SEPTIC VS. SEWER: A COST COMPARISON FOR COMMUNITIES IN SARASOTA COUNTY, FLORIDA

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ABSTRACT

In April 1997, the Sarasota Board of County Commissioners agreed that aging septic systems and small wastewater package plants were factors contributing to the pollution of Phillippi Creek, a major tributary to Sarasota Bay which has been designated as a National Estuary. In 1998, planning efforts were initiated whereby a total of sixteen (16) communities, within the urbanized, unincorporated area of Sarasota County were identified as requiring improvements to existing wastewater treatment practices to improve the water quality of Phillippi Creek and Sarasota Bay. Within the 50+ square mile watershed, a total of 14,000 parcels were utilizing septic systems, typically older systems situated on small parcels with sandy soils and a high groundwater table. These systems discharge wastewater volumes of approximately 3 million gallons per day (gpd) to the subsurface environment.

An assessment of available and applicable onsite wastewater treatment system (OWTS) upgrades and collection system technologies was completed to develop alternatives to improve the current wastewater treatment and disposal practices in these sixteen communities. Based on the assessment, cost comparisons of the various alternatives were made to determine whether existing OWTS should be upgraded or replaced by central sewer systems to provide needed water quality improvements in Phillippi Creek and Sarasota Bay. Cost analyses were performed based on the range of residential lot sizes in the area and included the following categories: Low Density (> 0.5 acre average lot size), Medium Density (0.25 - 0.5 acre average lot size), and High Density (< 0.25 acre average lot size). Three of the sixteen communities were selected as representative communities for low, medium, and high density communities, respectively.

The assessment of OWTS upgrade alternatives was completed based on their relative cost-effectiveness, treatment performance and land area requirements within the specific limitations of the study area. The capital and O&M costs for the selected alternatives were estimated based on information obtained from equipment manufacturers and local contractors, recent bid information, and general engineering experience. All treatment system sizes were based on a 3-bedroom single family residence with a flow of 300 gallons per day (gpd).

Wastewater collection alternatives were reviewed on the basis of numerous factors including technical feasibility, compatibility with the existing infrastructure in the project area, public acceptance, and cost of implementation. Three sewer collection alternatives were selected for detailed cost analysis: (1) conventional gravity sewers, (2) low pressure/grinder pump systems, and (3) vacuum sewers. Conceptual layouts for the same three communities (low, medium and high density) were developed for all collection alternatives and detailed cost analyses were performed.

Based on a comparison of estimated uniform annual cost per connection, the most cost effective alternative for a community depended significantly on density of development. The collection system costs for the different communities varied widely, not only because of the effects of development density, but also due to the difference in the total number of connections and existing street layouts used in the analyses. The vacuum collection system was the most cost-effective alternative for both the medium and high density areas, while the OWTS alternative (septic tank with mounded drainfield) was found to be the lowest cost alternative for low density areas. Results of this analysis were utilized for further definition of the collection system requirements under the preliminary design phase of the project. While selection of a wastewater alternative based on density was found to appropriate, this methodology did have limitations where development density is non-uniform and not contiguous. These situations required further detailed analysis during final design, considering existing infrastructure and the individual densities of sub-areas.

Considering the relatively dense urban development in the project area, Sarasota County selected central sewer collection systems as the design alternative for all 16 communities within the Phillippi Creek Study Area, with vacuum collection chosen for approximately 80% of the areas. The design, construction, and operation of central sewers proved to be the most cost-effective option for improving the current wastewater treatment and disposal practices in the Phillippi Creek study area.

KEYWORDS

Central sewer alternatives, collection systems onsite wastewater treatment systems, cost effectiveness, cost comparison, vacuum sewers, wastewater treatment alternatives, O&M costs, life-cycle costs

INTRODUCTION

Sarasota County is located on Florida's West Coast on the Gulf of Mexico. The area is one of the state's most affluent communities and recognized for its outstanding beaches and natural beauty. Phillippi Creek, which drains a 50+ square mile watershed primarily in the urban service area of unincorporated Sarasota County, has experienced a history of water quality problems associated with fecal coliform contamination. In 1997 the Sarasota County Health Department posted the creek "No Swimming" due to the continuous nature of the contamination problem.

Wastewater treatment for thousands of properties in the Phillippi Creek watershed has and continues to be provided by conventional septic systems, typically situated on small lots with sandy soils and a high groundwater table. In April 1997, the Sarasota Board of County Commissioners (BOCC) agreed that aging septic systems and small wastewater package plants were factors contributing to the pollution of Phillippi Creek, a major tributary to Sarasota Bay which has been designated as a National Estuary by the U.S. EPA. The BOCC directed County staff to initiate a program to replace or upgrade septic systems as needed and eliminate small package wastewater treatment plants in the Phillippi Creek area. This program was known as the Sarasota County Septic System Replacement Program (PCSSRP).

This paper presents the methodology by which OWTS and collection system alternatives were identified and selected in an effort to replace and/or upgrade septic systems in the Phillippi

Creek watershed. This manuscript discusses the basis for which capital and operation and maintenance costs were derived for each of the identified OWTS alternatives and the collection system alternatives. A cost comparison between the OWTS and collection system alternatives is presented based on parcel densities found in the Phillippi Creek project area. The results of this analysis were used for determining whether OWTS or central sewers provided the most cost effective means for sewering the urbanized, unincorporated area of Sarasota County.

METHODOLOGY

Many areas in Sarasota County have conditions unsuitable for conventional onsite systems, such as seasonal high water tables located less than 36 inches below ground surface, inadequate soil types, or enough available land for disposal. Many of the existing onsite systems were constructed prior to the adoption of standards requiring separation from groundwater and therefore did not have adequate unsaturated soil between the drainfield and groundwater. Due to these insufficient conditions, modifications to the conventional onsite wastewater treatment systems (OWTS) and/or conversion to a central sewer system were considered necessary options for improving wastewater treatment practices in the Phillippi Creek watershed.

The objectives of this study were to assess available and applicable OWTS and collection system technologies for their ability to improve wastewater treatment and disposal in the Phillippi Creek project area. This assessment was used in a wastewater service area analysis to evaluate which treatment technology would serve as the most cost-effective method to improve wastewater treatment. Previous studies as part of this project provided information on the number and location of onsite systems, soil types, high water table, and a variety of other information utilized in the evaluation provided in this paper (Hazen and Sawyer, 2000).

The assessment of available OWTS technologies for their use within the study area to upgrade existing OWTS was accomplished using the following methodology:

1. Developing a list of onsite treatment technologies that are suitable for use within the project study area to improve wastewater treatment prior to discharge to groundwater, and

2. Preparing a cost comparison analysis of each technology. The analysis includes present worth of both capital and annual operating costs using a discount rate adopted by County staff over a 20-year planning period.

The assessment of wastewater collection alternatives was accomplished using the following methodology:

1. Evaluating previous studies performed by the County with respect to alternative wastewater collection and transmission technologies;

2. Providing an independent evaluation of existing wastewater collection and treatment systems and an assessment of the degree to which these can be utilized for central wastewater collection and treatment; and

3. Analyzing potential alternative collection technologies for use in the study area. Three collection system technologies were selected for evaluation in each of

three example study areas. The alternative collection technologies were evaluated based on:

- maximum reasonable utilization of existing wastewater collection facilities;
- use of centralized, clustered, and decentralized approaches;
- inclusion of areas into the system where OWTS may be difficult to utilize;
- evaluation of benefits, feasibility, and cost over a 20-year planning period.

