COSTS FOR CLUSTER WASTEWATER SYSTEMS

Scott D. Wallace and Dennis F. Hallahan

Introduction

Small cities, townships and counties face many complex issues when it comes to wastewater treatment (Pinkham et al., 2004). Although centralized sewers are perceived as the preferred solution to wastewater problems, communities that have centralized sewers discharging to surface waters have been identified as a source of numerous pollution problems (U.S.EPA, 2004). In growing metropolitan areas, urban sprawl is closely associated with centralized, or regional sewers. Communities seeking to maintain their own identities may be skeptical about accepting regional sewer service because of the perceived impacts associated with urban growth (Sparks, 2005).

In the Twin Cities metropolitan area of Minnesota, cluster systems have proven to be an effective method to provide communities with high quality, cost-effective wastewater management while allowing communities to manage their own growth. These cluster systems have been wastewater systems that collect and treat wastewater from two or more homes, with the final discharge being to a soil infiltration system.

There are many barriers to cluster onsite wastewater treatment systems such as uninformed public, regulatory, and design communities. However, in retrospect, the biggest barrier may have developed due to the Clean Water Act itself. As a result of heavy federal funding under EPA's construction grants program, the whole wastewater industry has been geared toward the big treatment works and sewer networks. The resources, regulations, permits, and design knowledge have all been directed to expand and maintain this infrastructure model (Kreissl and Suhrer, 2005).

While this effort has been very effective in reducing point-source pollution, many communities in the United States still do not have sewer service (Wallace et al., 2005). A paradigm shift has begun in the industry realizing that there are other alternatives (Hallahan and Wallace, 2001). This shift is due to many reasons the biggest of which is economic; the "free lunch" is over. The construction grants program that went along with the Clean Water Act is gone; today's funding includes grants are of much smaller amounts and revolving fund loans that are required to be paid back.

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Another factor is the advent of technological innovation that is allowing small-scale cluster treatment facilities to treat to a high standard and associated products, which allow more efficient infiltration. When these innovations are combined with a reliable entity to provide quality management, operation and maintenance (MOM), cost-effective, environmentally responsible wastewater systems can be implemented.

Lake Elmo, Minnesota is a community that uses regional sewer, onsite systems, and cluster systems for wastewater management. Comparisons between these models offer insights into the relative costs of each infrastructure model.

Development of Cluster Systems: Lake Elmo, Minnesota

Lake Elmo is a municipality with population of 6,863 located in the "Twin Cities" metropolitan area of Minnesota. In many ways, Lake Elmo is a rural hamlet in the middle of a fast-paced metropolitan area of nearly 2.6 million people. Regional sewer was not available to Lake Elmo until 1992. Until that time the entire community was served by onsite wastewater systems.

Lake Elmo has purposely restricted its growth through zoning ordinances and land planning activities. In a desire to preserve open space and thereby protect the rural character of the community, Lake Elmo refused to connect to the regional sewer. The community believed that along with regional sewer came high-density development to pay for the high cost of "Big Pipe" infrastructure. This conflicted with growth plans created by the regional planning agency, the Metropolitan Council. The resulting legal battle went all the way to the Minnesota Supreme Court, with the result that Lake Elmo was forced to accept regional sewer along the Interstate 94 corridor and limited use elsewhere (Sparks, 2005). The remaining areas of the community are able to retain their current wastewater systems.

In 1995, a local developer, Robert Engstrom, proposed a development near the "Old Village", the central area of Lake Elmo. His plan, called The Fields of St. Croix, was to mirror the Old Village with large tracts of open space surrounding a cluster of homes to be served by a central water and sewer system. No ordinances were in existence to accommodate such a request, and wastewater treatment was a concern. After months of work with the City and State, the development was able to proceed with the first state-permitted subsurface flow wetland in Minnesota, as shown in Figure 1.

