UNITED STATES MILITARY ACADEMY

SEPTIC SYSTEM ALTERINTATIVES FOR THE TRI-LAKES COMMUNITY

EV481

SECTION 01J

LTC FLEMING

BY

CADET BILL GEHRUM, ‘01 CO D4
CADET JOE LACANLALE, ‘01 CO Hi
CADET ROBERT MILLER, ‘01 CO H4

WEST POINT, NEW YORK

12 DECEMBER 2000

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Project Objective

The objective of this project is to investigate the influence of septic systems in the Tri-Lakes Community and develop structural and nonstructural alternatives to protect this valuable resource. These alternatives will be evaluated according to engineering, economic, social / cultural, and environmental criteria to determine the best one to implement in the Tri-Lakes Community.

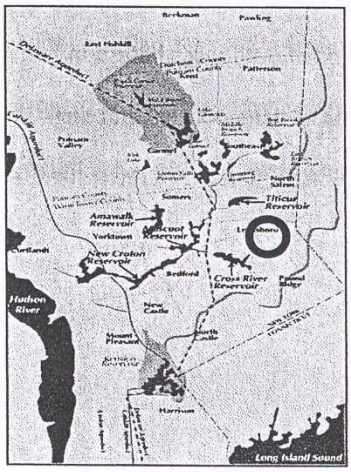
Introduction

The Tri-Lakes Community consists of 90 lakefront homes along the shorelines of Lakes Waccabuc, Oscaleta, and Rippowam (latitude 41°17'44"; longitude 73°34'39"). These lakes are glacial in origin with a maximum depth of 46 feet. The ratio of watershed to lake surface area is 7.5:2.[1] The Tri-Lakes Watershed is a sub-drainage basin of the Croton Watershed, a 318 square mile area that provides New York City with 10% of its total water supply.[2] Therefore, the Croton Watershed is a valuable resource that must be protected.

In recent years, coliform counts in the Tri-Lakes have been above normal levels for healthy bodies of water.[3] A coliform count is a tool that can help determine levels of bacteria in water. Our water management team has cause to believe that aging septic systems may be leaking effluent into the lakes, which increases the bacteria levels. If bacteria levels continue to increase, then the lakes will become unhealthy and in violation of Public Health Laws.

In response to this threat, five alternatives are proposed in an attempt to reduce the coliform level to a healthy standard. These alternatives are:

1. Vacuum Sewer Technology (structural)
2. Geographical Information System (non-structural)
3. Aerobic Treatment (structural)
4. Community Education (non-structural)
5. Status Quo



Croton Watershed with Tri-Lakes Region Circled

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These alternatives will be examined according to economic, environmental, social / cultural, and engineering criteria to determine which alternative would best serve the needs of the Tri-Lakes residents.

History of the Region

In the 1600's, most of the city's population lived in lower Manhattan and drew their water from local streams, ponds, and wells. As the population grew, the existing water supply became inadequate and polluted with garbage and raw sewage. In the 1830's, city leaders turned to the Croton River in Westchester County for a cleaner and more abundant source of water.[4]

In 1998 a unique program called the Croton Watershed Water Quality Program was initiated to address water quality issues. Prior studies, local municipal officials, government experts, resource professionals, and representatives of various businesses and environmental organizations voiced their concerns about the Croton Watershed. They determined the biggest threats to clean water and healthy communities are non-point source pollution. Most critical types of non-point source pollution are coming from failing septic systems, stormwater runoff, and fertilizer from lawns and gardens.[5]

The Tri-Lakes Community is an example of residential development that must be monitored to ensure that its water management practices are not detrimental to the water quality of the Croton Watershed. In the 1950's, developers constructed many lakefront cottages on the Tri-Lakes. Small families intended these cottages for seasonal use. The waste was first disposed of by means of outhouses before indoor toilets with outdoor pits evolved.[6] Currently, 90 homes utilize septic systems to treat and dispose of wastewater. These inadequate septic systems are aging and leaking effluents into the watershed.

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Alternative # 1

Vacuum Sewers

Why should the Tri-Lakes Community consider vacuum sewers?

Vacuum sewer technology was first patented in 1888 and has been used for commercial applications since 1959. Although considered to be a new or experimental technology, this view is rapidly changing. Today, there are approximately 200 municipal vacuum systems operating in the United States. Technology continues to improve as vacuum sewers expand into small communities.

Vacuum sewers may be a good option for the residents of the Tri-Lakes because they are practical for use in low-lying areas, such as lakeside or coastal communities. They are also option because the Tri-Lakes area has high groundwater and bedrock. Because vacuum sewers employ narrow pipes buried in shallow trenches, and do not depend on gravity to transport sewage, less excavation is necessary for their installation. Engineers can more easily adapt the configuration of the sewer lines to accommodate unforeseen obstacles and tight spaces. In addition, vacuum systems are entirely enclosed systems. An enclosed system minimizes inflow, infiltration, and exfiltration. For these reasons, vacuum sewers are often an option for environmentally sensitive areas.