Selection of OWTS Alternatives

Onsite wastewater treatment systems (OWTS) are wastewater systems that treat and dispose of waste at or very near the site of wastewater generation. These systems are used for wastewater treatment at individual homes and commercial establishments which are not served by central sewers. Modern OWTS are sophisticated treatment systems which rely on land treatment provided by soils for ultimate wastewater renovation and disposal. If constructed properly and operated and maintained over their lifetime, OWTS are capable of providing wastewater treatment performance that can equal the treatment achieved at a centralized wastewater treatment facility (U.S. EPA 1977; U.S. EPA 2002; Anderson and Otis, 2000; Otis and Anderson, 1994.). The objectives of this part of the study were to select OWTS technologies appropriate for the study area and to evaluate these alternatives for upgrading existing OWTS in the Phillippi Creek project area.

A field assessment of existing OWTS was conducted for the purpose of identifying soil and site conditions in the Phillippi Creek project area and to assist in the selection of technologies for upgrading existing systems. Details of this assessment can be found in Hazen and Sawyer (2000). The key observations of this assessment included:

- The soil characteristics determined in the field were found to be in general agreement with the Soil Survey of Sarasota County (Soil Conservation Service, 1991). The Soil Survey listed approximately 90 percent of the study area covered with soils categorized “severely limited” for conventional OWTS use. Out of the 20 existing OWTS selected for detailed field assessment, most systems did not meet the minimum separation requirement of 2 vertical feet between the seasonal high water table (SHWT) and the bottom of the drainfield. The exceptions to this were newer, mounded OWTS or systems immediately adjacent to deep drainage features. Most OWTS in the study area were likely located in soils containing a SHWT of less than two feet below ground surface, and may not maintain the required minimum separation between the SHWT and the bottom of drainfield.

- Approximately 40 percent of the OWTS selected for field assessment had drainfields smaller than the minimum size, as specified by Sarasota County Ordinance, and would also be in need of improvement. Many lots in the study area are less than 1/4 acre in size and increasing the drainfield size on these lots may not be possible due to physical space limitations. Based on these observations, the OWTS which had conventional drainfields and were located in soils categorized by the Soil Conservation Service as “severely limited” with a SHWT near the ground surface were prioritized for replacement or improvement.

The minimum standards for installation and operation of OWTS are listed in Chapter 64E-6, Florida Administrative Code (FAC) and enforced through Sarasota County Ordinance No. 83-83 which stipulates additional restrictions. Most of the onsite treatment technologies which are commercially available today are capable of meeting or exceeding the minimum level of treatment required for OWTS in Sarasota County. There are, however, some additional issues such as ease of retrofit, land availability, depth of seasonal high water table, and constructability which limit the number of feasible alternatives that are applicable to the Phillippi Creek project area.

Hence, the emphasis for choosing the OWTS alternatives was given to systems which are cost effective and capable of functioning within the specific limitations of the study area. Various OWTS technologies were reviewed in detail and their treatment efficiencies compared in earlier phases of the study (Hazen and Sawyer, 2000). Subsequently, the feasibility and cost-effectiveness of these alternatives were evaluated using the known site conditions and by estimating their capital costs, operation and maintenance costs, and replacement costs. Based on this preliminary screening evaluation, four identified OWTS alternatives (shown in Table 1) were selected for final analysis for upgrading existing OWTS in the Phillippi Creek project area.

Table 1. Summary of Selected OWTS Alternatives

Alternative	Description	Disposal System
I	Conventional OWTS	Septic Tank to Mounded Drainfield (various fill levels based on SHWT)
II	Landscape Irrigation OWTS	Septic Tank to Subsurface Drip Irrigation (SDI) (various fill levels based on SHWT)
III	Secondary Biological Treatment Unit	Mounded Drainfield or Subsurface Drip Irrigation (SDI)
IV	Advanced Biological Treatment Unit	Subsurface Drip Irrigation (SDI)

OWTS Alternatives. Alternative I utilizes a conventional septic tank with a mounded drainfield at various elevations (top of mound located 18 inches, 30 inches, and 42 inches above ground surface) depending on SHWT elevations. Alternative II utilizes subsurface drip irrigation (SDI) of septic tank effluent, also installed at various fill elevations (at-grade and top of mound located 8 inches, 20 inches, and 32 inches above ground surface) depending on SHWT elevations. These alternatives utilize a standard two-compartment septic tank for primary treatment. Alternative III utilizes a secondary biological treatment unit in combination with subsurface drip irrigation or a mounded drainfield with 24 inches of fill located beneath the disposal area. This alternative was selected for its opportunity to decrease the required system size by achieving a higher treatment level. Alternative IV was selected as an option for further treatment and additional size reduction. This alternative utilizes an advanced secondary treatment unit and subsurface drip irrigation and was evaluated for use on small lots where conventional OWTS could not be utilized due to size constraints.

Selection of Collection System Alternatives

The decision to utilize onsite wastewater treatment systems (OWTS) or central sewers and regional treatment facilities should be based on numerous factors, including feasibility, study area characteristics, ease of use, and cost. It was also recognized that all else being equal, the cost per connection of central sewerage decreases as density increases. Previous experience has shown that at densities of greater than 2 lots per acre, central sewers generally become more cost-effective than OWTS (U.S. EPA, 1987). This section presents the evaluation and selection of wastewater collection technologies that can be compared with the selected OWTS alternatives. The evaluation methodology was based on review of previous studies conducted on wastewater collection alternatives in Sarasota County and included the selection of three wastewater collection alternatives whereby cost analyses were performed based on example project areas. Costs were evaluated for the installation and operation of each collection alternative in selected project areas. The costs include capital, operation, maintenance, replacement, and uniform annual cost for a 20-year planning period. A line item for wastewater treatment cost was included to allow equal comparison with the OWTS alternatives.

The selection of an appropriate collection system is very site specific. The number of homes being served and the average density of the homes are two parameters that significantly impact the cost of any collection system. In addition, site conditions such as high groundwater, soil type, rock, and topography are other factors that influence the selection and cost of a specific collection technology for an area.

The most widely used wastewater collection technology is the conventional gravity sewer system. This technology consists of six to eight inch (minimum) diameter sewers installed at a specific grade sufficient to create a minimum self-cleansing velocity of 2 feet per second. The sewers drain to a lift station or wastewater treatment plant. Alternative collection systems that were considered in place of a conventional gravity system, if conditions and/or cost-effectiveness dictate, include the following:

Small Diameter Gravity Sewers. Small diameter gravity sewers (SDGS), also referred to as effluent sewers, collect settled wastewater from the outlet of a septic tank installed at each connection (Otis, 1986). With the setteable solids removed, smaller sewers, generally two inch minimum diameter, are installed with variable gradients to conform to the natural topography, but with sufficient fall to drain septic tanks at each connection without requirements for self-cleansing. This system requires perpetual easements for septic tank servicing.

