

***NEW WASTEWATER TECHNOLOGIES  
FOR PENNSYLVANIA***

***ON-LOT SYSTEMS AND  
SMALL FLOWS***

***RESEARCH AND  
DEVELOPMENT***

***WORKING WITH***

*Nature*

***W O R K I N G   W I T H***

*Nature*



This research and demonstration project was funded from fees collected by the Department of Environmental Protection under Section 10 of Act 537 for the review of sewage facilities planning modules for new land development.



# P

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## Thank You

*Teamwork:*

*Collaboration, co-operation,  
co-ordination, synergy. To each of  
you a special "Thank You!" for  
making this project happen. The  
work continues!*

*Larry Hepner,  
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**IN 1994** the Department of Environmental Protection and the Agronomy and Environmental Science Department at Delaware Valley College formed the Research and Demonstration Center for On-Lot Systems and Small Flow Technology.

Funded by the DEP, the objectives of the Center were as follows:

- Consolidate data and information on systems used or under evaluation in other states and other countries.
- Establish technology priorities based on climate, geology, and soil conditions in PA where current alternatives are not available or are too costly.
- Construct six technologies and evaluate.
- Develop a final report with conclusions on systems' applicability to PA.

**A**s a first step, on-lot systems technology components in use or under evaluation were reviewed nationally and internationally from published reports and direct contact with researchers, regulators, and industry people. A data base was developed to organize, store and access this information. Resource information for determining the technologies to be used at the center came from articles found through the Delaware Valley College Library's Dialogue Information Retrieval Service, direct contact with publishers, and through contact with the National Small Flows Clearing House at West Virginia University, surrounding states and the American Society of Agricultural Engineers. All information is held in the Agronomy and Environmental Science Department at Delaware Valley College.

**T**hree nationwide trends emerged from the review of existing research information, discussions with regulatory people and discussions with industry people:

- Place systems in the Bio-Active soil zone. The bio-active soil zone is the soil horizons close to the surface, the A and B horizons. Traditionally, soil based systems (especially conventional type systems) are placed in the C horizons, beneath the bio-active zone. Most renovation occurs in the bio-active zone.
- Solids and BOD removal is needed to increase the effluent infiltration rates of soil, especially slowly permeable soil.
- There is a need to attempt to determine the thickness of the soil required to adequately renovate effluent. (Renovative Thickness)



*Also, a Treatment Component Table was developed to organize information and aid in the selection process.*

### TREATMENT COMPONENT TABLE

#### PRIMARY

Septic Tank  
Aerobic Tank

#### SECONDARY

Intermittent Sand Filter  
Recirculating Sand Filter  
Peat Filters  
Biological Filters  
N Removal  
P Removal  
Disinfection

#### SOIL BASED

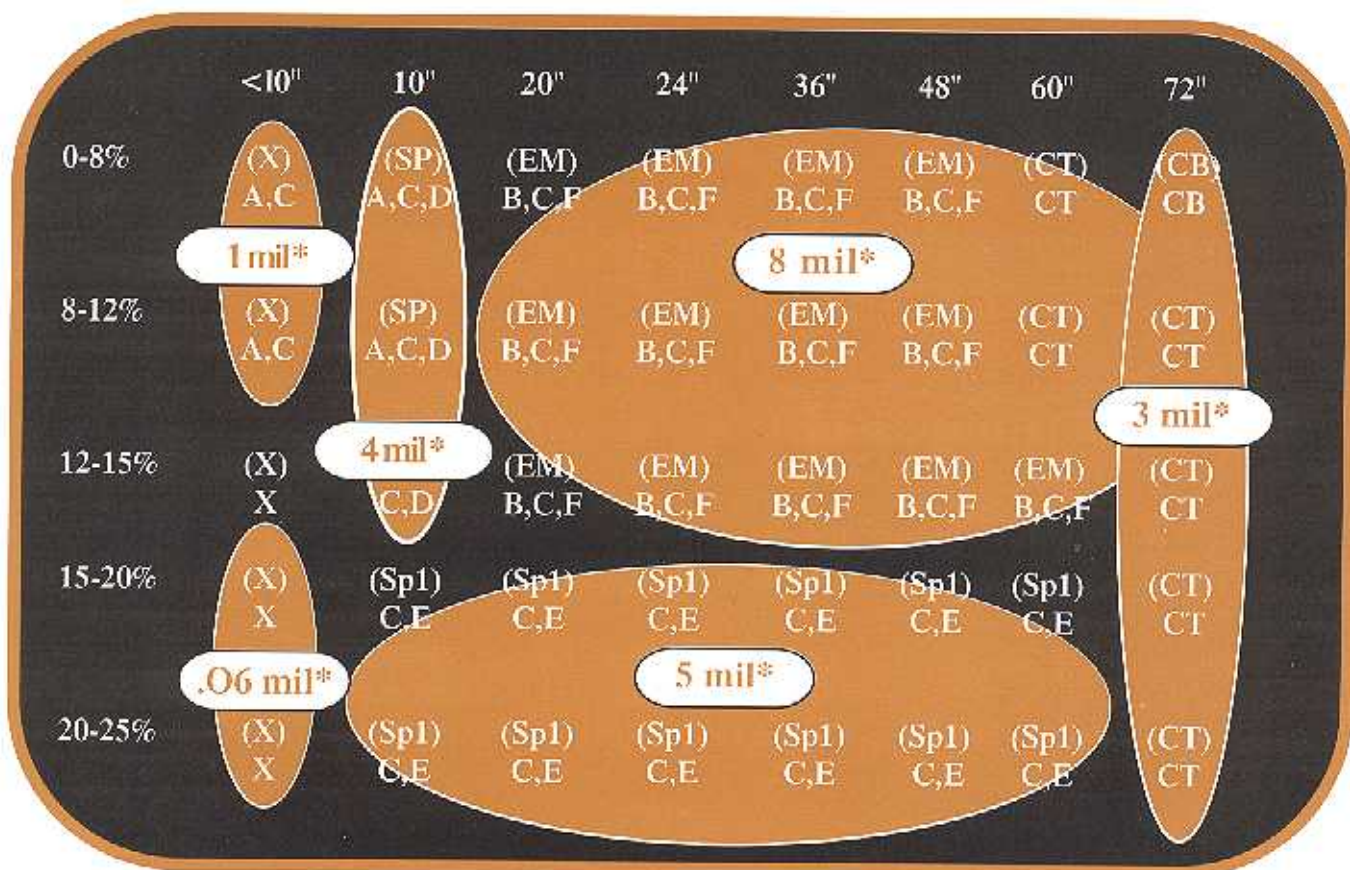
Wetland  
Spray Irrigation  
Low Pressure Pipe  
Drip Trickle  
At Grade  
Sand Mound

**S**election criteria were established for choosing the combination of primary, secondary and soil based components. The goal was to test technologies that would be applicable to the climate, geologic, and soil conditions in Pennsylvania, or specific areas of Pennsylvania. The technologies selected had the potentials to provide an alternative for those areas where no current alternative is available, or provide additional cost effective alternatives for existing system types.

**S**ix system technologies consisting of various primary treatment components, secondary treatment components, and soil based components were chosen for study as a result of the selection process. Full-scale models of these technologies were constructed for testing on the campus of Delaware Valley College. These technologies (A through F) are explained in this report. Site information, design information, and selected data are provided.



**T**HE TECHNOLOGIES THEMSELVES WERE SELECTED TO FIT AS POSSIBLE ALTERNATIVES WITHIN THE CURRENT SYSTEM MATRIX



\*Acres calculated from USDA NRCS soil survey database.

## CURRENT SYSTEM:

EM Elevated Mound  
CT Conventional Trench  
CB Conventional Bed

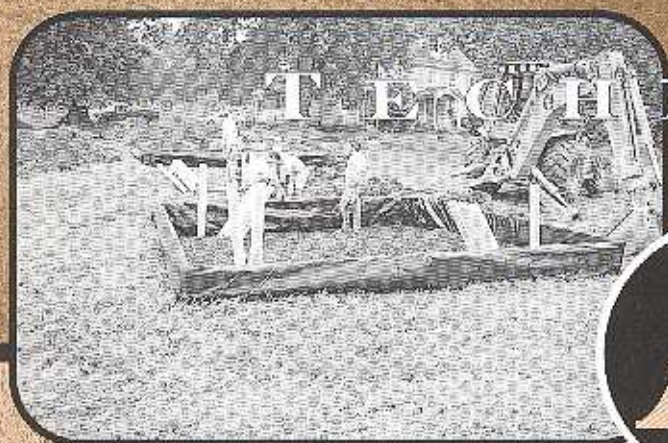
SP Spray Irrigation requiring 2 acre lot  
Sp1 Spray Irrigation requiring wooded lot