How vacuum systems work

Three general components make up a vacuum system; the valve pit package, the piping network, and the vacuum station. Refer to diagram. First, sewage from individual homes flows through gravity lines to a buried collection sump, which is part of the valve pit package. When 10 gallons of raw sewage accumulate in the sump, a pressure-controlled valve automatically opens and the sewage is sucked out of the sump by differential air. Second, the sewage travels through four-inch pipes laid in shallow trenches. Because of the vacuum, these pipes can be laid going uphill. Lastly, the vacuum station is the power behind the system. Vacuum stations contain an enclosed collection tank, sewage pump, vacuum pump, and electrical controls. When the collection tank fills to a

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predetermined level, a sewage pump pumps the sewage to a facility for treatment and disposal. These vacuum stations are prefabricated by a manufacturer and arrive to the community on skids. However, the community must provide a shelter to house the station.

Advantages of vacuum systems

- Reduce treatment costs by reducing inflow and infiltration
- Field changes in system configuration can be easily made if underground obstacles are encountered
- Shallow installation reduces project costs and environmental impact
- Enclosed system eliminates odors, protects the environment, and minimizes health risks
- Major leaks are detected and addressed immediately
- Only one source of power is necessary
- Exfiltration is eliminated

Disadvantages of vacuum systems

- Not cost effective for less than 50 homes
- May have difficulty accepting large flows
- A site and facility is required to house the vacuum station
- A full or part time operator is required

Costs

- Valve pits range from $2,500 to $3,500 installed. Two homes typically share one valve pit making the cost per home $1,250 to $1,750.
- The cost of vacuum stations run from $200,000 to $450,000
- Overall, vacuum systems range from $2,500 to $4,000 per home (Falvey, 2000)
- Operator salary is estimated at $50,000 per year.[7]

Five-year Cost per household: $10,666.42

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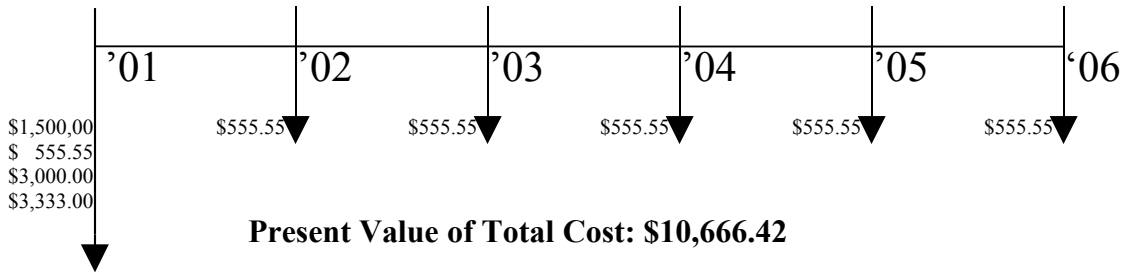
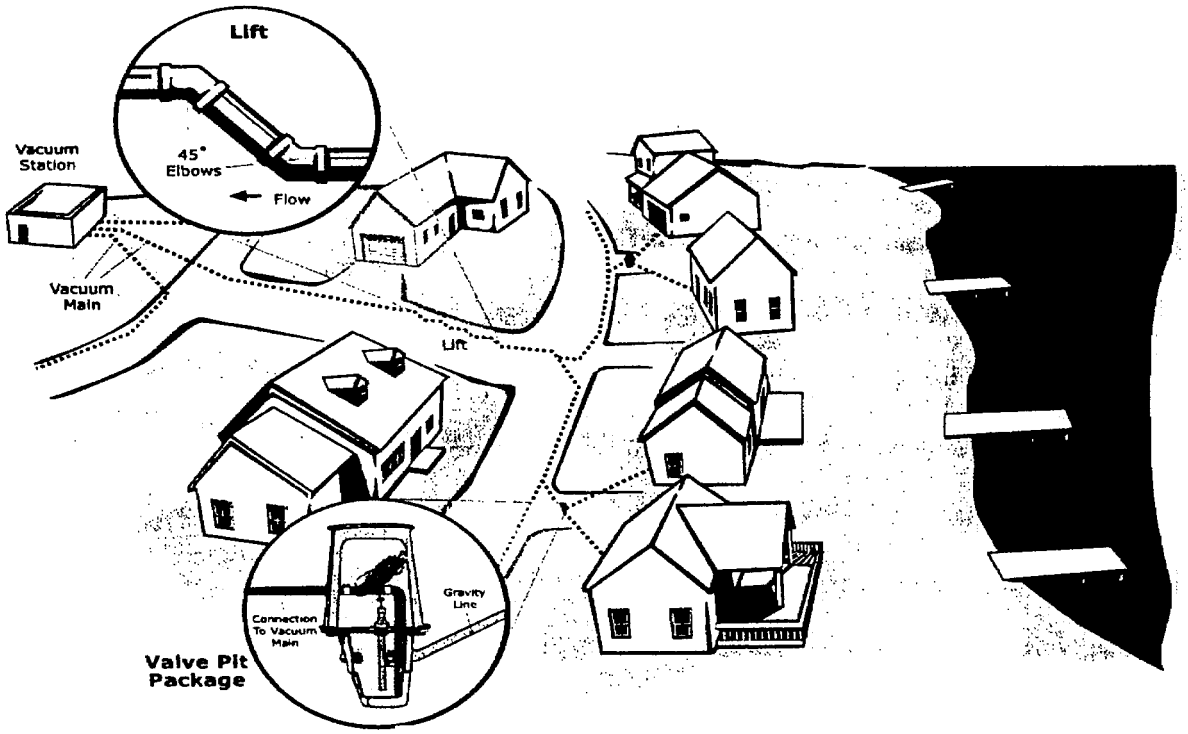
Alternative #1
Vacuum Sewers
Cash Flow Diagram