Simplified Sewers. Simplified sewers are an improved design variant of conventional gravity sewers. Four-inch minimum diameter sewers are installed to a specific grade determined by the necessary "tractive" force to carry wastewater solids. Rather than using a single self-cleansing velocity for all sewer sizes, this approach is based on the fact that smaller sewer diameters require a lower self-cleansing velocity than larger sewer diameters. The sewers are designed such that depths of flow in the pipe are maintained between 20 to 75 percent full to provide good cleansing. As a result, pipe sizes and gradients are lowered, which reduces costly excavation. This alternative also recognizes that improved pipe materials and joints, better construction methods, and advanced cleaning equipment reduce the need for expensive manholes. Less costly cleanouts are used in place of manholes except at major junctions. Buried boxes are used in place of manholes at changes in direction and grade.

Low Pressure/Grinder Pump Systems. Low pressure/grinder pump systems utilize a pump with a cutting head installed in a small sump at each connection. The pump grinds the solids in the wastewater and forces the slurry through two inch minimum diameter pressure sewers installed at uniform depth. The wastewater is pumped directly to the treatment plant or a municipal sewer connection. The sumps typically are located on private property but installed and maintained by the utility district. As with small diameter gravity sewers, perpetual easements must be secured by the utility for maintenance access.

Septic Tank Effluent Pump Systems (STEP). STEP systems pump settled wastewater received from septic tanks installed at each connection through one and one-half inch minimum diameter sewers installed at uniform depth. The settled wastewater is pumped from each connection to a treatment plant or municipal sewer connection. The tanks and pumps typically are located on private property but installed and maintained by the utility for maintenance access. This system requires perpetual easements for septic tank servicing.

Vacuum Sewer Systems. Vacuum systems collect raw wastewater and convey it through four inch minimum pressure sewers under a vacuum air system. A central vacuum station maintains vacuum in the sewers. Vacuum valves are installed at each connection that open by demand to allow raw wastewater to enter the collector followed by a volume of air. The wastewater forms a slug that is driven by the air due to differential pressure until the slug breaks up. The slug reforms in low points intentionally placed along the sewer. The reformed slug is driven further along the sewer by air when another upstream interface valve opens.

Further details on the design of low pressure (grinder and STEP), vacuum, and small diameter gravity sewers can be found in the U.S. EPA Design Manual *Alternative Wastewater Collection Systems* (U.S. EPA, 1991).

Technical feasibility, site conditions, construction costs, operation and maintenance costs, and public acceptance are some of the criteria which were used to select appropriate collection technologies. For Sarasota County, many of the alternatives discussed above are technically feasible. However, when site conditions are taken into consideration, the number of feasible alternatives becomes lower than the number of available technologies. In addition, preferences of the utility staff come into play when selecting the final alternatives for evaluation.

Most of the study areas in Sarasota County are characterized as having a high seasonal groundwater table, relatively flat topography, and contain mostly developed residential areas, consisting of various densities of single family homes. Within the County, there are existing sewered portions which are served by conventional gravity sewer collection systems. Conventional gravity sewers were therefore considered as an alternative, and as a baseline system that is well known. Since the majority of the OWTS areas are developed and built out, any new gravity collection systems would have to be installed within the right-of-way of existing roadways.

Because of the site conditions, the other identified gravity-based alternatives (simplified sewers and SDGS) were deleted from the alternative selection list. Flat topography and high groundwater typically generate high costs for these sewer alternatives. STEP and SDGS require operation and maintenance (O&M) on existing septic tanks, and were not preferred by Sarasota Utilities' staff. In the Phillippi Creek study area, many residences have septic tanks installed in the backyard. These situations create O&M problems for utility personnel, since access is required on private property behind many homes. Therefore, STEP and SDGS alternatives were also deleted from the selection list.

Vacuum sewer systems and low pressure/grinder pump stations were two additional collection system alternatives selected for comparison analysis with gravity sewers. Previous studies had evaluated gravity sewers, low pressure/grinder, and vacuum collection systems (PBS&J 1994). The Englewood Water District, located in south Sarasota County and northern Charlotte County, has begun installation and use of a large vacuum collection system in more recent years. Vacuum sewers require a minimum number of connections to be cost-effective due to the cost of the vacuum station. Since the area is uniformly flat and roadways already exist, the low pressure/grinder pump collection system was also considered to be a cost-effective alternative. Both pressure sewers and vacuum sewers could be installed along the right-of-way and require minimum cover. Low pressure systems are generally cost-effective in smaller service areas where vacuum system costs increase due to the fewer number of service connections.

Based on this discussion, three alternative collection systems were selected for the comparative analysis. These alternatives included gravity, low pressure/grinder pump, and vacuum sewer systems. These three systems were compared on the basis of cost per connection to the OWTS alternatives to determine the preferred method for wastewater improvements for the Phillippi Creek study areas.

Sixteen study areas, called wastewater project improvement areas (WPIAs), encompassing an estimated 14,000 parcels in northern Sarasota County (Figure 1), were evaluated for wastewater system improvements. These WPIAs were reviewed for the purpose of selecting individual project areas that would be utilized for the purpose of performing preliminary design and cost screening analysis for the selected alternative collection systems. Areas for this screening analysis were selected based on housing density: one area in a low, medium and high density WPIA were selected.

Density categories were defined as follows: 1) Low Density: contained, on the average, lots greater than 0.50 acre in size; 2) Medium Density: contained, on the average, lots between 0.25 and 0.50 acre in size; and 3) High Density: contained, on the average, lots less than 0.25 acre in size. Because some WPIAs contain parcels of significant size difference, sub-areas containing parcels of comparable size were selected from each of the three WPIAs. One representative project area from each density category was selected for the purpose of performing the cost screening analysis. The characteristics of these project areas are summarized in Table 2. A comparison of advantages and disadvantages of the three collection alternatives is presented in Table 2.

Table 2
Comparison of Advantages and Disadvantages of Collection Alternatives

Collection Alternative	Advantages	Disadvantages
Gravity Sewer	• Well established technology • No power is required from an individual residence • Excess capacity is typically built in allowing for easy expansion • The life of a conventional gravity system is typically 40 years before repairs, such as slip lining, or replacement is required	• High construction costs • Significant disruption of community during construction • Increased infiltration and inflow • Potential collection system odor problems in which may result in the need for chemical use • Placement of regional lift stations within communities may require changes in zoning and the acquisition of valuable property
Low Pressure/ Grinder Pump	• Requires less excavation to install the pressure sewers which are laid along the right-of-way, in comparison to gravity sewer systems • Performance is not affected by low flows • Infiltration and inflow are typically minimal • Installing pressure sewers along the right-of-way reduces the roadway restoration costs significantly as compared with the installation of conventional gravity sewers	• Possible use of individual homeowner's private property • Somewhat greater operation and maintenance costs than conventional gravity systems • Limited reliability or backup in the event of a long-term power outage • With older homes, there may be a need to upgrade electrical service at the residence to allow for addition of the pump unit. • To reduce costs, multiple connections may be used where one pump unit serves two or more homes; however, problems may arise due to one of the residences served would have to pay for the power used and seek reimbursement from the other residences
Vacuum	• Pump stations at the wastewater source are eliminated • A reduction in the number of pumps in the collection system that must be maintained • Vacuum valves at the service connection do not require power • One vacuum pit may be used to serve two or more homes • The collection system piping has similar advantages over conventional gravity systems as do low pressure/grinder systems, namely smaller diameters and lower cover requirements • Vacuum units are commercially available as simple packaged vault units, and can be installed below grade in the right of way or within an easement.	• O&M costs which may be slightly higher than gravity • Potential difficulty and cost associated with the purchase of available land for the vacuum station in a developed area • Collection system piping may be more expensive to install than low pressure systems because it is necessary to lay it to grade for gravity drainage to the "lifts" and the labor and fittings to install the "lifts" • The need to install numerous lift sections and the slightly larger pipe diameters required affect installation costs • System typically requires service connections of at least 100 vacuum vault units utilizing dual resident connections to a single pump vault to prove economically attractive