## NEW:

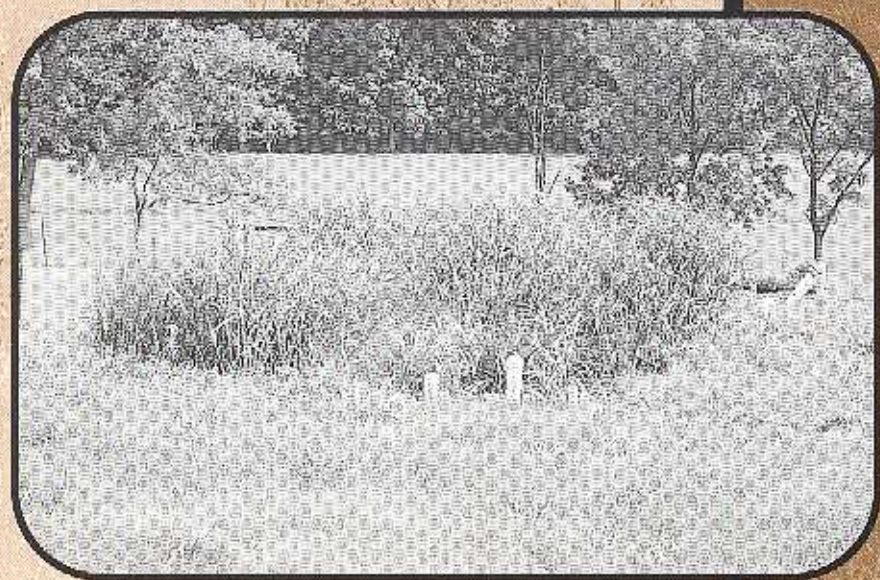
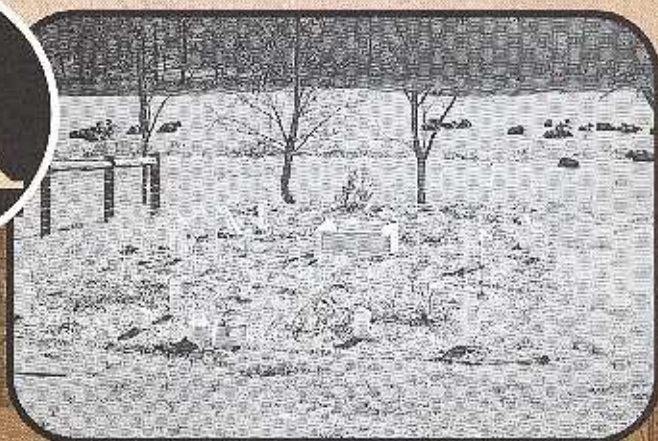
*Technologies A through F are illustrated in the positions that they could potentially fill. These technologies could provide options for 21 million acres in Pennsylvania.*

Technology A: Constructed Wetlands  
Technology B: Recirculating Sand Filters  
Technology C: Sand Filter Bank  
Technology D: At-Grade Pressure Bed  
Technology E: Drip Trickle  
Technology F: Renovative Thickness



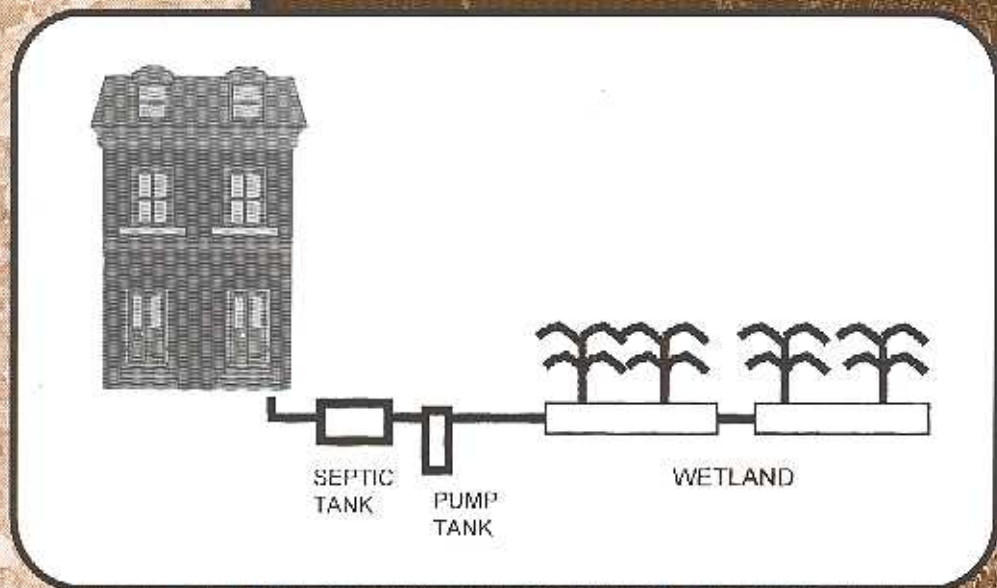


# TECHNOLOGY



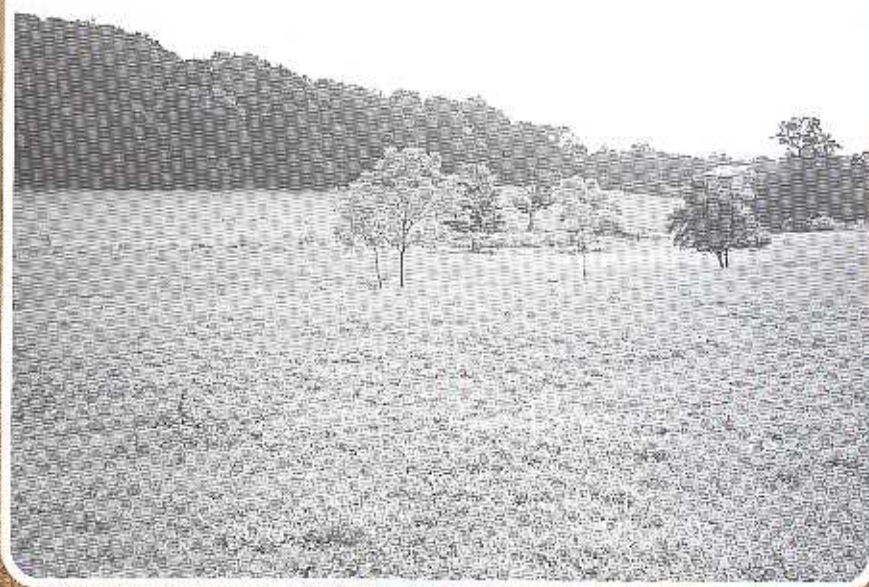


TECHNOLOGY

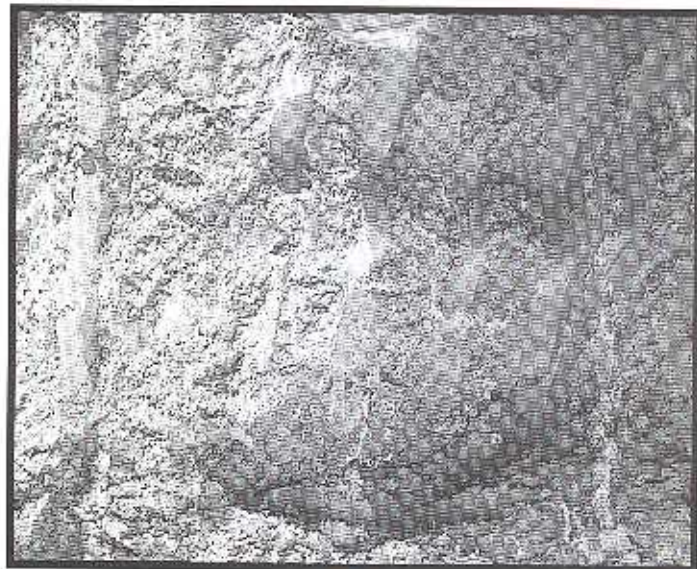


Constructed Wetlands





**A**bbottstown, somewhat poorly drained soil. Redox features (mottles) and polygonal structural cracks are common in this soil type. Seasonal high water table found at 10" beneath the surface.





*The Constructed Wetland* is a natural method of treating water. The physical and chemical processes that nature provides can be adjusted by altering factors including depth, media, and vegetation in the wetland.

There are two major categories of constructed wetlands: the free-water surface and the subsurface flow. A free-water surface wetland has water exposed to the atmosphere, while the water in a subsurface flow wetland remains below the surface of the media. This project utilizes subsurface flow wetlands.

The subsurface wetlands can have horizontal flow through the wetland, or vertical flow through the system. The wetlands on this project were designed to function by either flow method depending on valve settings. The root zone in a typical horizontal flow bed remains saturated and must rely on the macrophyte plants to supply the oxygen required for the conversion of ammonia to nitrate. Nitrate can then be converted to gaseous nitrogen in the anaerobic areas and released to the atmosphere.

Sizing guidelines provided by Tennessee Valley Authority were utilized. Calculations were performed in order to predict the minimum cross sectional area and surface area required to handle the hydraulic load and to treat the biochemical oxygen demand. The wetlands for this project were sized at 16 feet by 16 feet and approximately 2.5 feet deep. The media used was  $\frac{3}{4}$ " clean stone. *Scirpus sp.*, commonly known as bulrush, is a well-suited macrophyte due to its high ammonia tolerance and highly oxygenated rhizome. In addition, cattails and *Juncus* could be planted.

The system consists of two cells, each 16' by 16'. The first cell is lined with a 20 mil PVC liner. The second cell is open at the bottom, but lined around the sidewalls. Three wetlands were constructed. Each received septic tank quality effluent.

These systems produced an average reduction of 97% for fecal coliform bacteria, 55% for BOD, and 58% for ammonia. All values were statistically significant at the 95% level.



## Construction Time and Materials

### ITEM

1000 gallon septic tank  
500 gallon pump tank  
Outlet control box  
4" sch. 40 PVC  
4" perforated PVC  
2" sch. 40 PVC  
2" x 12" P. T. wood  
20 mil PVC cell liner  
20 mil PVC wall liner  
½ hp sewage pump  
Pump controller and alarm  
4" PVC ball valve  
¾" clean crushed aggregate  
Pea gravel  
Hardwood mulch  
Sand  
Wetland Plants  
Miscellaneous fittings