N=5
i=7%



Present Value of Total Cost: $10,666.42



Vacuum Sewer[8]

Alternative # 2

Geographical Information System

Why should the Tri-Lakes Community consider a geographical information system?

The Westchester County Health Department is required to perform septic system inspections and enforce codes that protect the environment and human health. The health department keeps records of each septic system installed in the county on file. This file includes the location of the property, the property owners, the location of septic system on the property, problems with a particular septic system, as well as many other categories of data. The health department must access this information every time it is called upon to inspect a septic system. However, the current system is organized on index cards that date back to the 1950's.[9] Therefore, finding information about a specific septic system can take up to two weeks. If there is an emergency, this delay could be detrimental to the environment and health standards.

A geographical information system could compile all of this data on a computer and make it much easier for the Westchester Department of Health to access and update this information. Without the delay of searching through index cards, the GIS would make the department more efficient and able to respond to emergencies and inspections with better data in less time.

How geographical information systems work?

"Geographic Information System (GIS), computer system that records, stores, and analyzes information about the features that make up the earth's surface. A GIS can generate two- or three-dimensional images of an area, showing such natural features as hills and rivers with artificial features such as roads and power lines. Scientists use GIS images as models, making precise measurements, gathering data, and testing ideas with the help of the computer.

Many GIS databases consist of sets of information called layers. Each layer represents a particular type of geographic data. For example, one layer may include information on the streets in an area. Another layer may contain information on the soil in that area, while another records

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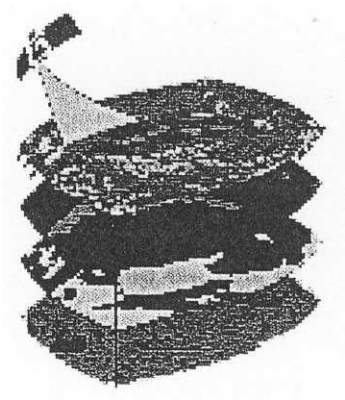
elevation. The GIS can combine these layers into one image, showing how the streets, soil, and elevation relate to one another. Engineers might use this image to determine whether a particular part of a street is more likely to crumble. A GIS database can include as many as 100 layers.

A GIS is designed to accept geographic data from a variety of sources, including maps, satellite photographs, and printed text and statistics. GIS sensors can scan some of this data directly—for example, a computer operator may feed a map or photograph into the scanner, and the computer "reads" the information it contains. The GIS converts all geographical data into a digital code, which it arranges in its database. Operators program the GIS to process the information and produce the images or information they need."[10]

Advantages of geographical information systems



- No need to disturb environment with structural solutions
- Relatively inexpensive
- Can be easily updated to accommodate future systems
- Department of Health, engineers, builders, and homeowners can access the information
- Keep records of inspections
- Monitor which areas of the county are experiencing most problems with septic systems

Disadvantages of geographical information systems

- No immediate solution to water quality
- Computer / GIS specialist needed to operate and maintain system

Costs*

Equipment		Staffing		Data	
Computer	$3,000	Personnel Salary	$2,600	Acquisition	$0
Network Maintenance	$ 250	Initial GIS Training	$ 495		
Overhead	$ 870				

* Costs mirror similar project completed by Tucson Department of Transportation Real Estate Division[11]

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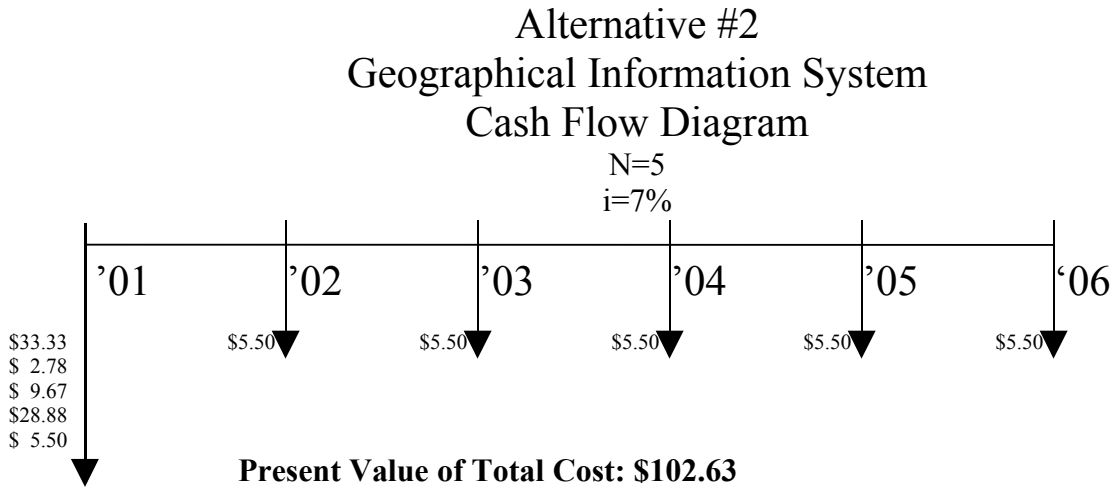
Total Cost of GIS Project: $7,215