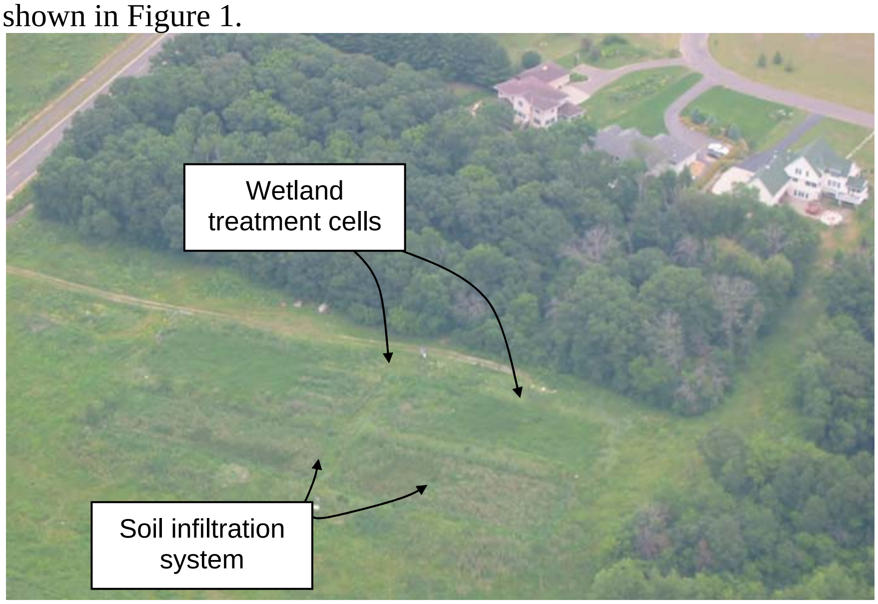


Photo courtesy S. Wallace

Figure 1. Constructed Wetland Treatment Facility at the Fields of St. Croix development in Lake Elmo, Minnesota.

This was the beginning of open space developments using decentralized wastewater technology within the community of Lake Elmo. Currently there are cluster systems in the area treating in excess of 118,000 gpd. Constructed wetlands and recirculating gravel filters have been used for pretreatment. Infiltration chambers have emerged as the preferred method of effluent disposal in this glacial till environment.

Photo courtesy North American Wetland Engineering

Figure 2. Infiltrator® Bed Under Construction Whistling Valley development in Lake Elmo, Minnesota.

Since the initial systems in 1998, cluster development has emerged as a preferred infrastructure model. Table 1 is a summary of systems currently operating in Lake Elmo.

Table 1
Cluster Wastewater Systems in Lake Elmo, Minnesota (Pinkham et al., 2004)

Development (date of start-up)	Number of homes	Design Flow (gpd)	Treatment System	Disposal Method	Notes	Permit
The Fields of St. Croix Phase I (1998)	45 homes	11,000	Subsurface Flow Wetland	Rapid Infiltration Bed	Phase I is connected to Phase II for redundancy and overflow treatment capability	State
Hamlet on Sunfish Lake (1998)	41 homes	8,200	Subsurface Flow Wetland	Infiltration Wetland		City

Tamarack Farm Estates (1998)	20 homes	4,000	Subsurface Flow Wetland	Mounds	Septic tanks on Individual lots. Small diameter gravity sewer on upper lots; pressure sewer on lower lots	City
Prairie Hamlet (1999)	15 homes	3,000	Subsurface Flow Wetland (aerated)	Drip Irrigation (subsurface)	Effluent used for landscape irrigation	City
The Fields of St. Croix Phase II (includes 20 homes at Tana Ridge) (2000)	88 homes	33,000	Recirculating Gravel Filter (aerated)	Infiltrator® trenches	Tana Ridge purchased capacity from The Fields 2 system	State
Carriage Station (2001)	109 homes; professional/ office space	44,875	Recirculating Gravel Filter (aerated)	Infiltrator® trenches	Also serves 40,000 sq. ft. commercial office space	State
Wildflower Shores (2001)	25 homes	3,600	Subsurface flow wetland (aerated)	Infiltrator® trenches		City
Whistling Valley (2004)	18 homes initially; 22 total	11,000	Recirculating Gravel Filter (aerated)	Pressure-dosed Infiltrator® beds		State

Note: All developments use conventional gravity sewer systems except for Tamarack Farms Estates.