### QUANTITY

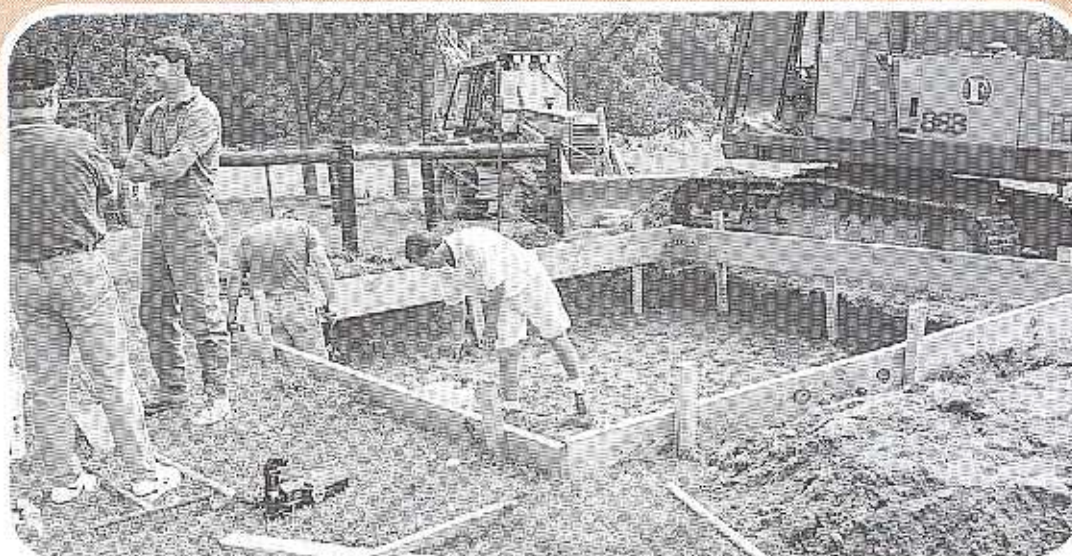
1  
1  
1  
96 l.f.  
40 l.f.  
50 l.f.  
128 l.f.  
440 ft.<sup>2</sup>  
320 ft.<sup>2</sup>  
1  
1  
1  
96 tons  
3.5 tons  
4 yds.<sup>2</sup>  
3.2 tons  
128  
varies

### LABOR

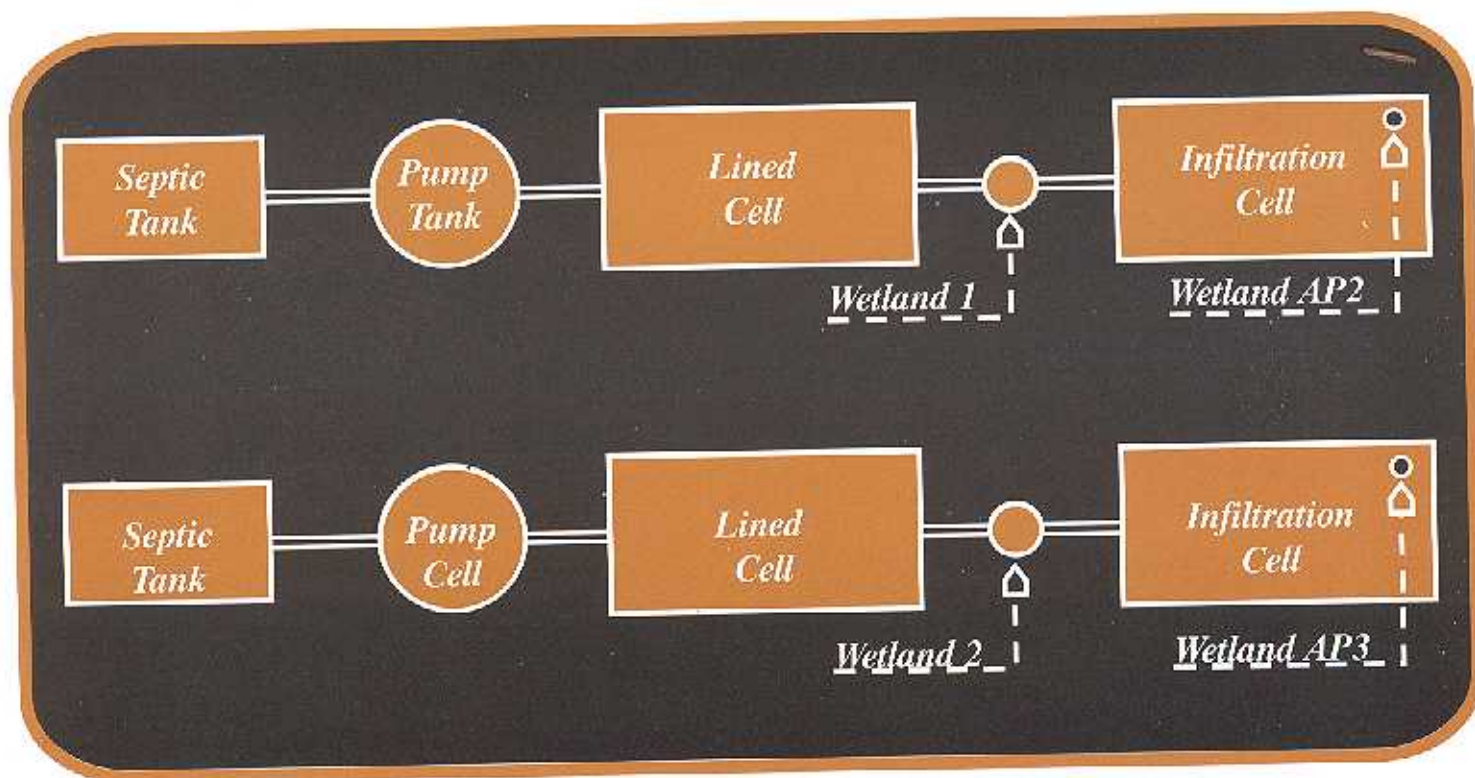
Excavation (Backhoe, operator and laborer)  
Wetlands cell assembly (2 laborers)  
Electrical (Electrician and laborer)  
Piping (2 laborers)

### TIME

36 hrs.  
24 hrs.  
8 hrs.  
10 hrs.

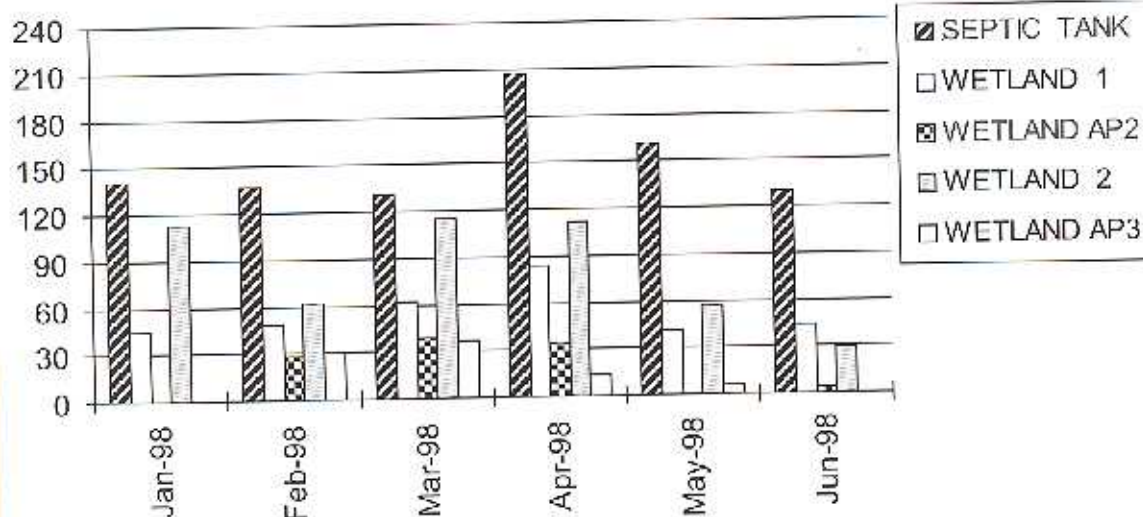






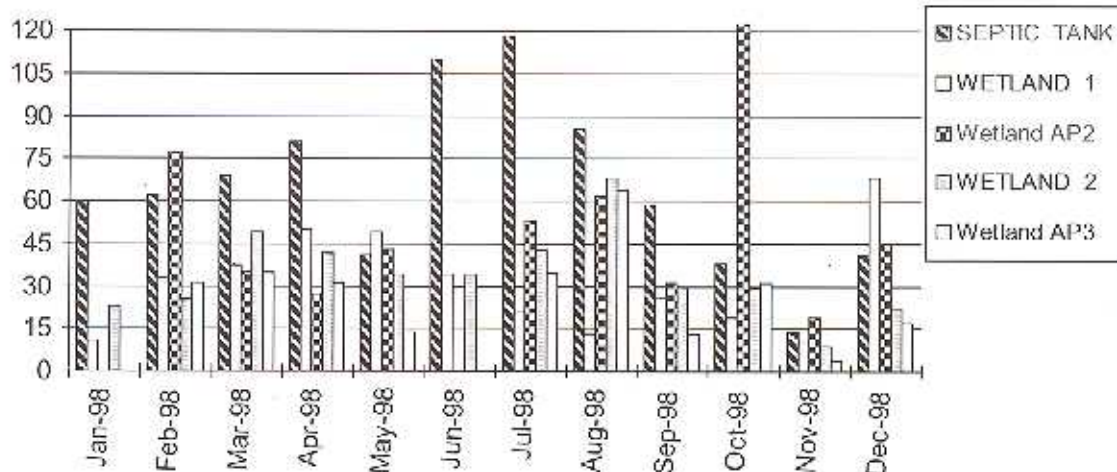
## Selected Data:

### Biological Oxygen Demand (BOD): mg/l

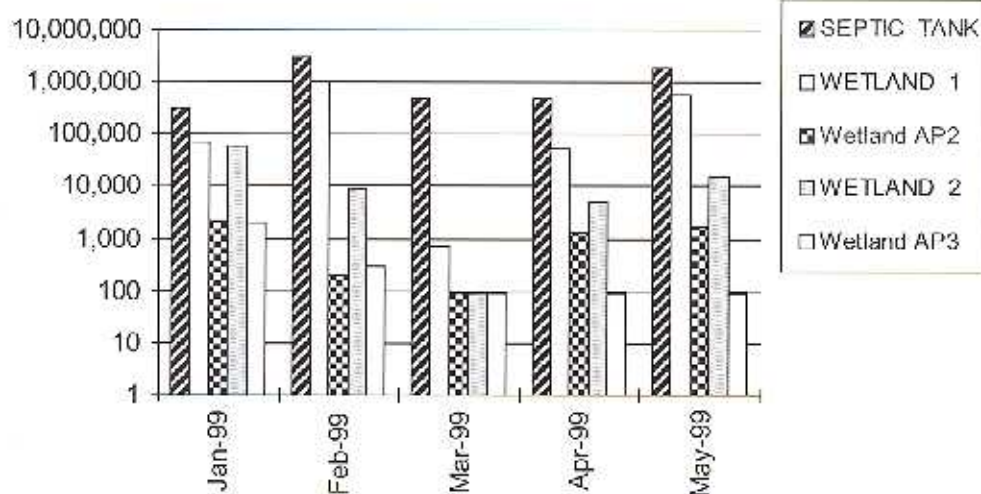




## Total Suspended Solids (TSS): mg/l



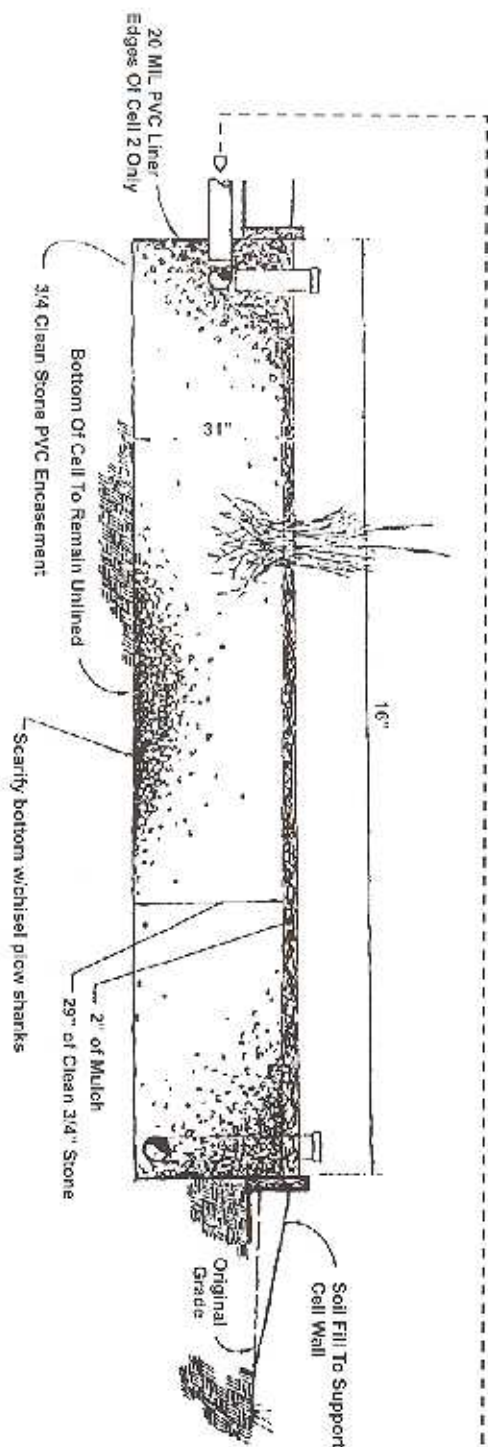
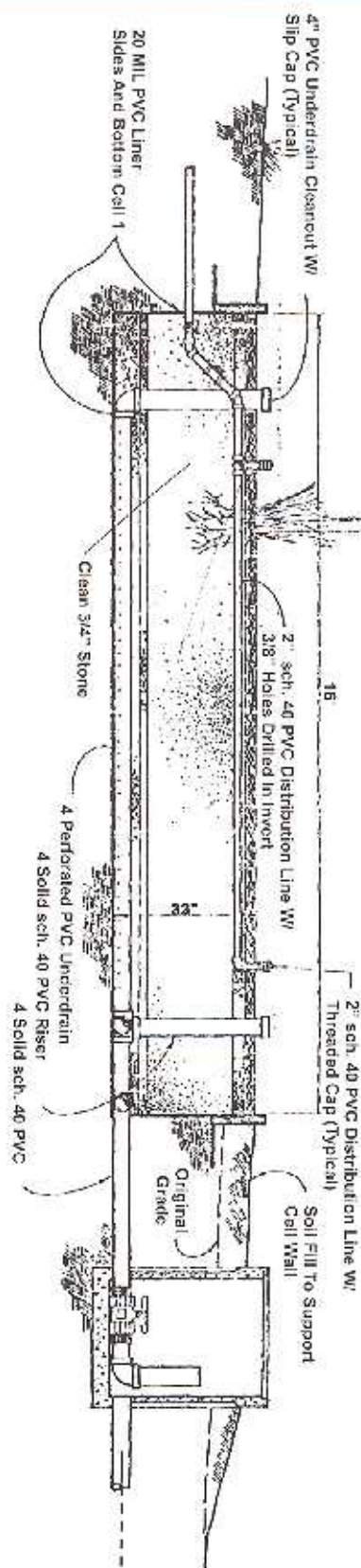
## Fecal Coliform Bacterial (FC): mpn/100 ml



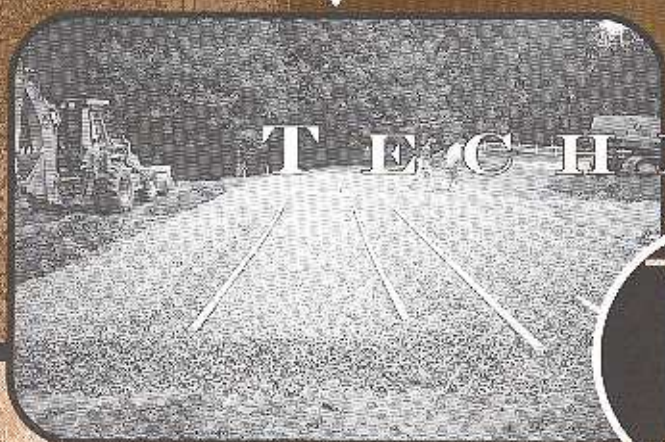
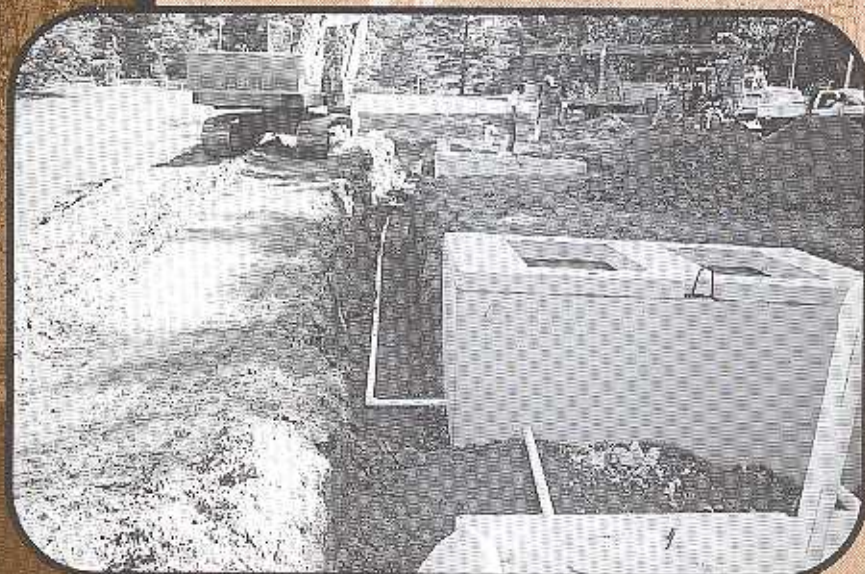


## Bed Design Diagrams

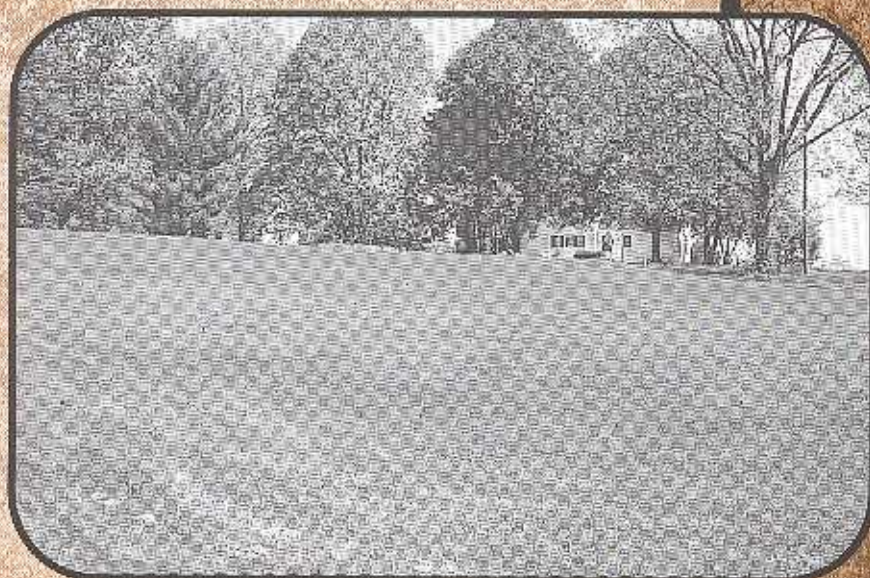
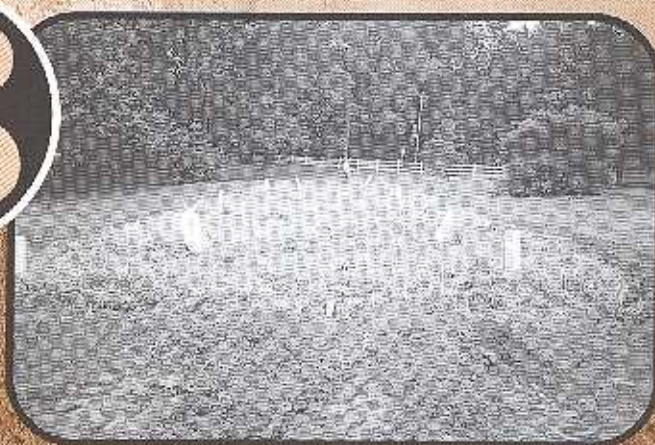
# Constructed Wetlands





