weekends and holidays. Additionally, each property owner must provide an access-and-maintenance easement.

Grinder Pumps Description

Similar to a STEP collection system, a grinder pump collection system uses pressurized sewer mains to collect and convey wastewater to the wastewater treatment plant. A grinder pump is located at each service connection. Wastewater flows from the building drain to the grinder pump sump. Within the sump is a grinder pump and pump control system (floats). Once the basin is full, the grinder pump turns on, grinds any solids within the sump and pumps the liquids and ground solids into the pressurized sewer main. The wastewater flows through the small diameter sewer piping to the wastewater treatment plant.

Since solids are conveyed with the wastewater to the treatment plant, facilities need to be included at the plant to handle solids. Like a STEP system, the grinder pumps are typically considered part of the wastewater infrastructure; maintenance and upkeep is generally provided by the wastewater authority. Unlike the STEP system, the grinder pump system does not require a septic tank. Otherwise, maintenance and access issues are quite similar.

Design Criteria

The pressurized sewer system was developed using design criteria prescribed in the *Washington State Department of Ecology Criteria for Sewage Works Design, Water Quality Program, December 1998* (“Orange Book”) and flow generation criteria developed in Chapter 4 – Population, Flow and Loads.

The key design criteria used in the development of the pressurized collection system are as follows:

- Average Daily Flow = 60 gpcd (no I/I allowance) based upon flow assumptions in Chapter 4 – Population, Flow and Loads.
- Peak Flow – Peak flow as described in Section C1-10.2.2A of the Orange Book. The equation is as follows:
$$Q_{\text{peak}} = 15 + .15 P; \text{ where } P = \text{population.}$$
- Minimum Pipe Diameter = 2-inches.
- Headloss Calculation – Hazen Williams Formula.
- Hazen Williams Roughness Coefficient $C = 150$ (PVC Pipe).
- Pump Shutoff Head = 300 feet for STEP high-head pumps.

Proposed Layout

The proposed pressurized collection system is shown in Figure 5-4. The layout and pipe sizes are the same for both STEP and grinder pump technologies. The pressurized sewer system was laid out to convey flow to the same central collection point as identified for the gravity collection system. This was done for consistency when comparing the two alternative collection system technologies.

Advantages and Drawbacks of STEP Collection Systems

Advantages

- Low initial cost for collection mainlines compared to gravity.
- Smaller pressurized sewers can follow the terrain reducing the depth of excavation.

Drawbacks

- Septic tank (and access to the tank) required.
- Must develop ownership agreements for equipment with property owner.
- Easements required for wastewater authority to access and maintain the equipment.
- Pumping of septic tank on regular schedule. High disposal costs of septic tank solids.
- Electrical connection, electrical panel, and control panel must be located on the property or side of home.

Advantages and Drawbacks of Grinder Pump Collection Systems

Advantages

- Good when terrain does not work well with gravity sewers and septic tanks are not desired.
- Low initial cost for collection mainlines compared to gravity.
- Smaller pressurized sewers can follow the terrain reducing the depth of excavation.

Drawbacks

- Pump must pass solids (more difficult than passing liquids only, additional maintenance required because of harder duty).
- Must develop ownership agreements for equipment with property owner.
- Easements required for wastewater authority to access and maintain the equipment.
- Electrical connection, electrical panel, and control panel must be located on the property or side of home.

EVALUATION OF COLLECTION SYSTEM ALTERNATIVES

Collection System Alternatives

The shortlisted technologies were applied to the sewer service area to develop alternative collection systems for evaluation. Three distinct alternatives were developed. These alternatives were a gravity collection system, a pressurized sewer system (STEP or grinder pump), or a dual technology system consisting of gravity collection in the 6-year planning area (or “core” area) and pressurized sewer in the outlying 20-year planning area.

The proposed gravity collection system layout is shown in Figure 5-2. The proposed pressurized sewer layout is shown in Figure 5-4. The dual technology system is shown in Figure 5-5.

Evaluation Criteria

The following evaluation criteria were used when comparing the collection system alternatives:

Phasing

Does the system lend itself to phasing? Does it provide flexibility for expansion in the future? Does the collection system adapt well to population increases and in-filling?

Easement Requirements

Are easements on private property required?

Constructability

Are there constructability issues associated with the alternative technology that would be a concern for the Port Hadlock Area? This could include issues such as pipe depth, depth to groundwater, significant areas of bedrock, extensive utility conflicts, etc.