Costs of Cluster Wastewater Systems

In order for cluster systems to be considered an attractive infrastructure option, they must be cost-competitive with other infrastructure models. The issue is not what the systems cost, but what is the *relative* cost between a cluster system and competing alternatives. Each of the three major infrastructure models (onsite systems, cluster systems and regional sewer) are best suited to different land uses, as summarized in Table 2:

Table 2
Land Use Density and Infrastructure Type

Land Use	Infrastructure Type
Low Density	Onsite Systems
Medium Density	Cluster Systems
High Density	Regional Sewer

The US Environmental Protection Agency has demonstrated that misapplying an infrastructure model, such as attempting to regionalize low-density areas, or install onsite systems in urban areas, is not cost effective (U.S.EPA, 1997).

The open-space preservation zoning adopted by Lake Elmo requires 50% of the available land to be set aside as permanent open space. Homes are clustered on the remaining area. This results in groups of homes located on relatively small lots, and the housing groups are geographically isolated from one another. The resulting developments are not well suited for individual onsite systems due to the small lot size. The long distance between housing groups drives up the cost of regional sewer. The City chose instead to promote the use of cluster systems to treat all of the wastewater from a residential development, with each development having its own wastewater system.

Capital Cost of Cluster Systems

In the case of Lake Elmo, some systems were built directly by the developer and capital cost information is not available. Capital costs for selected systems are shown in Table 3:

Table 3
Capital Cost of Cluster Systems in Lake Elmo, Minnesota

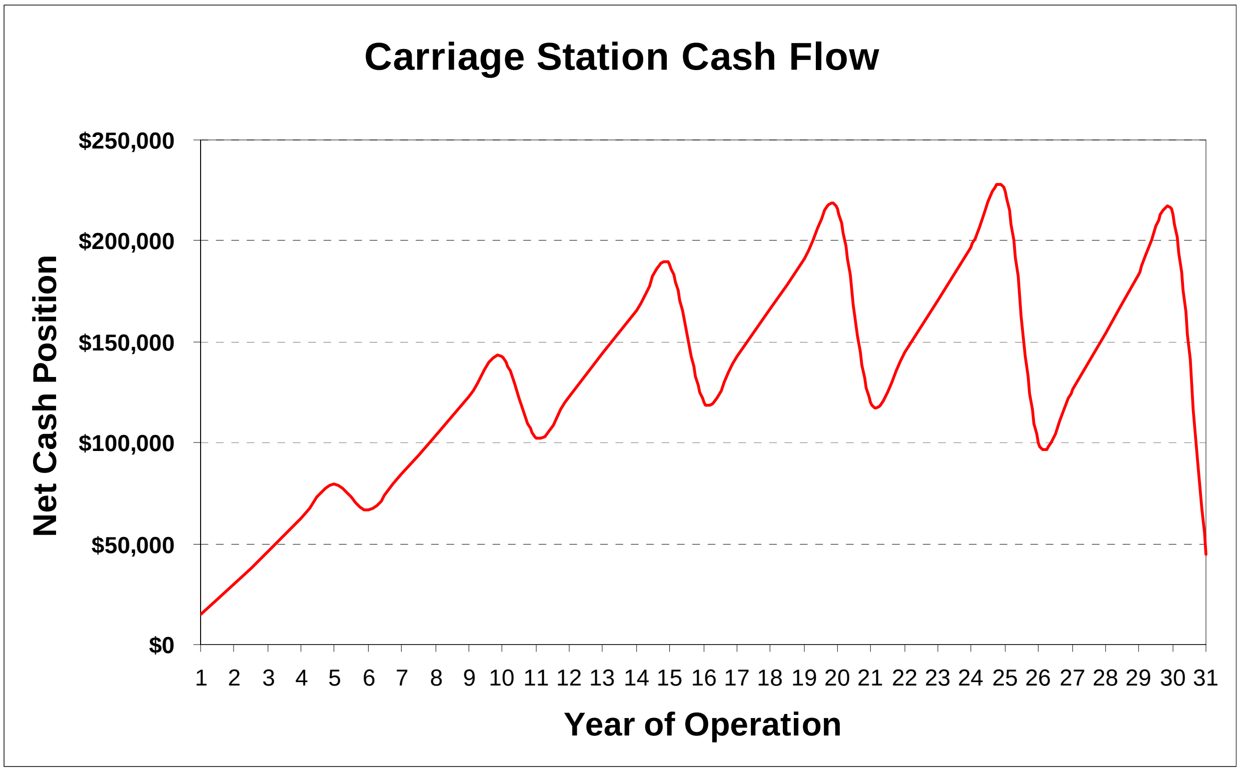
Development (date of start-up)	Number of homes	Capital Cost per connection
The Fields of St. Croix Phase II (includes 20 homes at Tana Ridge) (2000)	88 homes	$5,524
Carriage Station (2001)	109 homes; professional/office space	$6,466
Wildflower Shores (2001)	25 homes	$9,935
Whistling Valley (2004)	18 homes initially; 22 total	$13,599