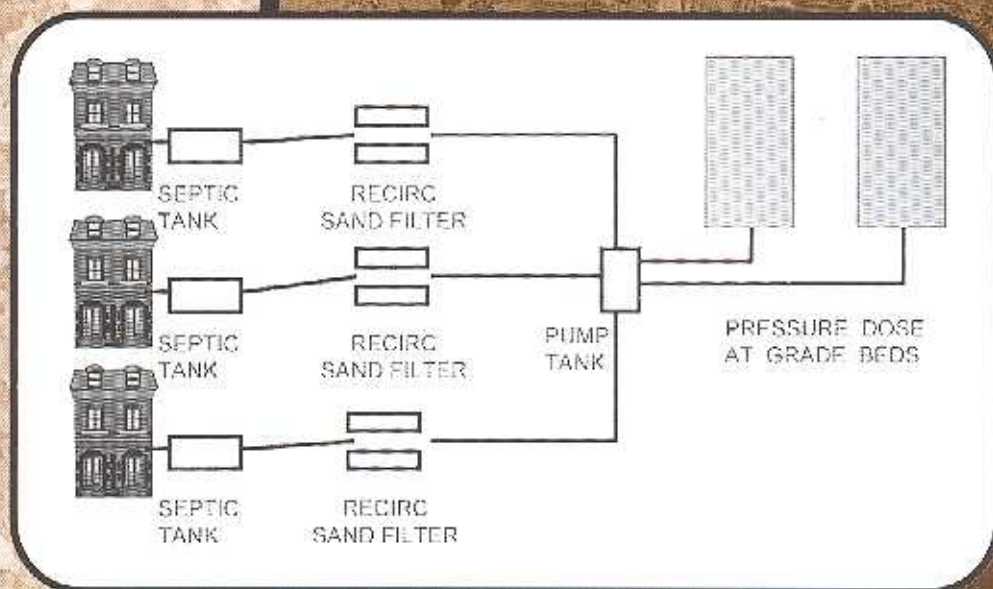


TECHNOLOGY





TECHNOLOGY---



**A COMMUNITY SYSTEM**

*Recirculation Sand Filters  
Plus  
At-Grade Pressure  
Distribution Beds*

Recirculation Sand Filters



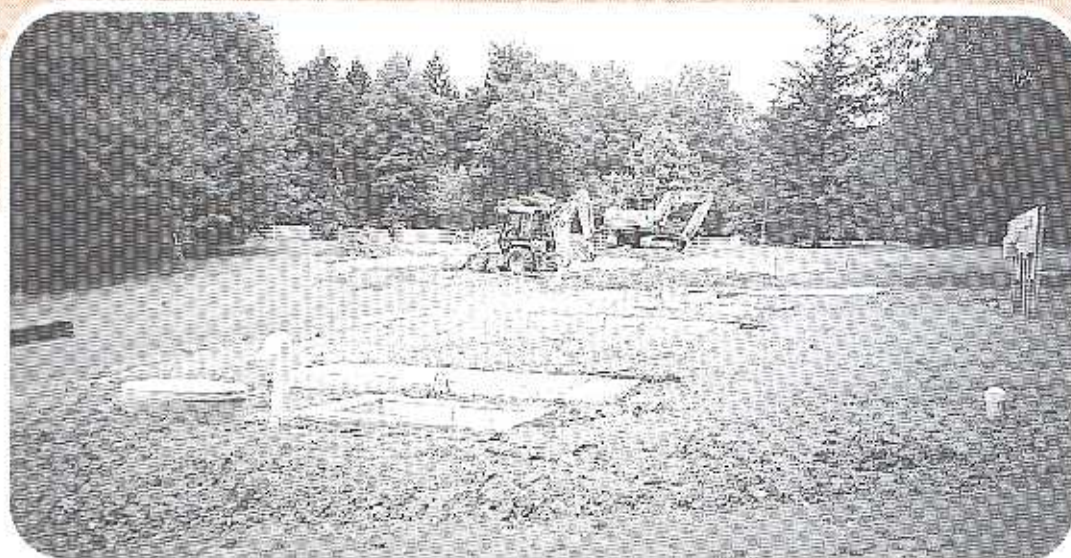


- Ap 0-7" 10YR 4/3 brown silt loam; moderate medium granular structure; clear wavy boundary; 4% coarse fragments.
- BA 7-16" 10YR 4/4 dark yellowish brown silt loam; moderate medium subangular blocky structure; abrupt irregular boundary; 3% coarse fragments.
- Bt 16-24" 10YR 5/8 yellowish silt loam with few faint 10YR 5/3 brown mottles; moderate medium angular blocky structure; abrupt wavy boundary; 3% coarse fragments.
- 2Btx1 24-34" 7.5YR 5/4 brown loam with common to many 7.5YR 6/2 pinkish gray and 7.5YR 5/8 strong brown mottles; strong very coarse prismatic and strong medium to coarse angular blocky structure; clear wavy boundary; 10% coarse fragments.
- 2Btx2 34-52" 7.5YR 5/4 brown channery loam with common prominent 5YR 6/2 pinkish gray and 7.5YR 5/8 strong brown mottles; strong very coarse prismatic and strong medium to coarse angular blocky structure; clear wavy boundary; 15% coarse fragments.
- 2C 52-70+" 10YR 7/2 loam; structureless massive; 10% coarse fragments.



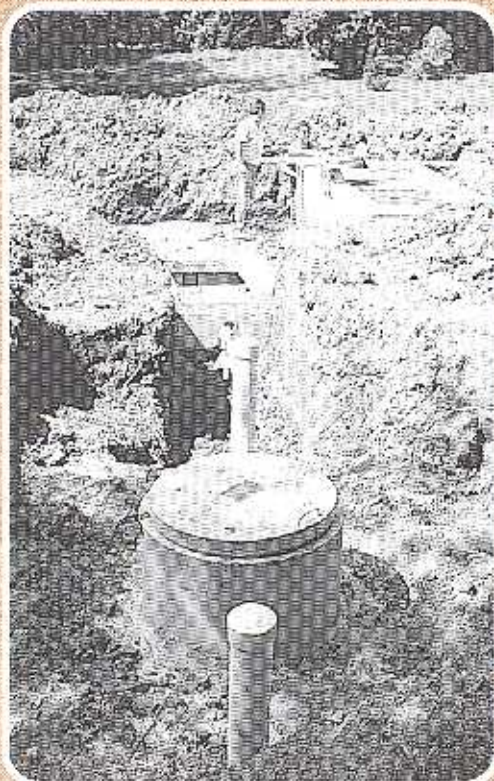
***This Technology*** is a small community system handling three individual homes. The system consists of a septic tank and recirculating sand filter for each home. The effluent from each system then flows to a common pump chamber for distribution in a community at-grade pressure distribution bed. A summary of key components is as follows:

- 1,500 gallon concrete septic tank
- 1,500 gallon concrete two compartment anoxic tank with pump chamber and rock filled chamber
- 1,500 gallon sand filter with 1mm uniform sand (coefficient of uniformity <2)
- Raw effluent flows from house through septic tank, through rock filled chamber into pump chamber of second tank. Effluent is pumped into sand filter.
- Recirculation valve in sand filter determines amount of effluent sent through sand filter and amount sent to soil absorption field. Recirculation ratios of 3:1 and 15:1 were utilized. Effluent passing through sand filter for bacteria reduction, BOD reduction, and nitrification travels back to anoxic tank (rock filled) for nitrification.
- Soils: Lawrenceville series with faint mottles at 16 inches beneath the surface; prominent mottles at 24 inches beneath the surface and a fragipan at 24 inches beneath the surface.
- Limiting zone: Several pits examined over site with mottles ranging from 17" to 24" beneath the surface.
- Slope of site: 8.2 to 10.1 percent.
- Percolation rate: Average 10.4 to 36.5 minutes per inch. Range was 6.5 minutes per inch, to 120 minutes per inch.
- Hydraulic conductivity rates: 2.0 cm/day to 4.2 cm/day.
- Dosing cycle: Beds were demand dosed.





## Typical Recirculating Sand Filter Construction One Required for Each House



### ITEM.....QUANTITY

Denitrification Tank	1
Sand	5 tons
Nitrification Tank	1
½ hp sewage pump	1
Pump controller and alarm	1
2" sch. 40 PVC	20 l.f.
4" sch. 40 PVC	16 l.f.
4" perforated PVC	24 l.f.
2" ball valve	2
4" concrete blocks	12
Pipe hangers	3
Access covers (36" square, minimum)	3
¾" clean stone	1 ton
Pea gravel	¼ ton
Miscellaneous fittings	varies

### LABOR.....TIME

Excavation (backhoe, operator and laborer)	16 hrs.
Sand and rock filter construction (2 laborers)	24 hrs.
Electrician	4 hrs.