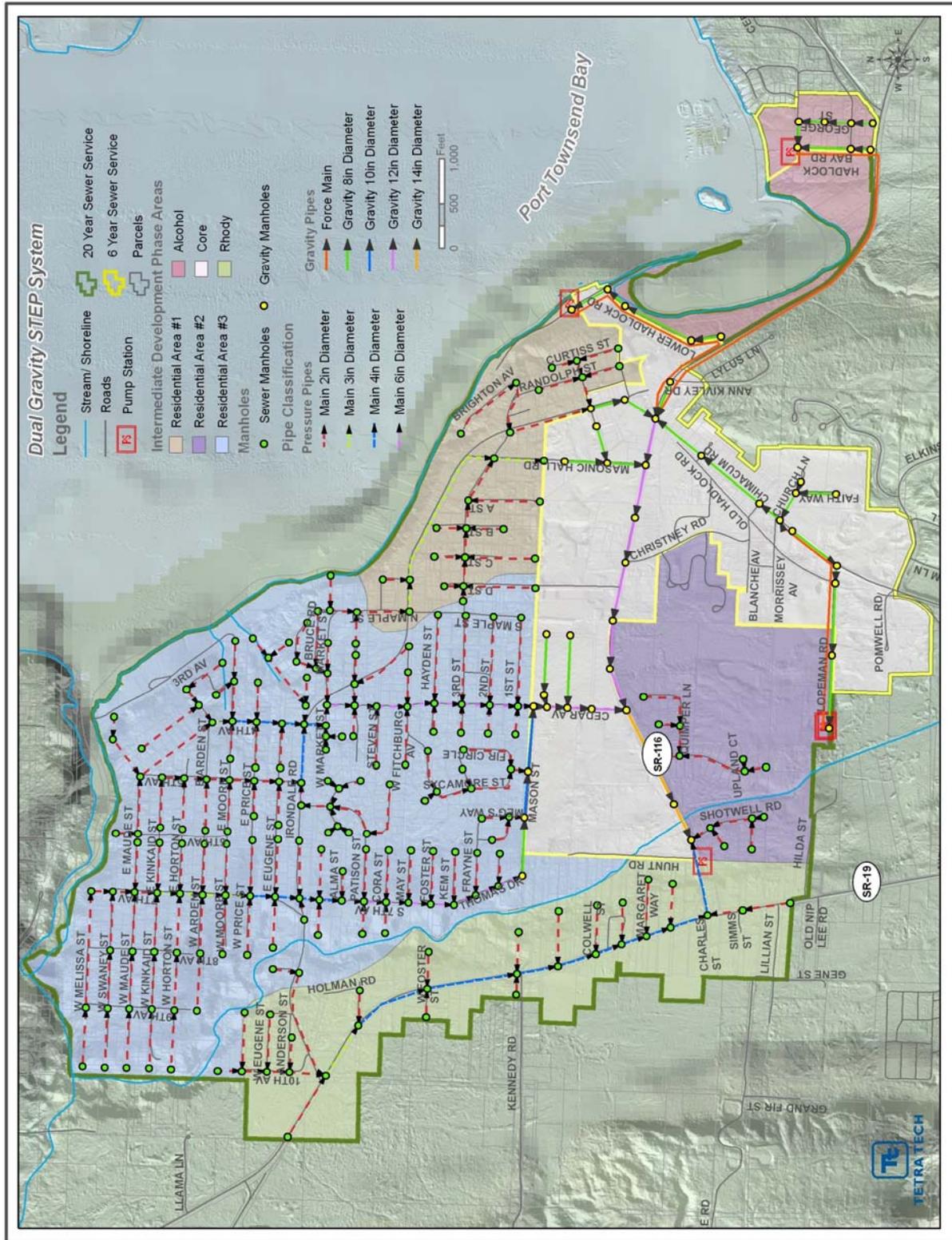


Figure 5.5. Proposed Dual Technology (Gravity/Pressurized) Collection System

Operation and Maintenance Requirements

What are the key operation and maintenance requirements which will be needed for the collection system on an ongoing basis? This will have a significant impact on the long term life cycle costs for the system. It also may affect the quality of service for the end user due to service calls and on-site pump malfunctions, etc.

Odor and Corrosion Potential

What are the odor and corrosion potential issues typically associated with each collection system?

Life Cycle Costs

What are the life cycle cost differences between the alternatives which include capital costs for collection and conveyance, on-site costs (on private property), and operation and maintenance costs (including equipment replacement, electricity, and other incidentals)? Costs are compared on a 20-year life cycle since most systems require significant equipment replacement in 20-years. Some consideration is given for longer life cycles to see if systems costs compare differently over a longer term.