Cluster System Operation, Maintenance and Management Costs

The key to success of any wastewater system is proper management. Lake Elmo chose a model where the Homeowners Association for each development would own the wastewater system. Lake Elmo's belief was that the residents directly served by the wastewater system would have the greatest interest in making sure the system was operated properly. Lake Elmo's experience with homeowners associations has been mixed. Homeowners Associations were often slow in securing a maintenance entity. When they did hire an operator the management entity put the minimum of effort into understanding the systems they were operating. Many associations were reluctant to fund routine maintenance work and set aside adequate funds for replacement of worn-out components. This eventually led to operational problems.

In order to address these concerns, the City began to hold regular meetings with all of the homeowners associations so they could share knowledge and expertise. A single management company began to operate most of the systems. This standardized operations and lead to proactive management. The management company began to work with associations to set budgets based on 30-year life cycle costs and cash flow analyses to cover all aspects of system management. The details of this cash flow analysis are outside the scope of this paper, but an example of the types of information presented to the Homeowners Associations is presented in Figure 3:

Figure 3
Example Cash Flow Analysis



Analyzing system costs from a life cycle and cash flow standpoint allowed the Homeowner Associations to set rates based on current and anticipated future costs. Monitoring, operation, and maintenance (MOM) costs are summarized in Table 4:

Table 4
MOM Costs for selected Lake Elmo Cluster Systems

System	Recommended Monthly Service Charge
The Fields of St. Croix (Phases I and II)	$30.48
Carriage Station	$41.11
Wildflower Shores	$33.01
Whistling Valley	$60.11

Note: Costs are monthly fees for single-family homes.

MOM costs vary based on the size of the development, the type of treatment and infiltration method used, and permit-driven monitoring requirements. Typically, a range of costs is presented to homeowners because some assumptions must be made about how inflation and interest rates will vary in the future. A major difference between MOM costs borne by the homeowners association and municipal sewer charges is that capital replacement is funded through up-front contributions from the homeowners. This “pre-payment” plan ensures that adequate funds are in the bank when major repairs are needed.

Clusters vs. Onsite Treatment Systems

In Lake Elmo, individual onsite systems typically are mounds and cost between $12,000 and $14,000 per system. However, the cost of onsite treatment systems varies widely across the United States, and can vary 40% or more within a particular state (Williams et al., 2005). As a result, onsite system costs in Lake Elmo are not necessarily representative of other parts of the country.