## PERMEABILITY DATA Soil Absorption Beds

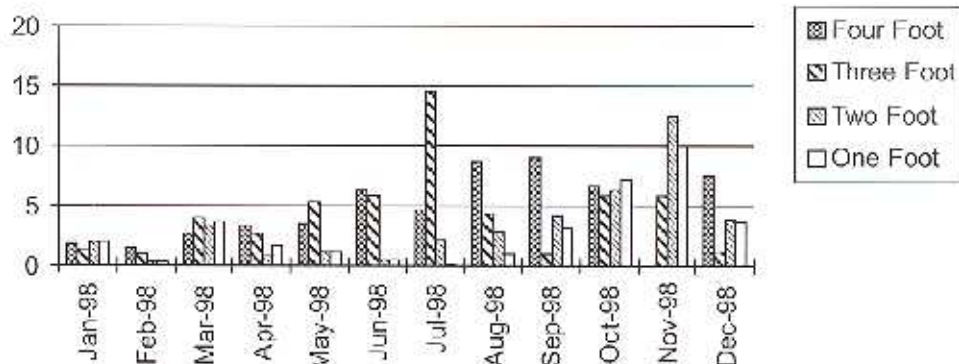
<i>Bed B1</i>	<i>Hole #</i>	<i>Perk MPI</i>	<i>cm/Day</i>	<i>Guelph Rate (cm/day)</i>
<i>Size: 15x60</i> <i>Ave. Slope: 8.2%</i>	1	10.4	351.9	3.72
	2	14.1	259.6	1.04
	3	8.9	411.2	
	4	8.6	425.6	
	5	12.0	305.0	
	6	12.6	290.5	
	7	6.5	563.1	
	8	10.0	366.0	
<i>Average</i>		10.4	352.3	2.4
<i>Geometric Mean</i>		10.1	361.5	2.0

<i>Bed B2</i>	<i>Hole #</i>	<i>Perk MPI</i>	<i>cm/Day</i>	<i>Guelph Rate (cm/day)</i>
<i>Size: 15x60</i> <i>Ave. Slope: 10.1%</i>	1	14.1	259.6	5.70
	2	34.3	106.7	2.78
	3	40.0	91.5	
	4	20.0	183.0	
	5	48.0	76.3	
	6	120.0	30.5	
	7	7.7	475.3	
	8	7.5	488.0	
<i>Average</i>		36.5	100.4	4.2
<i>Geometric Mean</i>		24.5	149.5	4.0

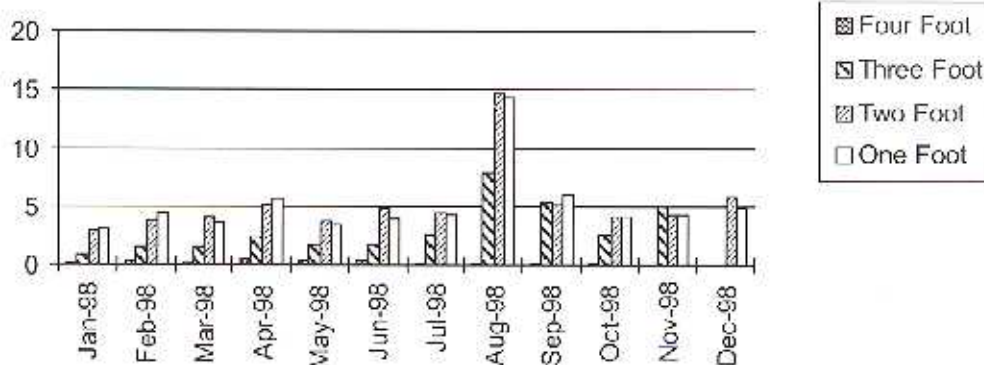


## GRAVITY LYSIMETERS BENEATH SOIL ABSORPTION BEDS

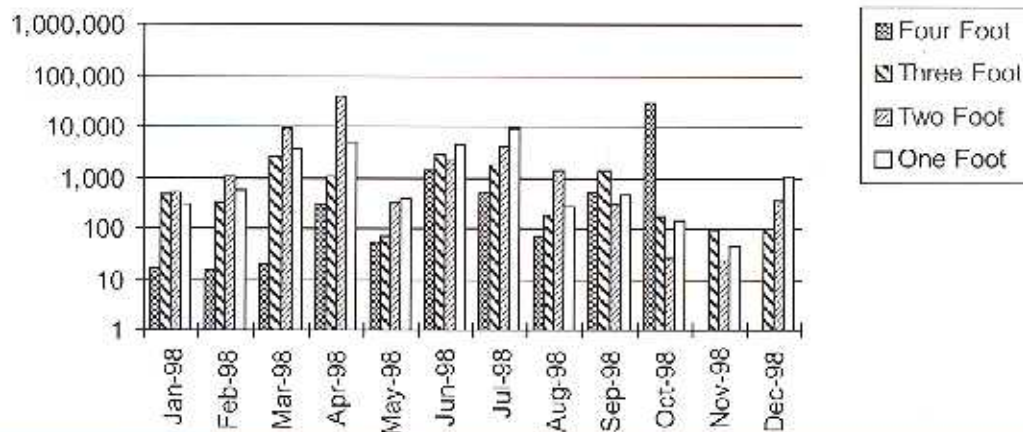
**Average NO<sub>3</sub>-N: Tech. B-1998 (mg/l)**



**Average Total Phosphorous: Tech. B-1998 (mg/l)**



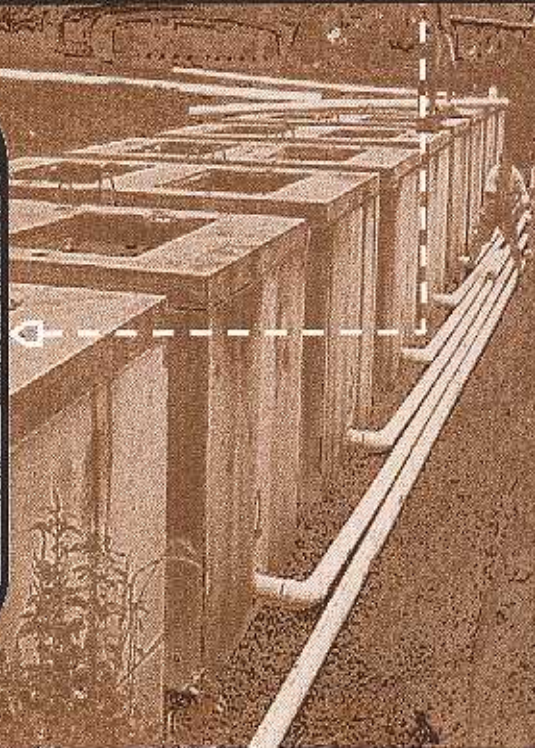
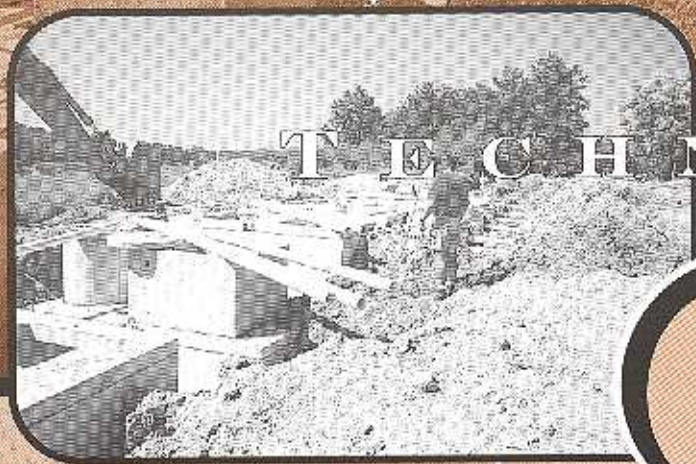
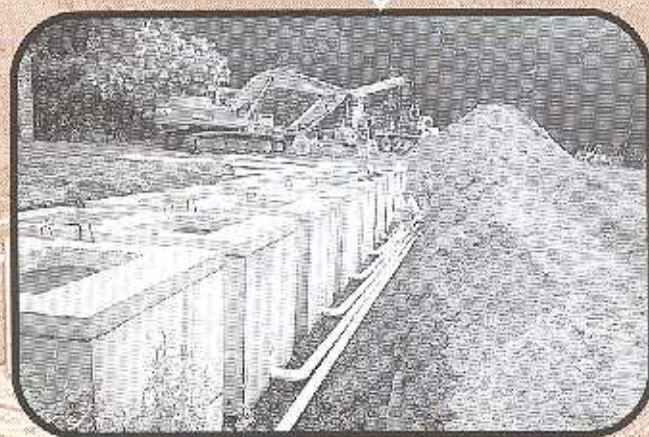
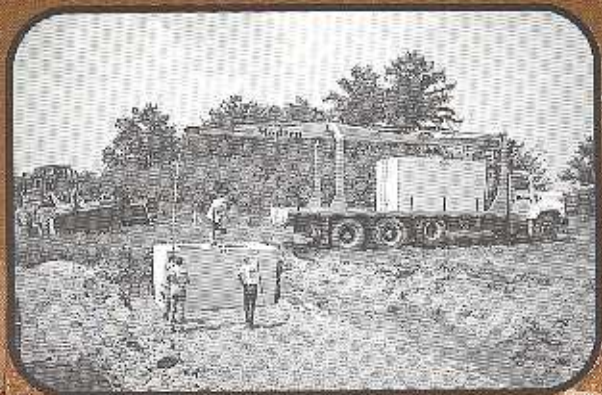
**Geo Mean Fecal Coliform: Tech. B-1998 (MPN/100ml)**