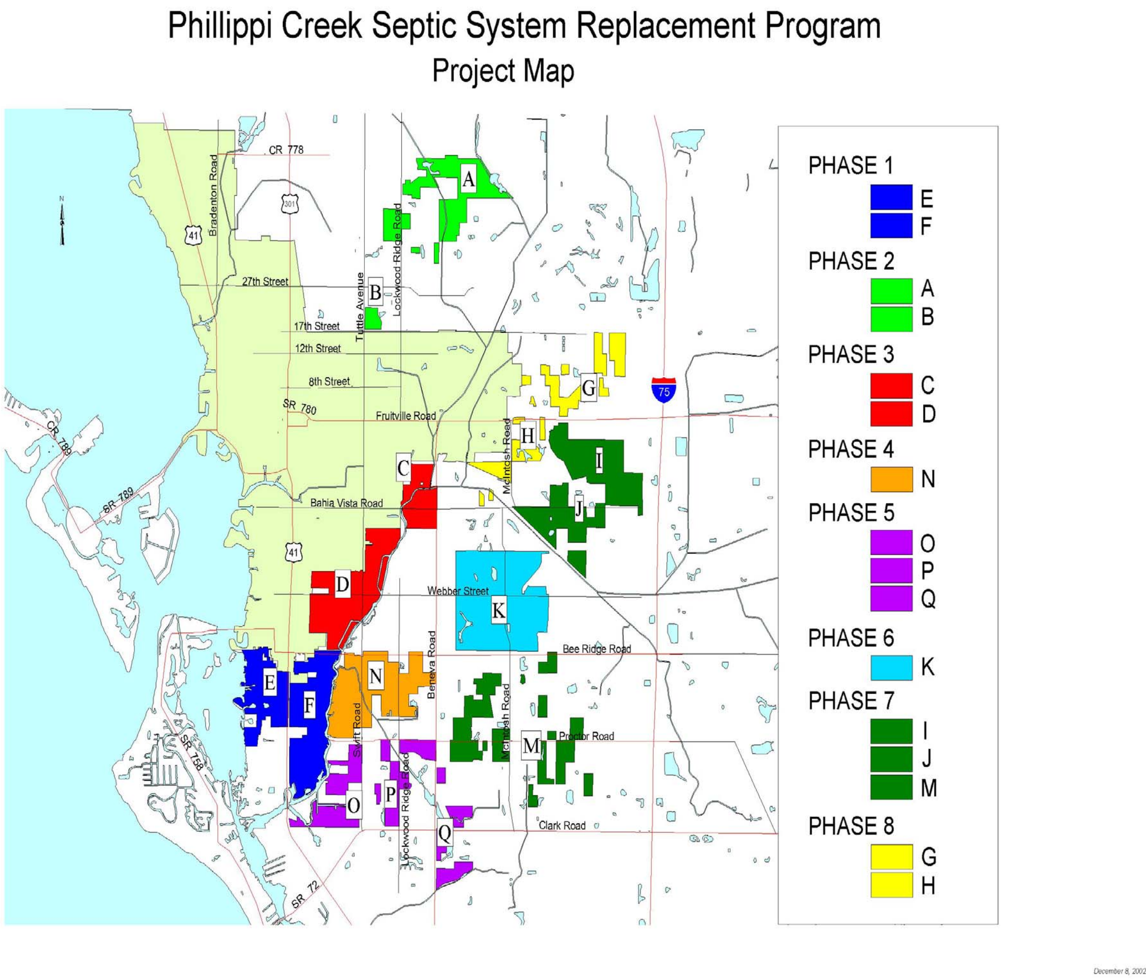

Figure 1. Phillippi Creek Septic System Replacement Program Project Map

Table 2. Mean and Median Parcel Areas for the Selected Sub-Areas

WPIA Sub-Area	Approx. Parcel Count	Mean Parcel Area (acres)
F-1	810	0.33
K-1	1,368	0.21
J-1	226	0.93

Maps, generated based on the project GIS, were used to sketch preliminary layouts of the collection systems, including siting of lift stations and vacuum stations. These maps were subsequently used to develop conceptual sewer system layouts and perform preliminary cost analyses for each of the three collection alternatives. Preliminary design and cost information for low pressure and vacuum sewer systems were obtained from various equipment manufacturer's representatives. The preliminary gravity sewer layout and conceptual design and cost information was developed based on standard design procedures. The capital cost, installation, and construction cost estimates for the preliminary layouts were obtained from the equipment manufacturers, previous cost analyses studies, local contractors, and recent bids on Sarasota County Utility projects. All of the cost estimates are provided in 1999 dollars.

RESULTS

This section presents cost evaluations for the previously identified OWTS alternatives and the identified collection system alternatives. Costs for wastewater collection and onsite wastewater treatment systems could then be compared on a cost per connection basis. These costs, along with other planning criteria, such as existing infrastructure, service area boundary, compatibility, operational constraints, permitability, and constructability were evaluated for areas currently utilizing OWTS. A comparison of these criteria between OWTS and collection system alternatives was then used to select wastewater treatment improvement strategies for the Phillippi Creek service area.

Cost Evaluation of OWTS Alternatives

The selected OWTS alternatives were evaluated on the basis of the field assessment evaluations and cost, land area requirements, system complexity, system reliability, and treatment performance. Costs derived in this section were used as planning and evaluation tools, and were determined at present worth over a 20-year planning period. Costs include both capital and operating and maintenance (O&M) for four alternatives. For two alternatives, costs were determined for several fill elevations so that costs could be applied to areas with different water table elevations.

Capital Cost: The capital costs for the selected OWTS alternatives were estimated based on quotes obtained from equipment manufacturers. Estimates of installation and construction costs were based on local area contractors' estimates and engineering experience with similar construction projects. All cost estimates are provided in 1999 dollars. The present worth was calculated using a discount rate of 7 percent over a 20-year planning period. The actual interest rate varies depending on the timing, sources, and amounts of borrowed funds. A discount rate of 7 percent was used for this project planning effort since it represented the average Moody Municipal Long-Term Bond yield over the past 15 years (1983 to 1997).

A list of assumptions and criteria used in developing the costs for the selected OWTS alternative is provided below:

- For comparison, all treatment system sizes were based on a 3-bedroom single family residence with a flow of 300 gallons of wastewater per day (gpd) (Chapter 64E-6, Florida Administrative Code (FAC)).
- The required size of a conventional drainfield, was assumed to be 500 square feet (Sarasota County Ordinance No. 83-83). Based on Florida Department of Health (FDOH) performance standards, 25 percent and 30 percent reductions in the size of the SWIS were taken if secondary treatment standards or advanced secondary treatment standards, respectively, were met.
- Fill volume for mounded drainfields was determined based on the required 12-inch deep gravel infiltration bed with 6-inches of cover plus a 5-foot shoulder from the bed to the 3:1 foot side slopes.

- Fill for subsurface drip irrigation (SDI) beds was determined based on 6-inch deep driplines plus an 18-inch shoulder from the bed to the 3:1 side slopes.