Five-year cost per household: $102.63

Alternative #3

Aerobic Wastewater Treatment Systems

Why should the Tri-Lakes Community consider aerobic wastewater treatment?

For many decades, the lakeside residents of this part of Westchester County have relied on septic systems as their method of wastewater treatment. However, because of their close proximity to the water, septic systems have presented a problem in terms of their potential for groundwater pollution and seepage into nearby lakes.

Aerobic wastewater systems provide a reliable alternative to the anaerobic septic systems currently in use. While aerobic wastewater treatment systems have been around for about fifty years their use has been fairly limited, mostly because of the predominant acceptability of septic systems. Septic systems in the Tri-Lakes Community contribute to pollution, in part, because of a high groundwater table in the area. Further, because of their closeness to the lakefront, there may not be adequate space for septic systems to function properly and efficiently much longer. In recent

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years aerobic treatment has seen greater application because of failing septic systems. For these reasons, the Tri-Lakes Community should presently consider aerobic wastewater systems to replace their current method of wastewater treatment.

How Aerobic Wastewater Systems Work

Aerobic systems treat wastewater in several stages. Often the process begins with pretreatment. This stage is included in order to reduce the amount of solids that enter the system. When pretreatment is conducted, treatment will often be more effective because clogging of the unit by solid matter including greases and oils will be minimized. Most aerobic units utilize a process called suspended growth. In these units, the main compartment is an aeration chamber in which air is mixed with the wastewater. Oxygen in the air encourages the growth of bacteria that consume solids in the wastewater. The term suspended growth derives its name from this principle in that the bacteria will grow in the wastewater while unattached to any surface. Any solids not digested by bacteria will settle out as sludge. The sludge may be returned to the aeration chamber because it contains bacteria which furthers digestion of more solids. However, at least once a year the sludge needs to be pumped out in order to prevent clogging of the system. Flow through the system may be continuous or as a batch process. Among final treatment options are use of a soil-adsorption field, a sand filter, an evapotranspiration bed, or disinfection. Soil adsorption fields, however, are the most common method for final treatment.

Advantages of Aerobic Wastewater Treatment

- Higher level of treatment than a septic tank
- Provides an efficient and more environmental-friendly alternative to septic systems
- Suitable to replace failing septic systems
- Might extend life of the drainfield
- Requires a smaller drainfield

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Disadvantages of Aerobic Wastewater Treatment

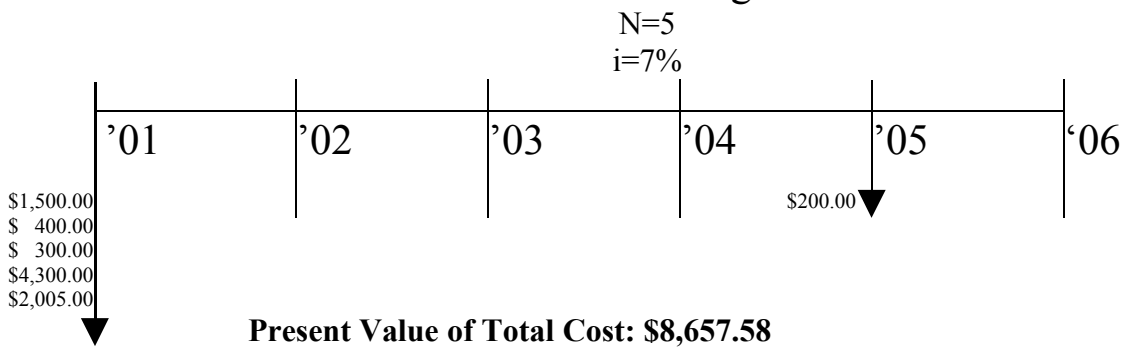
- Operating costs are higher than for septic systems
- Electricity needed to force air into aeration chamber
- Includes mechanical parts that might fail and require servicing
- Frequent maintenance required
- Decreased performance under heavy (batch) loads
- Release of more nitrates in groundwater[12]