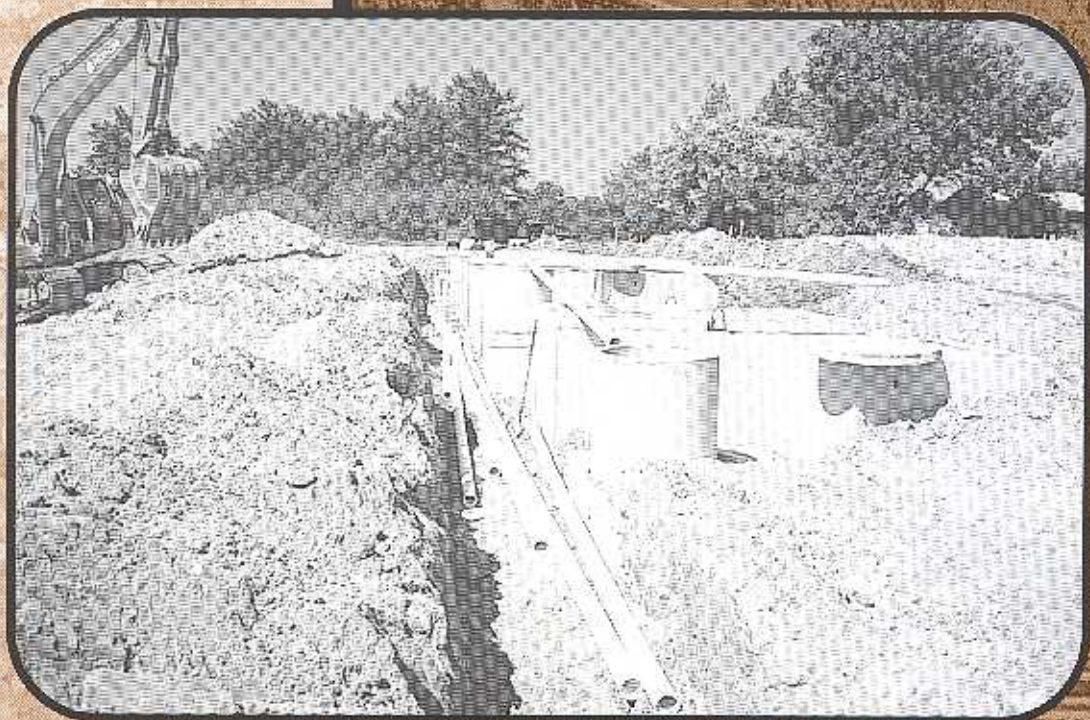








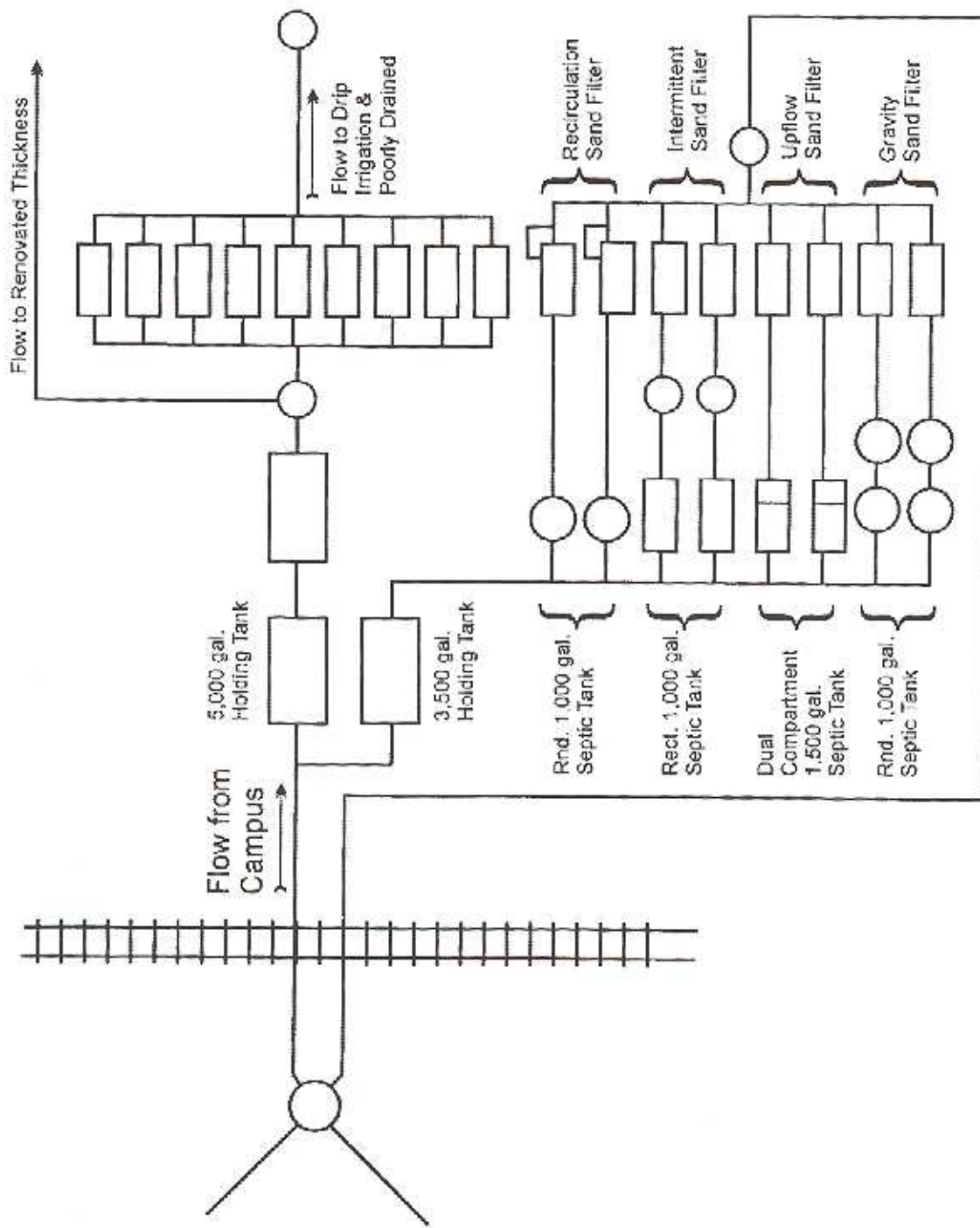
TECHNOLOGY---



Sand Filter Bank



## Schematic



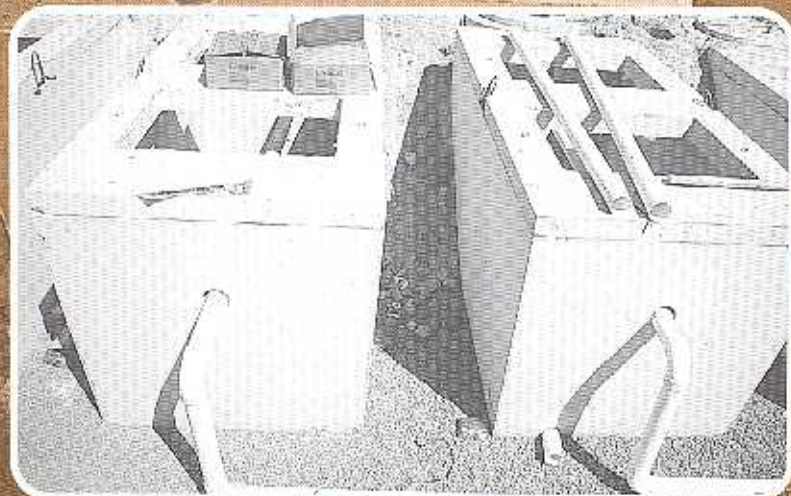
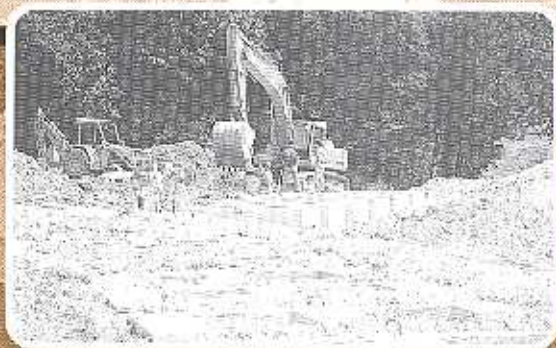


# TECHNOLOGY C: Sand Filter Bank

*Various septic tanks* and sand filters were evaluated. Effluent was drawn from the campus sewer line. The following sequences were used:

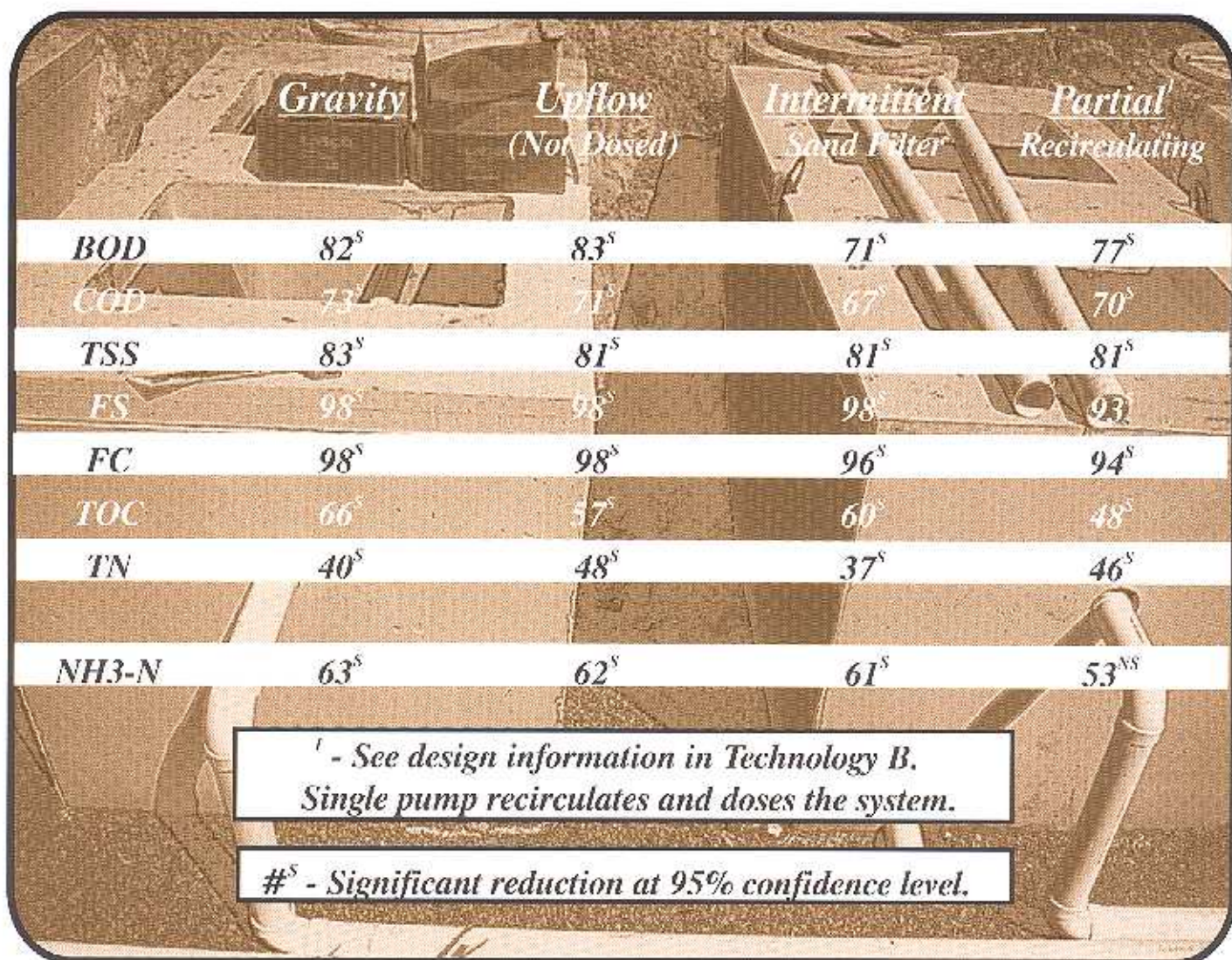
- Two 1,000 gallon round septic tanks in series to a gravity sand filter.
- One dual compartment 1,500 gallon rectangular tank to an up-flow sand filter.
- One single compartment rectangular tank to a pressure dosed single pass sand filter.
- One 1,000 gallon round septic tank to a recirculating sand filter.
- Loading rates: 8-gal./square foot/day; 5-gal./square foot/day; and 3-gal./square foot/day. Clogging occurred immediately at 8-gal./square foot/day. All sand filters functioned at 5-gal./square foot/day with the exception of the pressure dosed sand filter. Clogging occurred at the 5-gal./square foot/day-loading rate. The pressure dosed sand filter did not clog at the 3-gal./square foot/day rate.