- Permitting and operating fees were obtained from Chapter 64E-6,Florida Administrative Code, effective March 1998 and Sarasota County Ordinance No. 83-83, effective October 1983.

- The septic tank size was assumed to equal 1,050 gallons based on Sarasota County Ordinance No. 83-83 for a three-bedroom home.

- Installation costs were derived from estimates obtained from various local contractors. A lump sum labor and equipment cost, including two laborers and backhoe with operator, was estimated at $900 per day. A 20 percent increase in cost was applied to the drip irrigation systems to account for any additional labor required for equipment assembly. A 40 percent increase in cost was applied to those systems with biological treatment units to account for the additional labor required to install and start-up the treatment units.

- A lump sum cost for miscellaneous piping, fittings, and appurtenances was obtained from various local suppliers.

- Unit costs for tanks, drainfield media, and fill material were estimated from suppliers' and manufacturers' quotes.

- A 20 percent contingency factor was applied to the total capital cost of each system.

- Engineering, legal, and administrative fees were not included in the OWTS alternative analysis.

In general, the capital costs demonstrate that the least costly alternative is the mounded OWTS at fill levels less than 24 inch (see Alternative I in Table 3). However, this alternative requires more available land as the mound height increases. Many residences in the project area will not have enough land available to install this type of system. Alternative II, with drip irrigation, costs approximately $6,700 if installed in the natural grade. This alternative would be feasible if the seasonal high water table is found 36 inches or more below ground surface. Alternative IV, with the advanced secondary biological treatment unit, allows the homeowner to reduce the drainfield by 30 percent, but is the most expensive alternative. However, Alternative IV may be the only feasible onsite treatment option for homeowners when available land is the limiting factor.

Operation and Maintenance Costs. Annual costs associated with the operation and maintenance (O&M) of the OWTS alternatives were estimated based on review of the manufacturer’s literature and prior experience in the operation of onsite systems. Many homeowners do not currently maintain their onsite systems on an annual basis. Therefore, the O&M costs shown in Table 3 reflect the estimated costs associated with maintaining a properly operating system. Operation costs include energy and permit fees. Maintenance costs include an annual performance check and maintenance visit, repair, replacement, and residuals disposal. However, annual maintenance was not considered a necessity for the conventional OWTS alternatives. All cost estimates were prepared in 1999 dollars. The present worth of each O&M cost was calculated using a discount rate of 7 percent over a 20-year planning period.

Provided below is a list of assumptions and criteria used in developing the annual O&M costs:

- O&M visits are performed every five years or on an annual basis depending on the system. The visit includes routine system checks and performance monitoring. Additional labor time was added during annual O&M visits to conduct preventive maintenance activities. O&M requirements vary according to the system but a minimum level of effort is required to maintain system performance. The O&M visits are based on the minimum requirements to maintain system performance and enforce the manufacturer's standard warranty contract. Labor costs were estimated at $50 per visit or $30 per hour, depending on system complexity. An additional estimated cost of $50 for miscellaneous repair parts was included.

- Energy costs were assumed to be $0.09 per kilowatt-hour (kW-hr), based on an average for the Sarasota County area.

- Annualized costs were estimated for replacement of mechanical equipment including pumps, blowers, and air compressors over a 20-year period.

- A residual disposal fee of $175 was estimated for septage removal from the settling tank. The fee was based on quotes obtained from local contractors. Septic tanks were estimated to require primary sludge removal every 5 years. Biological treatment units were estimated to require primary and/or activated sludge removal every 3 years.

The annual operation and maintenance costs for the onsite alternatives, provided in Table 3, list only one O&M cost for Alternative I and Alternative II since the O&M cost is not dependent on the mound level. Detailed O&M cost breakdowns for each alternative are provided in Hazen and Sawyer (2000).

In general, average O&M costs for systems with disposal areas requiring fill are higher, attributed to the pump system operation. The annual cost for SDI disposal is higher than that for a mounded drainfield, due to the complexity of the system. The addition of an ATU will cause operational costs to more than double with some of the additional cost in the required annual permit fee. This permit fee is also required with the advanced secondary system. Although these two alternatives are more expensive to maintain, they require less available land for effluent disposal.

Uniform Annual Costs. Summaries of the uniform annual costs are provided in Table 3. Annualized costs were calculated based on a 20-year period at a 7 percent interest rate. Capital and O&M costs were combined to obtain a uniform annual cost for comparison of alternatives.

Uniform annual costs for the OWTS alternatives ranged from $612 (Alternative I) to $2,050 (Alternative IV). As would be anticipated, the engineered biological treatment system alternatives, which provide a higher level of treatment, will cost significantly more than the other alternatives on an annual basis.

Table 3. Summary of Estimated Annual Costs (1999$)

System Alternatives		Capital Cost	Annualized Capital Cost[1]	Annual O&M Cost[2]	Uniform Annual Cost
I	Septic Tank with Mound				
	At-grade	$ 5,053	$ 477	$ 135	$ 612
	12-inch Fill	$ 5,934	$ 560	$ 135	$ 695
	24-inch Fill	$ 7,072	$ 668	$ 135	$ 803
II	Septic Tank with SDI				
	In existing grade	$ 6,690	$ 632	$ 421	$ 1,053
	At-grade	$ 7,340	$ 693	$ 421	$ 1,114
	12-inch Fill	$ 7,859	$ 742	$ 421	$ 1,163
	24-inch Fill	$ 8,576	$ 810	$ 421	$ 1,231
III	Secondary Biological Treatment (with SWIS, 24-inch Fill)	$ 8,374	$ 790	$ 927	$ 1,717
	Secondary Treatment (with SDI, 24-inch Fill)	$ 8,578	$ 810	$ 1,029	$ 1,839
IV	Advanced Secondary Biological Treatment (with SDI, 24-inch Fill)	$10,280	$ 970	$ 1,079	$ 2,050

Notes:
1. Annualized costs were based on an interest rate of 7.0% over 20 years
2. Replacement costs were annualized based on an interest rate of 7.0%.

Cost Evaluation of Collection System Alternatives

This section provides a summary of the collection system costs on a cost per connection basis for the low, medium and high density study sub-areas. The low density study area contained 226 connections, the medium density study area contained 810 connections, and the high density study area contained 1,368 connections. Detailed breakdowns of this cost analysis are provided in Hazen and Sawyer (2000).

Capital Costs. Based on the preliminary design of the collection alternatives, capital costs were estimated for each of the selected sub-areas. The following paragraphs present the results of the cost comparisons for each collection alternative based on the low, medium and high density sub-areas.

Table 4 presents a summary of the construction costs per connection for the low-density area. In the low-density area, the largest portion of cost for vacuum and gravity sewer systems lies with the pipe, fittings, and installation. Restoration costs per connection for the low pressure and vacuum systems were similar, due to both being installed in the road right-of-way as compared to the restoration cost for the gravity sewer system, which is typically installed in the roadway. The station cost per connection for the low-pressure system was the highest in the low-density area when compared to the other two alternatives. The station costs for the low-pressure system should be higher than the other collection alternatives as the main portion of a low-pressure system is the individual pump station required at each connection.