Costs

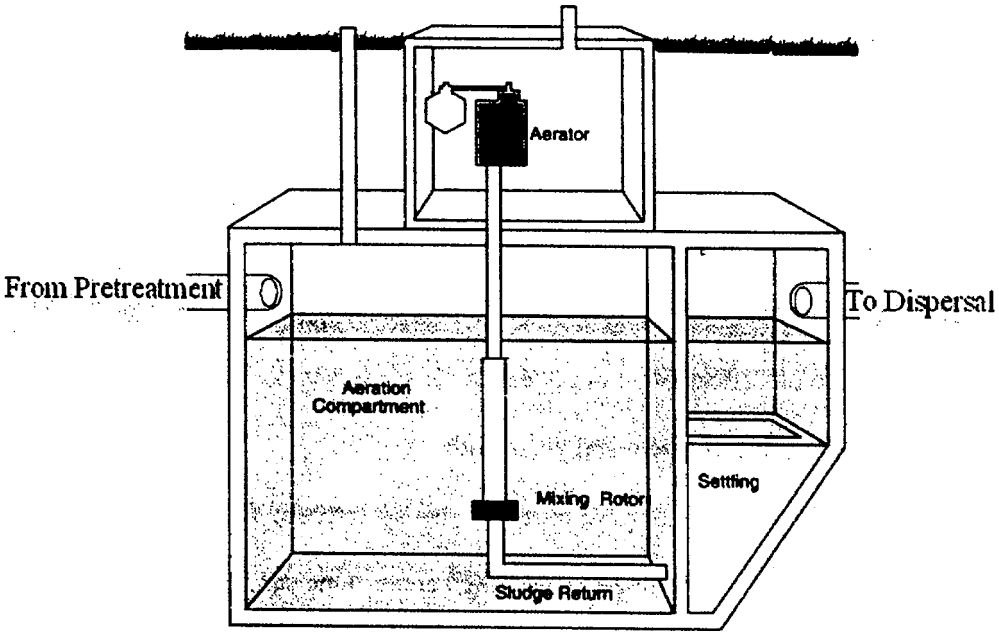
Pump, filter, piping	$1,500
Plumbing	$ 400
Gravel, soil, sand	$ 300
Labor	$4,300
Additional Options	$2,005
Total	$8,505

Five-year cost per household: $8,657.58

Alternative #3
Aerobic Wastewater Treatment System
Cash Flow Diagram



Present Value of Total Cost: $8,657.58



Aerobic Treatment[13]

Alternative #4

Educating the Residents of the Tri-Lakes Community

Why should the Tri-Lakes Community consider an educational program?

By implementing an educational program, the residents of the Tri-Lakes Community region will be able to mitigate and reduce the impact and overuse that septic tanks pose to the surrounding area. Since people can directly affect the surrounding watershed areas, they should be aware of the possible contamination and effects that septic tanks are capable of. Also, many people are simply unaware of the affects and reasons why pollution through the use of septic tanks may occur. In order to prevent this and help remedy this problem, an educational program can be effective. This will allow home owners that use septic tanks to become familiar with the system, its effects, and ways to help counter and reduce possible pollution into the environment and surrounding watershed areas. Also, an educational program is one of the less expensive methods to help the

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community deal with septic tanks. The Tri-Lakes community should consider an educational program, simply because it can have a positive impact with little cost, and simply because the majority of the people may be unaware of some of the long term problems that septic tanks can cause. By educating people, the environmental awareness on this issue will increase and help prevent and lessen the negative effects of septic tanks.

How can a community implement an educational program?

There are many ways to implement an educational program in the Tri-Lakes region. The basic concept of education is to put information out and provide some way for the surrounding community to interact and learn by audio and visual aids.

One suggestion may be to hold local town meetings that specifically focus on septic tanks and the effects they may have on the surrounding water shed areas. One can also have a guest speaker from the Department of Health to hold seminars on septic tanks. A septic tank hot-line, a question and answer session, or even just a phone number can greatly help educate people. Just by making information available at a certain time and place can help people greatly, especially if it is at their convenience. House to house visits upon request or appointment may also help accommodate people's busy schedule. Also, one can offer classes on a weekly basis to just to give information to the public on how to operate and ensure that your septic tank is useful.

Another form of education can simply be the use of commercials, television programs, and even pamphlets and flyers that are simple and easy to understand. This is fairly an inexpensive method that can be distributed and passed out to homes or at key locations and function. Also, education among the youth in schools by field trips or videos can help increase the interaction of the entire population. There are many ways to implement such programs that specifically deal with educating the public.

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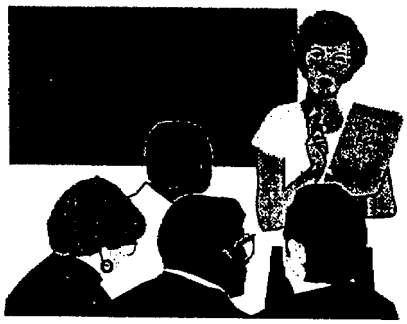
Advantages of an Educational Program



- Simple way to make people aware of problem.
- Relatively inexpensive
- Improve community relations
- Keeps people informed

Disadvantages of an Educational Program

- Takes time to educate
- Effects of education are difficult to monitor on a consistent basis
- Response to education may not be positive.

Costs*

Equipment		**Staffing**	
Visual Media (pamphlets)	$ 500	Volunteers	$0
Video	$1,000	Guest Speakers	$0

*The cost of an educational program seems to be a minor point, the only great cost is implementation time.