LIFE CYCLE COST ESTIMATING

Cost Assumptions

Total present worth and annualized costs were estimated for a 20-year period. The 20-year period is consistent with an approach of designing mechanical equipment to its expected life. Structures, such as buildings, were sized based on anticipated needs for a 50-year time span. A detailed breakdown of the estimates is attached in Appendix C. Estimated costs were identified from the following sources:

- Price quotes from local equipment suppliers.
- Unit prices for construction based on industry standards (Means 2008 Building Construction Cost Data).
- Bid tabulations from similar projects.

The capital cost represents the total project cost for implementation of each alternative. It includes equipment costs, installation costs for piping, electrical, and controls, site work, mobilization/demobilization/bonding, contractor overhead and profit, escalation to mid-point of construction, planning-level contingency, engineering design and construction management, and Washington state sales tax. These amounts are reflected in the attached cost estimates.

Annual O&M costs were estimated based on power requirements, chemicals, and labor (general maintenance and cleaning). Additionally, replacement cost of equipment and structures are included in the comparative life cycle costs. Replacement costs represent a dollar amount required each year to be set aside in order to replace building, structures, and equipment. Replacement allowances of 2 percent for buildings and structures (replace every 50-years), and 4 percent for equipment (replace every 20 to 25 years) were included in the life cycle cost estimates. These amounts are reflected in the attached cost estimates.

Cost Assumptions for Pressurized Sewers: STEP and Grinder Pump Systems

Throughout the evaluation, it was determined that STEP and grinder pump systems were comparative equal on a life cycle cost basis. The on-site costs for equipment were similar (about \$4,000 per

connection) and the costs for electrical connection and building drain connections were equivalent. Costs for operation and maintenance were also deemed about equivalent. Equipment replacement costs may be higher for grinder pumps due to wear and tear on grinder blades (this is dependent upon the individual user). However, there are costs associated with septic tank pumping for a STEP system not associated with a grinder pump system. When these factors are considered, both systems projected basically equivalent life cycle costs.

Detailed cost estimates are included for a STEP collection system within Appendix C. These costs are assumed equivalent to a grinder pump system for each alternative that includes a pressurized sewer system.

Summary of Life Cycle Costs

Table 5-1 below summarizes the 20-year life cycle costs for each of the collection system alternatives.

TABLE 5-1. SUMMARY OF 20-YEAR LIFE CYCLE COSTS			
Capital Costs	Alternative		
	Gravity Collection	STEP Collection	Dual Technology
On-Site ^a	\$14,868,000	\$42,275,000	\$37,605,000
Shared ^b	\$32,011,000	\$6,454,000	\$15,708,000
Subtotal Capital Costs	\$46,879,000	\$48,729,000	\$53,313,000
Annual Costs			
O&M + Replacement	\$7,620	\$17,400,000	\$17,178,000
Total 20-year Life Cycle Cost	\$54,499,000	\$66,137,000	\$70,491,000
<p>a. On-Site Costs include service connection from house and all other applicable equipment and appurtenances on private property (STEP tank, grinder pump, control equipment, electrical connection, etc.)</p> <p>b. Shared Costs include costs for over-sizing equipment which serves more than one neighborhood.. This typically involves costs for sizing gravity conveyance lines larger than 8-inch diameter and pressurized sewer lines larger than 2-inch diameter. It also includes costs for regional pump stations which collect and transmit wastewater from several neighborhoods to the wastewater treatment plant.</p>			

Evaluation of Alternatives

Each of the alternatives was evaluated against the above described criteria. Table 5-2 is a summary of the evaluation of the alternatives against the criteria.