Compared to individual onsite systems, cluster systems have an immediate disadvantage in the cost of the collection system. Building a sewer collection network is not a cost developers face when using individual onsite systems. The cost of the collection system must be offset by economies of scale in the treatment and disposal systems. Experience in Lake Elmo has shown that the “cross-over” point between individual onsite systems and a cluster system is around 7 homes. This is the size range at which the savings in the treatment and disposal system are great enough to offset the added cost of the collection system. This “rule of thumb” is dependent on the local soil sizing factors and regulatory requirements, so the relative cost of onsite treatment systems vs. cluster systems will vary across the United States.

Comparing the average capital cost of onsite systems ($12,000 to $14,000) versus the cluster system costs presented in Table 3, it is clear that cluster systems can offer capital cost savings over individual onsite systems. The relative cost benefit of cluster systems increases as the size of the development increases. Also, systems constructed earlier in time tend to have lower per-lot costs than newer systems. This is due to factors such as inflation but also represents changes in regulations. For instance, the sizing criteria for large septic tanks have increased 3-fold in Minnesota since 1998 in response to concerns over treatment efficiency and frequency of pumping.

Cluster systems can offer other advantages over individual onsite systems. For example, cluster systems allow lots to be positioned for optimal market value, not just based on where the good soils are. Cluster systems can be designed to preserve open space. Due to the open space and smaller lot sizes cluster system developments can have lesser amount of roadway construction thereby resulting in less construction costs, this coat savings is not reflected in the cost comparisons. Finally cluster systems are much more practical to operate from a MOM standpoint.

Clusters vs. Regional Sewer

If cluster systems are cost-effective (within a reasonable range of development sizes) compared to onsite treatment systems, how do they compare to regional sewer? It is difficult to make direct cost comparisons, because for regional sewer, the costs are spread amongst multiple governmental jurisdictions, each of which may choose to subsidize sewer fees through other revenue sources.

In the Twin Cities, the regional sewer and associated treatment plants are operated by the Metropolitan Council Environmental Services (MCES). MCES currently has a sewer availability charge (SAC) of $1,350 (Metropolitan Council Environmental Services, 2004). This is the “wholesale” cost for sewage capacity for a single-family home in the regional network. However, this does not pay for the collection systems operated by the individual municipalities that are under MCES’ jurisdiction. In reality, municipalities take MCES’ base charge for SAC and add their own costs on. Additional funds are collected by the municipalities to deal with sewer maintenance, pumping stations, and correction of systemic infiltration/inflow (I/I) problems. Within the Twin Cities region, SAC charges vary between $1,500 and $15,000 per home, with a median value of about $7,500.

SAC fees do not pay for the sewer within the development, or the cost of connecting the home to the development. In Lake Elmo, sewer costs in new residential developments are about $3,500 per home, and connecting the house to the sewer is costs about $500 for new construction. This indicates that the “average” cost of regional sewer is approximately $11,500 per home. This is comparable to the range of capital costs for the cluster systems presented in Table 3.

What about operating costs? In the Twin Cities region, the median monthly charge for municipal sewer services is $15.50 per month (Metropolitan Council Environmental Services, 2004). The average MOM cost for the cluster systems presented in Table 4 is $41.18 per month. This would seem to indicate that monthly costs for regional sewer service are less expensive than cluster systems. This may be attributable to the higher development density in areas served by regional sewer.

Another major impact on MOM costs is the degree to which future capital replacement is funded in the monthly sewer bill. The MOM costs summarized in Table 4 are based on the assumption that all future capital replacement is funded through the monthly user charges (no future borrowing required). Municipalities have a much wider range of financial capability, and they can bond or assess to repay debt. While some municipalities “pay ahead” and stockpile reserves (like the MOM costs in Table 4), others choose to incur debt when capital replacement is needed.

Conclusions

The Lake Elmo experience has demonstrated that for medium density land uses, the cost of cluster wastewater systems is comparable to individual onsite systems and regional sewer. As the size of the development increases, cluster systems offer increasing capital cost savings over onsite systems. Capital costs between regional sewer and cluster systems is comparable. Monthly costs for regional sewer appears to be less expensive than cluster systems, although this is complicated by the degree to which future capital costs are funded through monthly user charges.

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