Five-year cost to household: $39.44

Alternative #4
Education
Cash Flow Diagram
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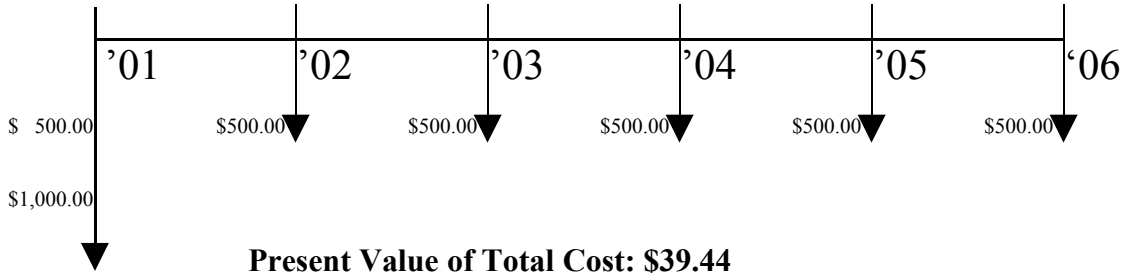
i=7%



Present Value of Total Cost: $39.44

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Alternative # 5

Status Quo

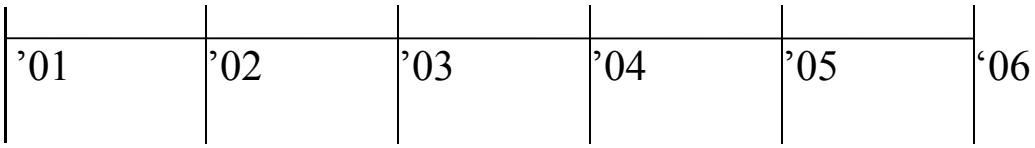
Why should the Tri-Lakes Community consider not taking any action on the septic systems?

The Tri-Lakes community may choose not to take any action to address the problem of failing septic systems. Not doing anything will result in the continuation of effluents escaping from failing septic systems into the lake water. The effluents serve as nutrients for bacteria in the lake water to grow to unhealthy levels. Unhealthy levels of bacteria are dangerous to human and animal life that comes into contact with the lake.

The Office of Ground and Drinking water sets a limit on the coliform count in lakes. "A violation occurs at systems collecting 40 or more samples per month when more than 5.0 percent of the total coliform samples are positive."[14] If effluent continues to escalate coliform levels in the Tri-Lakes, then a violation of state law will result.

Five-year cost to household: $0

Alternative #5
Status Quo
Cash Flow Diagram
N=5
i=7%



Present Value of Total Cost: $0.00

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Analysis of Alternatives

Each alternative was analyzed using four categories of criteria: economic, environmental, social/cultural, and engineering. A set of four impact points was asked in each category to evaluate that alternative's effect on the community.

Economic

1. Benefit to cost ratio

Environmental

1. Disturbance of wetland areas
2. Reduction of coliform levels
3. Increased turbidity of lake water during construction of alternative
4. Danger of environmental hazard during implementation of alternative

Social / Cultural

1. Disturbance to Tri-Lakes residents
2. Impact of construction on recreational use of lakes
3. Damage to homeowner property
4. Impact of alternative to aesthetic beauty of Tri-Lakes community

Engineering

1. Time to complete alternative
2. Operation and maintenance of alternative
3. Feasibility of project (availability of energy, materials, technology)
4. Feasibility to accommodate future systems

Each alternative was rated on a scale from 1 - 10 according to the above criteria, with a lower rating being the best. After summing each category, the rating scores were put into the horizontal axis of a utility curve to determine a normalized utility score. The function of a utility curve is to

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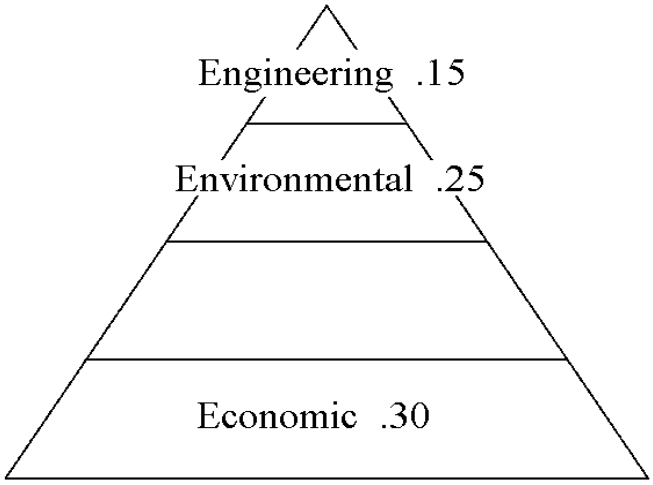
analyze all the alternatives on a level playing field. The utility curves for each criterion are located in Appendix A.

Using a decision matrix program, each criterion was weighted according to the values of the Tri-Lakes community.



The decision matrix multiplied the criterion weights times the normalized utility scores to determine the total utility scores. The least total utility score is the best alternative for the needs of the Tri-Lakes Community.