Table 4. Summary of Construction Costs (per connection) - Low Density

	Low Pressure	Vacuum	Gravity
Materials[1]	$1,669	$4,746	$6,826
Restoration	$1,117	$1,147	$3,607
Stations[2]	$2,993	$1,510	$580
Total	$5,779	$7,403	$11,013

Notes:
1. Cost includes piping, valves and cleanouts.
2. Cost includes all costs associated with pump stations required in low pressure and gravity systems or vacuum stations required in vacuum systems.

Table 5 presents a summary of the construction costs per connection for the medium density area. Capital costs for the low pressure and gravity sewer system alternatives were higher than the vacuum system. Installation and materials were, however, still lower for the low-pressure system. This cost, which does not include the pump stations, was estimated at $800 per connection for the low-pressure system as compared to $2,600 and $3,100 for the vacuum and gravity systems, respectively. The restoration cost for the gravity sewer system was higher than the other alternatives, again due to the extensive amount of roadwork required for installation. Station costs were, again, highest for the low-pressure system. The vacuum station cost is approximately $160 per connection more than the gravity sewer system cost. In the medium density area, the vacuum station became a comparable option to the traditional lift stations required in the gravity sewer system, especially when there is a limitation to how deep gravity sewers can be installed before a lift station is required.

Table 5. Summary of Construction Costs (per connection) - Medium Density

	Low Pressure	Vacuum	Gravity
Materials[1]	$825	$2,634	$3,100
Restoration	$623	$655	$1,636
Stations[2]	$2,993	$480	$324
Total	$4,441	$3,770	$5,060

Notes:
1. Cost includes piping, valves and cleanouts.
2. Cost includes all costs associated with pump stations required in low pressure and gravity systems or vacuum stations required in vacuum systems.

Table 6 presents a summary of the construction costs per connection for the high density area. Vacuum and gravity systems have similar costs for materials and stations, but the restoration cost for the gravity system is higher than the vacuum system cost. Restoration costs for the low-pressure system and vacuum system were similar, estimated near $600 per connection. The costs should be similar as the same amount of roadway restoration was estimated based on having to install pipe across the roadway for at least half the connections. The remaining pipe installation is in the right-of-way of the road.

Table 6. Summary of Construction Costs (per connection) - High Density

	Low Pressure	Vacuum	Gravity
Materials[1]	$758	$2,406	$2,680
Restoration	$576	$581	$1,418
Stations[2]	$3,255	$301	$288
Total	$4,589	$3,288	$4,386

Notes:
1. Cost includes piping, valves and cleanouts.
2. Cost includes all costs associated with pump stations required in low pressure and gravity systems or vacuum stations required in vacuum systems.

Operation and Maintenance Costs: Operation and maintenance (O&M) costs developed for each system include operation, maintenance, repair, and replacement. Estimates for operation and maintenance of the collection systems over the 20-year planning period were made to provide annualized cost comparisons for all systems on a 20-year basis. Table 7 summarizes the O&M cost per connection for each collection alternative. Detailed O&M cost breakdowns are provided in Hazen and Sawyer (2000).

Table 7. Summary of Annual Operation and Maintenance Costs (per connection)

	Estimated O&M Cost (1999 $)[1]		
	Pressure	Vacuum	Gravity
Low Density	$188	$ 138	$89
Medium Density	$185	$ 74	$51
High Density	$185	$ 62	$46

Note:
1. Replacement costs were annualized based on an interest rate of 7% over 20 years

Table 8 presents a summary of the O&M costs per connection for the low density area. O&M costs in the low-density area were lowest for the gravity sewer collection system. Energy costs are comparable among the three systems. The separation in the O&M costs occur in both the maintenance and replacement costs where both the low pressure and vacuum systems are higher than gravity. Replacement costs for the low-pressure system were estimated at $96 per year, while the vacuum cost was $27 per year. The replacement cost for the gravity sewer system was estimated at $6 per year, primarily for materials related to the lift stations.

Table 8. Summary of O&M Costs (per connection) - Low Density

	Low Pressure	Vacuum	Gravity
Energy	$ 16	$ 18	$ 18
Maintenance	$ 76	$ 93	$ 66
Replacement	$ 96	$ 27	$ 6
Total	$ 188	$ 138	$ 89

Table 9 presents a summary of the O&M costs per connection for the medium density area. O&M costs in the medium density area were lowest for the gravity sewer collection system. Again, energy costs were comparable among the three systems. The annual maintenance cost for the low pressure system is higher than the vacuum and gravity systems, primarily due to the maintenance required on the pump stations. Due to the large quantity of pumps required in the low pressure system, the annual replacement cost for this collection alternative is the highest of all three alternatives.

Table 9. Summary of O&M Costs (per connection) - Medium Density

	Low Pressure	Vacuum	Gravity
Energy	$ 16	$ 18	$ 18
Maintenance	$ 73	$ 43	$ 30
Replacement	$ 96	$ 13	$ 3
Total	$ 185	$ 74	$ 51

Table 10 presents a summary of the O&M costs per connection for the high density area. Similar to the other areas, the gravity sewer system is the lowest alternative to operate and maintain. Again, the low-pressure system cost more each year than the other alternatives, due to maintenance and replacement costs for the individual pump stations.

Table 10. Summary of O&M Costs (per connection) - High Density

	Low Pressure	Vacuum	Gravity
Energy	$16	$18	$18
Maintenance	$72	$34	$26
Replacement	$96	$9	$3
Total	$185	$62	$46

Uniform Annual Costs: Uniform annual costs were calculated based on the 20-year planning period using an interest rate of 7% to annualize capital and replacement costs. A wastewater treatment capacity fee of $1,642, currently included as a charge in Sarasota County Utilities rates and charges, was annualized and included in each uniform annual cost. Table 11 provides the estimated uniform annual collection system cost per connection for each area where all three collection alternatives were evaluated.

Table 11. Summary of Uniform Annual Costs (per connection)

	Collection System Alternatives	Capital Cost	Annualized Capital Cost[1]	Annual O&M Cost[2]	Estimated Uniform Annual Cost
Low Density					
	Low Pressure	$ 10,389	$ 1,136	$ 188	$ 1,324
	Vacuum	$ 12,825	$ 1,366	$ 138	$ 1,504
	Gravity	$ 18,241	$ 1,877	$ 89	$ 1,966
Medium Density					
	Low Pressure	$ 8,102	$ 920	$ 185	$ 1,105
	Vacuum	$ 7,096	$ 825	$ 74	$ 898
	Gravity	$ 9,032	$ 1,008	$ 51	$ 1,059
High Density					
	Low Pressure	$ 8,045	$ 914	$ 185	$ 1,099
	Vacuum	$ 6,093	$ 730	$ 62	$ 792
	Gravity	$ 7,740	$ 886	$ 46	$ 932

Notes:
1. Annualized costs were based on an interest rate of 7.0% over 20 years and include a capacity fee of $1,642 per connection.
2. Replacement costs were annualized based on an interest rate of 7.0%.

The collection system costs for each density varied widely not only because of the effects of the density of the area, but also due to the difference in the total number of connections and existing street layouts used in the analyses. Overall, the vacuum alternative appeared to have the lowest cost in the medium and the high-density areas; although the cost for a gravity system was next lowest in both of these areas. The low-pressure sewer system appears to be the least costly option for low-density areas and was equal to the gravity system cost in the medium density area. However, the decision on which technology is best suited for an area is also based on other considerations such as service area boundary, compatibility with existing systems, operation constraints, permitability and constructability.