**TABLE 5-2.
SUMMARY OF ALTERNATIVES EVALUATION**

Evaluation Criteria	Alternative		
	Gravity Sewer	Pressurized Sewer (STEP or Grinder Pumps)	Combination of Gravity Sewer and Pressurized Sewer
Ease of Phasing	Provides the highest degree of flexibility. The system can receive wastewater from subsequent phases employing pressurized sewers. Well suited for higher density in-filling in the future (greater than 2.5 connections/acre)	Least flexible. If the initial phase is pressure sewer, subsequent phases would need to be pressurized. Any initial savings is reduced when area develops and in-fills beyond 2.5 connections per acre.	Provides flexibility. Core area can be developed to full density and pressurized sewers can be implemented in less dense residential areas.
Easement Requirements	No private easements required.	Private easements required to access on-site pumping equipment.	No easements required in core area with gravity collection. Easements required in outlying areas where pressurized sewers are installed.
Constructability	Sewers would be laid between 8 and 25 feet deep. Depths to groundwater are between 20-30 feet deep so some groundwater would be encountered. Soils are typically Vashon Lodgement Till and Vashon Recessional Outwash. Significant bedrock is not anticipated.	Sewers would be laid between 6 to 15 feet deep. Little groundwater is anticipated. Significant bedrock is not anticipated.	Considerations for gravity sewer would apply to core area, and considerations to pressurized sewers would apply to the outlying areas.
Operation and Maintenance Requirements	Fewest operation and maintenance requirements. Operations and maintenance would involve operation and maintenance of pumping stations, routine servicing of the pump station, flushing of lines, and replacement of equipment in pump stations.	Highest operation and maintenance costs. Costs would involve servicing of pumps at individual connections, electricity to operate the pumps, pump replacement, service calls for pump malfunctions, and pumping and disposal of septic tank solids (for STEP system).	High operation and maintenance costs. This system would have costs associated with the pump stations for a gravity collection system and for on-site pumps associated with the pressurized system. There would also be additional odor and corrosion facility maintenance associated with sewage from the pressurized system connecting to the gravity system.

**TABLE 5-2 (CONTINUED).
SUMMARY OF ALTERNATIVES EVALUATION**

Evaluation Criteria	Alternative		
	Gravity Sewer	Pressurized Sewer (STEP or Grinder Pumps)	Combination of Gravity Sewer and Pressurized Sewer
Odor and Corrosion Potential	There would be odor potential at the pump stations. Facilities would have to include some provisions for odor control at pump stations and at the wastewater treatment plant depending upon location.	Minimal odor potential along the collection system since the sewer mains are pressurized and there is little opportunity for fugitive odors. Additional odor control would be required at the treatment plant since in the influent is septic.	High odor and corrosion potential at location where pressurized sewer discharges into the gravity collection system. Septic tank effluent has high odor and corrosion potential when exposed to air within gravity collection system. Additional odor and corrosion facilities would be required along the collection system.
Comparative 20-year Life Cycle Costs	\$54,499,000	\$66,137,000	\$70,491,000

RECOMMENDED COLLECTION SYSTEM ALTERNATIVE

Stakeholder Workshop Process

The results of the alternative evaluation were presented to the Jefferson County of Board of County Commissioners at a workshop on March 16, 2006. The workshop was open to the public and some key stakeholders in the community were invited to attend. A presentation was given outlining the alternative technologies, their relative advantages and drawbacks, and their respective life cycle costs.

The design team received feedback and questions from the Board of County Commissioners, County staff, the stakeholders/public attending the workshop. This feedback was considered in the technical recommendation.

Recommendation

It was recommended that a gravity collection system be selected as the preferred collection system technology for the Port Hadlock sewer service area.

The gravity collection system was recommended based upon the following key reasons:

1. Lowest 20-year life cycle cost. The 20-year service area can be economically developed to planned densities at a lower cost than for pressure sewers. This is because the individual on-site costs and additional space requirements for a gravity collection system are less than for a STEP or grinder pump system.

2. Provides the highest degree of flexibility for system expansion. The core area can be implemented as a gravity system and the County then has the flexibility to implement pressure sewers in the outlying areas in the future. If a pressure sewer is implemented in the core area, gravity sewers cannot be installed in the outlying areas. This is because pressure sewers can discharge into a gravity collection system, but gravity sewers cannot discharge into a pressurized sewer system.
3. No maintenance-and-access easements are required.
4. Fewer operational and maintenance requirements.

POPULATION AND SYSTEM PHASING

The alternative collection systems were sized using population projections described in Chapter 4 – Population, Flow and Loads.

The sewer service area boundary was divided into sub-areas which represent distinct phases that the sewer system is anticipated to develop. Table 5-3 shows the anticipated number of equivalent residential units (ERU's) for each phase of the sewer system's development. Refer to Figure 4-2 in Chapter 4 – Population, Flow and Loads for a map showing the areas which represent each phase of the sewer system's development.

TABLE 5-3. EXPECTED NUMBER OF SEWER SYSTEM CONNECTIONS BY PHASE			
Phase	Anticipated Year of Sewer Service Availability	Year 2024 Equivalent Residential Units (Residential & Commercial)	Year 2030 Equivalent Residential Units (Residential & Commercial)
Core	2010	1,323	1,544
Alcohol	2010	145	170
Rhody	2013	627	729
Area 1	2016	282	331
Area 2	2019	216	255
Area 3	2024	975	1,147
Total		3,568	4,176