DECISION MATRIX

Weight	0.30	0.25	0.30	0.15	Total
Criteria / COA	Economic	Environmental	Social / Cultural	Engineering	
Vacuum Sewers	100	23	12	23	29.407
GIS	5	5	4	10	5.189
Aerobic	79	22	12	21	26.729
Education	1	25	8	7	5.587
Status Quo	1	10	15	10	5.660

Evaluation and Recommendations

With a total utility score of 5.189, the Geographical Information System Alternative best suits the needs of the Tri-Lakes Community.

A sensitivity analysis concludes that if the weights of economic and engineering criteria are slightly adjusted, then the optimal alternative might be education. A more detailed study on the values the Tri-Lakes residents place on the criteria may determine that the educational alternative might be better than the geographical information system alternative.

Economic
- **Changes at 1.00. Optimal is Education**
- **Changes at 1.00. Optimal is Education**

Environmental: Not Sensitive
Social / Cultural: Not Sensitive
Engineering
- **Changes at 1.00, Optimal is Education**
- **Changes at 1.00. Optimal is Education**

Implementation, Surveillance, and Monitoring

Implementing the Geographical Information System alternative involves three major phases. To complete the first phase, the Tri-Lakes Community must purchase a computer and GIS software, such as ArcView. Secondly, the community must hire and train a GIS specialist to operate and maintain the system. Lastly, data from the card catalogues must be combined with maps of the Tri-Lakes region to create the database. This process should be approximately two months in duration. The GIS specialist and the Department of Health should update the database information annually.

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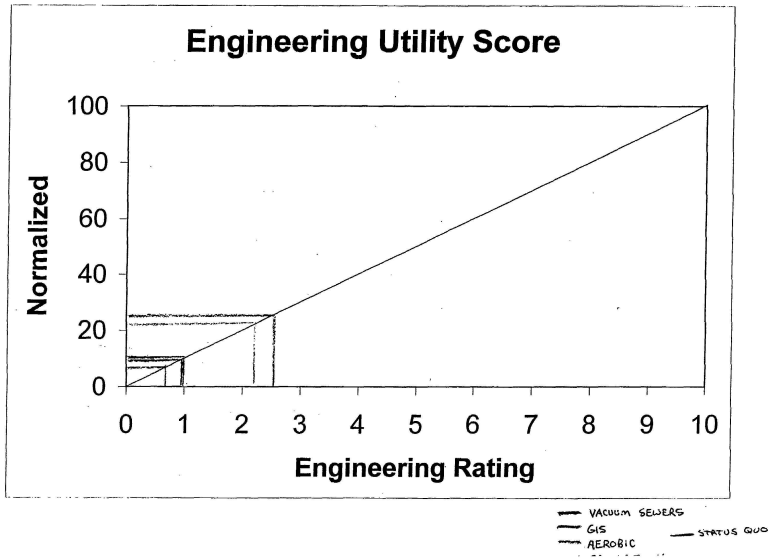