DISCUSSION

The goal of the Sarasota County Septic System Replacement project was to improve wastewater treatment practices in the Phillippi Creek area. The results of this study provided an assessment of several available alternatives for wastewater treatment improvements within the project area. The results include cost analyses on the various selected alternatives to evaluate their cost-effectiveness. These costs are used to evaluate alternatives for the various wastewater improvement project areas.

Comparison of OWTS and Collection Technologies

As part of this study, alternatives were selected and evaluated with respect to feasibility and cost-effectiveness in the Phillippi Creek project area. Construction, operation and maintenance (O&M) and uniform annual costs were calculated based on information provided by equipment manufacturers, local contractors, previous cost analyses studies, and the Sarasota County

Utilities Department. OWTS alternatives suitable for use in each density category were selected based on the average lot size of each WPIA. Costs are shown for alternatives installed in various soil conditions. Tables 12, 13, 14, and 15 present a cost summary of the alternatives selected previously.

Table 12 presents the construction costs associated with the most appropriate onsite wastewater treatment system and the three selected collection alternatives. Information in the table is based on screening analyses performed on three areas located in the Phillippi Creek study area of differing density. The following summarizes the information provided in Table 12:

- The least cost alternative in the low density area appears to be upgraded OWTS. Even with the seasonal high water table at the ground surface, the OWTS alternative construction cost is lower than the three collection system alternative costs.

- The vacuum collection alternative is the least cost alternative in the medium and the high density areas. This is primarily due to the size of the sub-area selected for the analysis. However, for medium and high density areas containing fewer than approximately 700 connections, the vacuum collection alternative may not always be the lowest in cost.

- OWTS alternative costs for systems evaluated for the medium and the high density areas were higher than the collection alternatives.

Table 12
Estimated Construction Cost of Sewer and OWTS Alternatives
(per connection)[4, 9]

Alternative	Low Density[1] >0.5 acre lots	Medium Density[2] 0.25 - 0.5 acre lots	High Density[3] <0.25 acre lots
Low Pressure GP[9,10]	$8,700	$6,800	$6,700
Vacuum[9,10]	$10,600	$6,000	$5,100
Gravity[9,10]	$14,900	$7,500	$6,400
OWTS[5]			
0’ WT	$7,070[6]	$8,580[7]	$10,280[8]
1’ WT	$5,930[6]	$7,860[7]	$9,780[8]
2’ WT	$5,050[6]	$7,340[7]	$9,410[8]
>3’ WT	$4,890[6]	$6,690[7]	$8,960[8]

Notes:
1. Cost based on screening analysis of an area with 226 connections and average lot size of 0.93 acres
2. Cost based on screening analysis of an area with 810 connections and average lot size of 0.33 acres
3. Cost based on screening analysis of an area with 1,368 connections and average lot size of 0.21 acres
4. Construction costs include 20% contingency and On-Lot costs
5. Water table (WT) depth shown is the estimated SHWT depth below ground surface
6. Cost is for OWTS Alternative I: Septic tank with mounded drainfield
7. Cost is for OWTS Alternative II: Septic tank with SDI disposal
8. Cost is for OWTS Alternative IV: Advanced Secondary Treatment System
9. Costs do not include engineering, legal, and administrative costs

Table 13 presents the operation and maintenance (O&M) costs associated with the most appropriate onsite wastewater treatment system and the three collection alternatives. The following summarizes the information provided in Table 13:

- Overall, OWTS alternatives cost more to maintain and operate than the collection alternative at the medium and high densities.
- The low pressure alternative cost more than the other two collection alternatives due to the number of pumps and stations required in this system.
- The gravity sewer collection system cost the least to operate and maintain. The lower O&M cost is primarily a result having fewer mechanical systems to maintain.

Table 13
Estimated Annual O&M Cost (per EDU)[1, 2]

Alternative	Low Density[3] >0.5 Acre Lots	Medium Density[4] 0.25-0.5 acre lots	High Density[5] <0.25 acre lots
Low Pressure GP	$190	$190	$190
Vacuum	$140	$70	$60
Gravity	$90	$50	$50
OWTS[6]			
0' WT	$140[7]	$420[8]	$1,080[9]
1' WT	$140[7]	$420[8]	$1,080[9]
2' WT	$140[7]	$420[8]	$1,080[9]
>3' WT	$140[7]	$420[8]	$1,080[9]

Notes:
1. Costs include O&M and replacement
2. Replacement costs are annualized at an interest rate of 7% over 20 years
3. Costs based on screening analysis of an area with 226 connections and average lot size of 0.93 acres
4. Costs based on screening analysis of an area with 810 connections and average lot size of 0.33 acres
5. Costs based on screening analysis of an area with 1,368 connections and average lot size of 0.21 acres
6. Water table (WT) depth shown is estimated SHWT depth below ground surface
7. Cost is for OWTS Alternative I: Septic tank with mounded drainfield
8. Cost is for OWTS Alternative II: Septic tank with SDI disposal
9. Cost is for OWTS Alternative IV: Advanced Secondary Treatment

Table 14 presents the uniform annual costs associated with the selected onsite wastewater treatment systems and the three collection system alternatives. Uniform annual costs include the sum of the annualized capital cost (7% over 20 years) and the annual O&M costs. The collection alternative costs include an estimated transmission and treatment cost so they could be compared to the OWTS alternatives on a like cost basis. These costs were based on information obtained from the Sarasota County Utilities Department. Figure 2 shows a comparison of this data graphically.

Table 14. Estimated Uniform Annual Cost (per connection)[9, 10, 13]

Alternative	Treatment and Transmission Cost ($/Connection)	Low Density[2] >0.5 acre lots	Medium Density[3] 0.25-0.5 acre lots	High Density[4] <0.25 acre lots
Low Pressure GP[11]	$105	$1,270[1]	$1,080[1]	$1,070[1]
Vacuum[11]	$105	$1,400[1]	$900[1]	$800[1]
Gravity[11]	$105	$1,760[1]	$1,020[1]	$910[1]
OWTS[5]				
0’ WT	N/A	$800[6]	$1,230[7]	$2,050[8]
1’ WT	N/A	$700[6]	$1,160[7]	$2,000[8]
2’ WT	N/A	$610[6]	$1,110[7]	$1,970[8]
>3’ WT	N/A	$600[6]	$1,050[7]	$1,930[8]

Notes:

1. Estimated treatment and transmission cost applied to all collection system alternatives
2. Costs based on screening analysis of an area with 226 connections and average lot size of 0.93 acres
3. Costs based on screening analysis of an area with 810 connections and average lot size of 0.33 acres
4. Costs based on screening analysis of an area with 1,368 connections and average lot size of 0.21 acres
5. Water table (WT) depth shown is below ground surface
6. Cost is for OWTS Alternative I: Septic tank with mounded drainfield
7. Cost is for OWTS Alternative II: Septic tank with SDI disposal
8. Cost is for OWTS Alternative IV: Advanced Secondary Treatment
9. Uniform Annual Cost includes materials, construction, operation and maintenance, and replacement costs
10. Costs do not include Engineering, Legal and Administrative Costs
11. Includes Capacity Fee of $1,642 per EDU
12. Includes Treatment Cost of $105 per EDU per year (Sarasota County Utilities)
13. Annualized construction cost, impact fees, and replacement costs are based on an interest rate of 7% over 20 years

Table 14 presents the uniform annual costs associated with the selected onsite wastewater treatment systems and the three collection system alternatives. Uniform annual costs include the sum of the annualized capital cost (7% over 20 years) and the annual O&M costs. The collection alternative costs include an estimated transmission and treatment cost thereby allowing a comparison to the OWTS alternatives on a like cost basis. These costs were based on information obtained from the Sarasota County Utilities Department. Figure 2 shows the comparison of this data graphically.