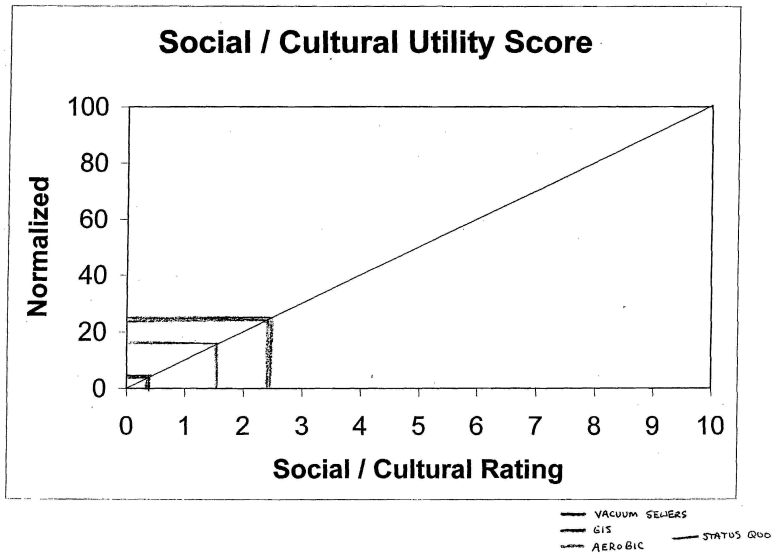

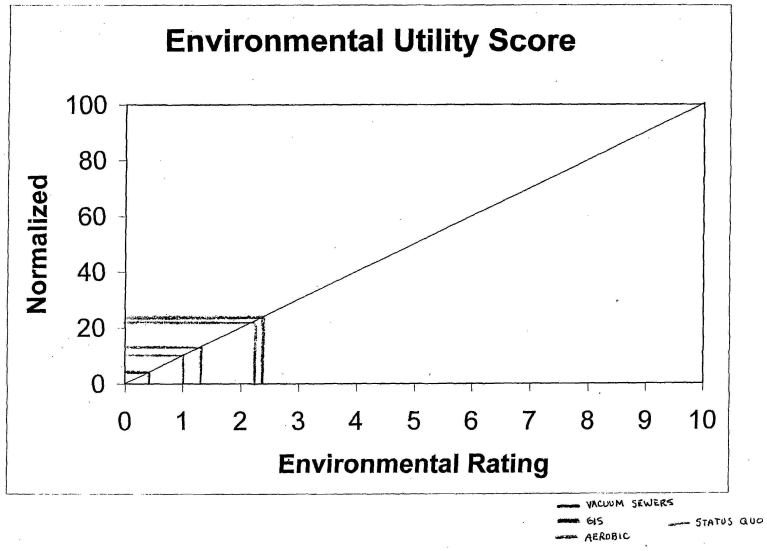

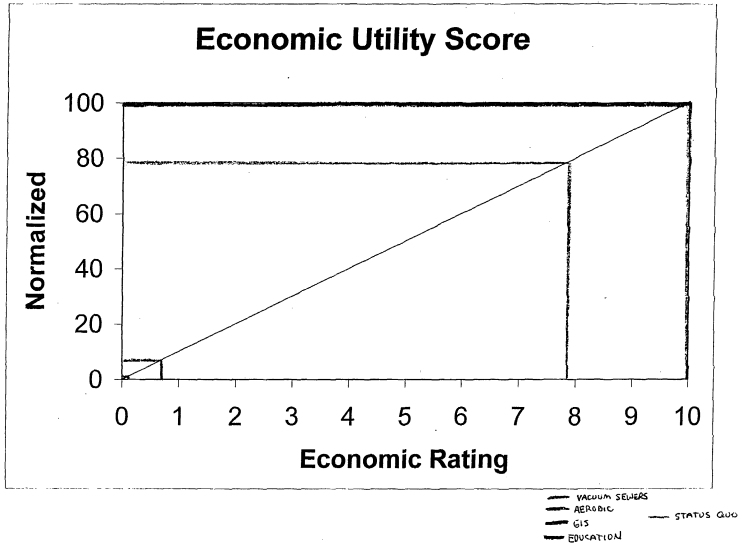

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Charney, Sabrina. From Town to Tap. Linking Watersheds and Communities. Issue 1. November 1999.

This source is a Westchester County publication with information about watersheds, septic systems, volunteer programs, and community health concerns.

Delaney, Ed. Interview. 1 October — 15 November 2000.

Mr. Delaney spoke with us many times over the telephone. He is the Head of the Westchester County Department of Health. Lie provided information on the history of the region, effects of septic systems on the watershed, the evolution of wastewater in Westchester, and described that the card catalogue could be updated with GIS.

Encarta. "Geographical Information System." Source online; accessed 12 November 2000. Available from http://encarta.msn.com/find/Concise.asp?ti+06A0000)

This source is an encyclopedia article defining GIS.

Falvey, Cathleen. "Vacuum Sewer Technology Comes of Age." Small Flows Quarterly (Fall 2000): 32-35.

This article describes vacuum sewers, how they work, their costs, and why a small community might implement one for their wastewater disposal.

Koss, David. Bang for the Buck: City of Tucson Real Estate Division Leaps Ahead with ArcView GIS. [source online] accessed 30 November 2000; available from http://dot.ci.tucson.az.us/realestate.htm.

This online source describes how the city of Tuscon's Department of Transportation Real Estate Division updated its old maps with 015. We modeled our costs after this program because it is very similar to a program that would benefit our project.

Miller, Steve. Interview. 28 October 2000.

Mr. Miller described the functions of septic systems, how they are installed, the importance of a sufficient drainfield, costs of labor and materials in Westchester County, history of the region, and provided many publications listed in this bibliography. He also provided the names of Mr. Ed Delaney and Dr. Peter Treyz for contacts.

National Small Flows Clearinghouse Pipeline. Alternative Sewers: A Good Option for Many Communities. (Fall 1996: Vol. 7, No. 4).

This article endorses alternative sewers which are similar to vacuum sewers.

Palmer, Liz. Water Quality Changes in Lake Waccabuc from 1986-1996: A Preliminary Data Analysis. 2000.

Liz Palmer is a resident of the Tri-Lakes community that studied the water quality changes in Lake Waccabuc, one of the Tri-Lakes. Her report gave us some good information about the lakes.

Small Flows Quarterly. "Quality Maintenance Key to ATU Performance in Texas." (Fall 2000): 8.

This article describes how aerobic systems work and provided a diagram of such a system.

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NOTES

1. Liz Palmer, Water Quality Changes in Lake Waccabuc from 1986-1996: A Preliminary Data Analysis. 2000.

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3. Henrietta Treyz, Determining the Cause For Increased Coliform Counts on Lakes Waccabuc. Oscaleta. and Rippowam.

4. Ed Delaney, Head of Westchester Department of Health. Interview October 2000.

5. Sabrina Charney, From Town to Tap. Linking Watersheds and Communities. November 1999.

6. Delaney

7. Falvey

8. Ibid.

9. Delaney

10. Encarta, "Geographical Information System" Source online; available from http://encarta.msn.com/findlConcise.asp?ti+06DA0000) accessed 12 November 2000.

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14. Westchester County Water Quality Management Program. Individual Sewerage Systems. "Best Management Practices Manual Series, A Guide for Design, Construction, and Use."

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