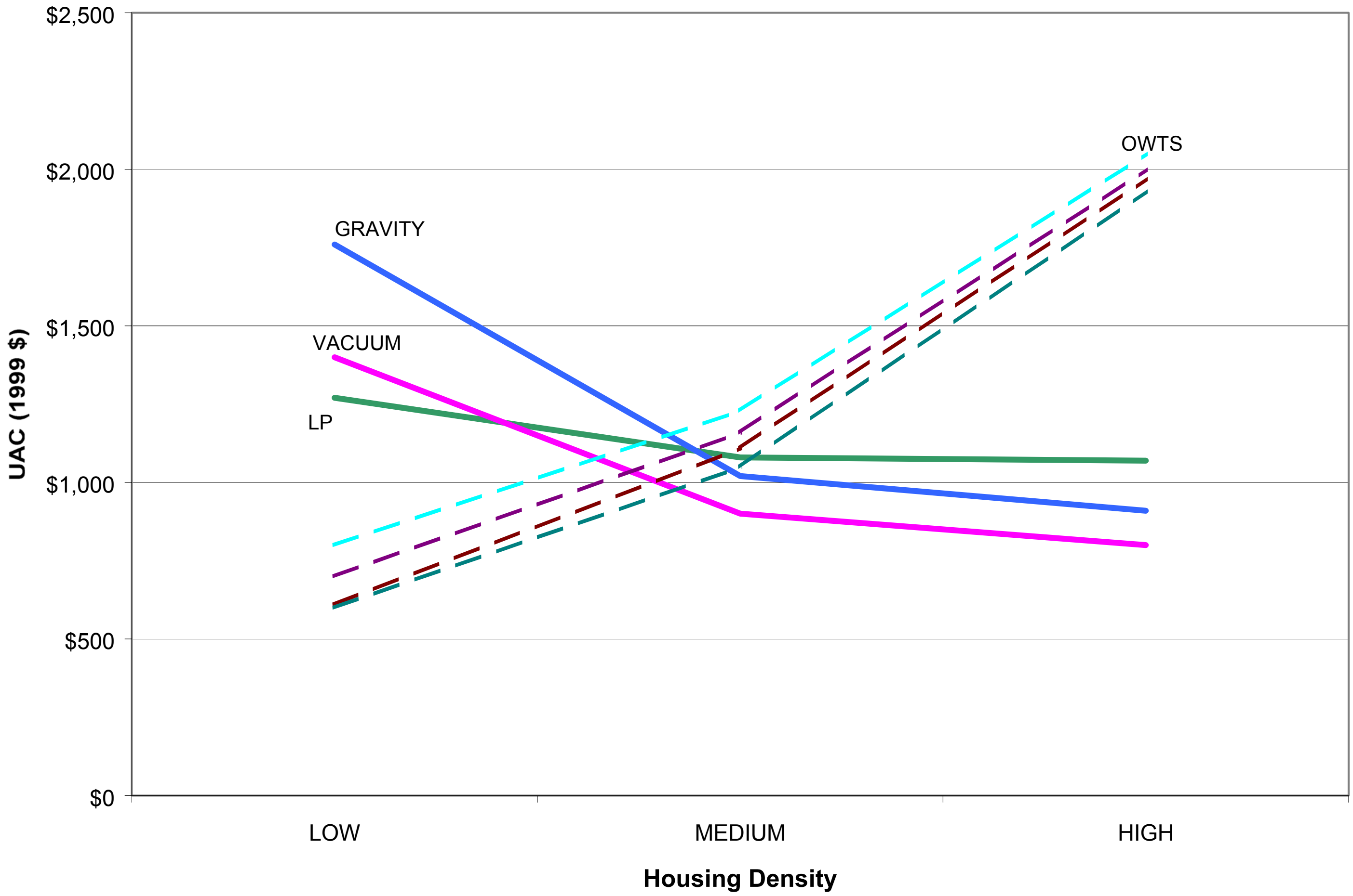

Figure 2. Cost vs. Density Comparison of OWTS and Collection Alternatives for Communities in the Phillippi Creek Project Area

The following summarizes the information provided in Table 14 and Figure 2:

- The OWTS Alternative I: Septic Tank with mounded drainfield was the least cost alternative in the low density area, based on the screening area evaluated in this memorandum. Overall, the OWTS alternatives had lower uniform annual costs than the collection system alternatives of low density.

- The vacuum sewer system is the least cost alternative in the medium and the high density areas, based on the screening areas evaluated in this memorandum.

CONCLUSIONS

Each wastewater project improvement area identified within the Phillippi Creek area is unique with regards to the number of connections and the corresponding equivalent dwelling units. (EDUs). Because of this variation, the cost for providing sewer service to an individual connection (whether via an OWTS or by central sewers) was shown to vary based on the cost comparisons conducted for this project area.

Uniform annual costs for a number of OWTS alternatives were evaluated based on various soil conditions and varying degrees of treatment efficiency. Cost evaluations of OWTS indicate that engineered biological treatment systems (Alternative IV) cost significantly more than other alternatives when compared on a uniform annual cost basis.

Cost comparisons of central sewer collection alternatives were performed on a cost per connection basis for low, medium and high density sub-areas within the Phillippi Creek project area. Comparisons were evaluated for three central sewer alternatives that included gravity sewers, low pressure sewers (w/ grinder pumps), and vacuum sewers. The vacuum sewer system alternative was the lowest in uniform annual cost for the medium and high density areas, while the low pressure sewer system was the least costly option for low density areas (mean lot size greater than 0.5 acre). Less than 300 of the 14,000 parcels in the entire project area fall into the low density category

Construction, O&M, and uniform annual costs for the selected OWTS were compared with collection system alternatives that were applicable to the Phillippi Creek project area based on density categories. Previous rules of thumb based on density (U.S. EPA, 1987) held true in this study: at densities greater than 2 lots per acre, sewers were generally more cost effective than OWTS. Based on the comparative analysis, vacuum sewers were found to be the most cost effective alternative for serving the medium and high density project areas within the Phillippi Creek watershed. In low density areas (lots greater than 0.5 acre in size), the lowest cost alternative was upgraded OWTS when compared with costs for three collection system alternatives.

Considering the dense, urban development of the Phillippi Creek project area in Sarasota County, central sewer collection systems were selected as the design alternative for the 16 communities. With the exception of one WPIA, the majority of the project areas have a mean lot size of less than 0.5 acre whereby the project areas are classified as either medium or high density. For approximately 80 percent of these areas, vacuum sewers were recommended and chosen as the method of sewering.

Using central sewers proved to be the most cost effective option for improving the existing wastewater treatment and disposal practices in the Phillippi Creek project area and protecting Sarasota Bay, a valuable natural resource. While the selection of a wastewater alternative based on density was found to be appropriate for sewering a developed urban area, this methodology was found to have limitations where development density is non-uniform and non-contiguous. When these situations are encountered, further detailed analysis is required whereby the individual densities of sub-areas and existing infrastructure must be evaluated on a case by case basis.

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