Effluent was delivered to each septic tank from a common pump chamber. Flow pattern mimics the pattern of an individual single family home, peaking in the morning and again in the evening. Loading rates were 5-gallons/squarefoot per day for all systems except the intermittent filters, which were loaded at 3-gallons/square foot per day for a portion of the test period.





## Percentage Reduction in Selected Parameters: Various Sand Filters



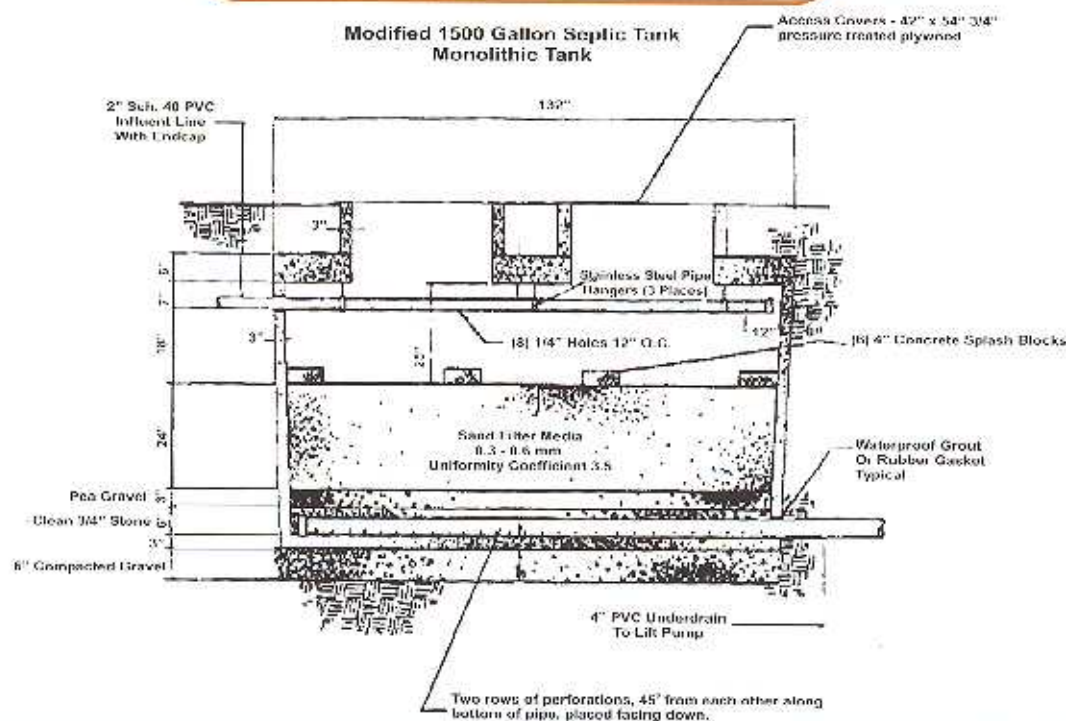
	<i>Gravity</i>	<i>Upflow (Not Dosed)</i>	<i>Intermittent Sand Filter</i>	<i>Partial<sup>1</sup> Recirculating</i>
<b>BOD</b>	82 <sup>s</sup>	83 <sup>s</sup>	71 <sup>s</sup>	77 <sup>s</sup>
<b>COD</b>	73 <sup>s</sup>	71 <sup>s</sup>	67 <sup>s</sup>	70 <sup>s</sup>
<b>TSS</b>	83 <sup>s</sup>	81 <sup>s</sup>	81 <sup>s</sup>	81 <sup>s</sup>
<b>FS</b>	98 <sup>s</sup>	98 <sup>s</sup>	98 <sup>s</sup>	93 <sup>s</sup>
<b>FC</b>	98 <sup>s</sup>	98 <sup>s</sup>	96 <sup>s</sup>	94 <sup>s</sup>
<b>TOC</b>	66 <sup>s</sup>	57 <sup>s</sup>	60 <sup>s</sup>	48 <sup>s</sup>
<b>TN</b>	40 <sup>s</sup>	48 <sup>s</sup>	37 <sup>s</sup>	46 <sup>s</sup>
<b>NH3-N</b>	63 <sup>s</sup>	62 <sup>s</sup>	61 <sup>s</sup>	53 <sup>NS</sup>

<sup>1</sup> - See design information in Technology B.  
Single pump recirculates and doses the system.

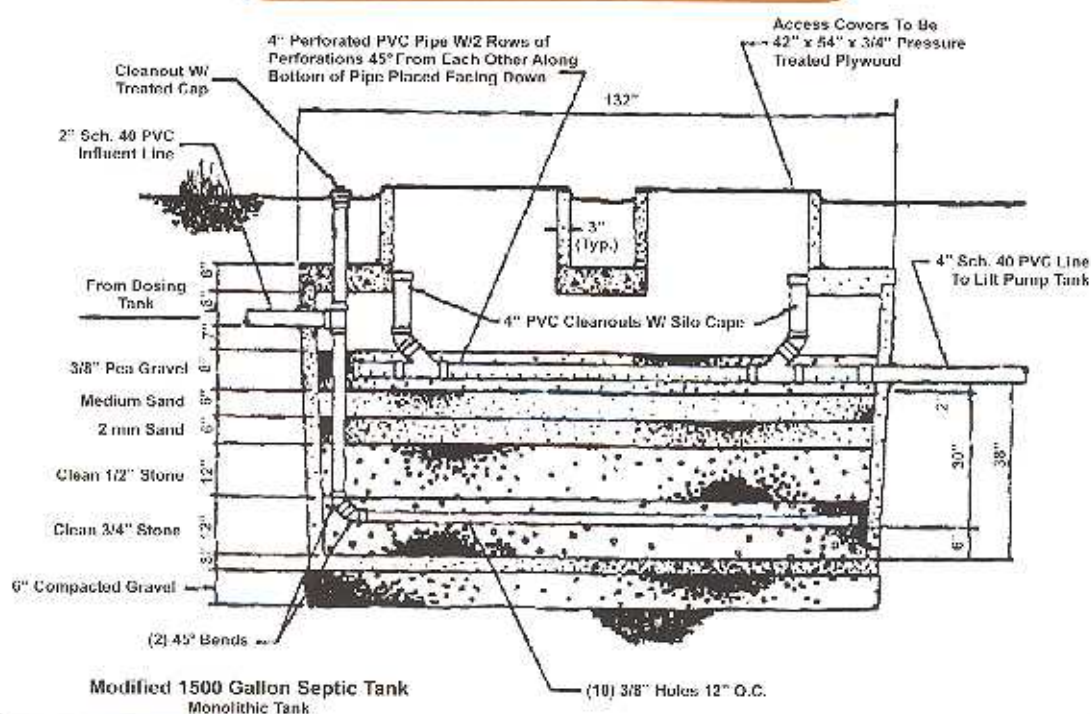
#<sup>s</sup> - Significant reduction at 95% confidence level.



## Intermittent Sand Filter



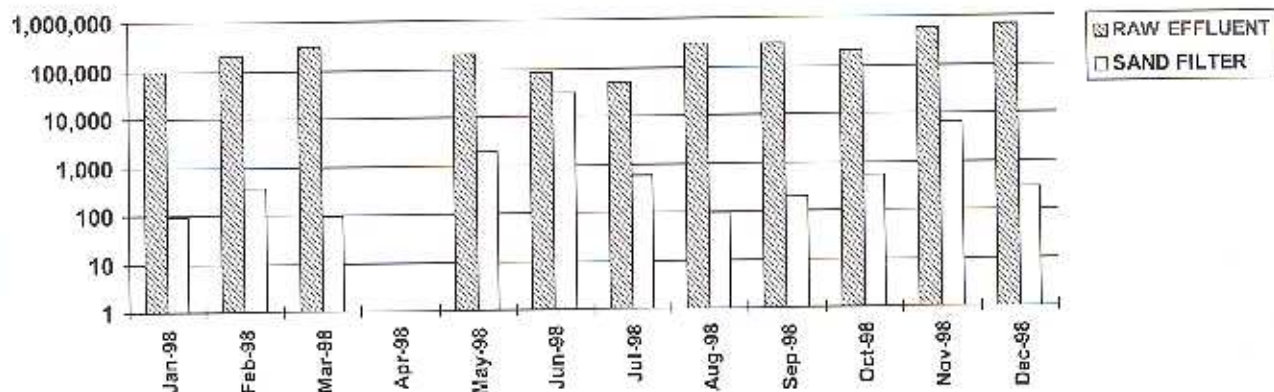
## Upflow Sand Filter



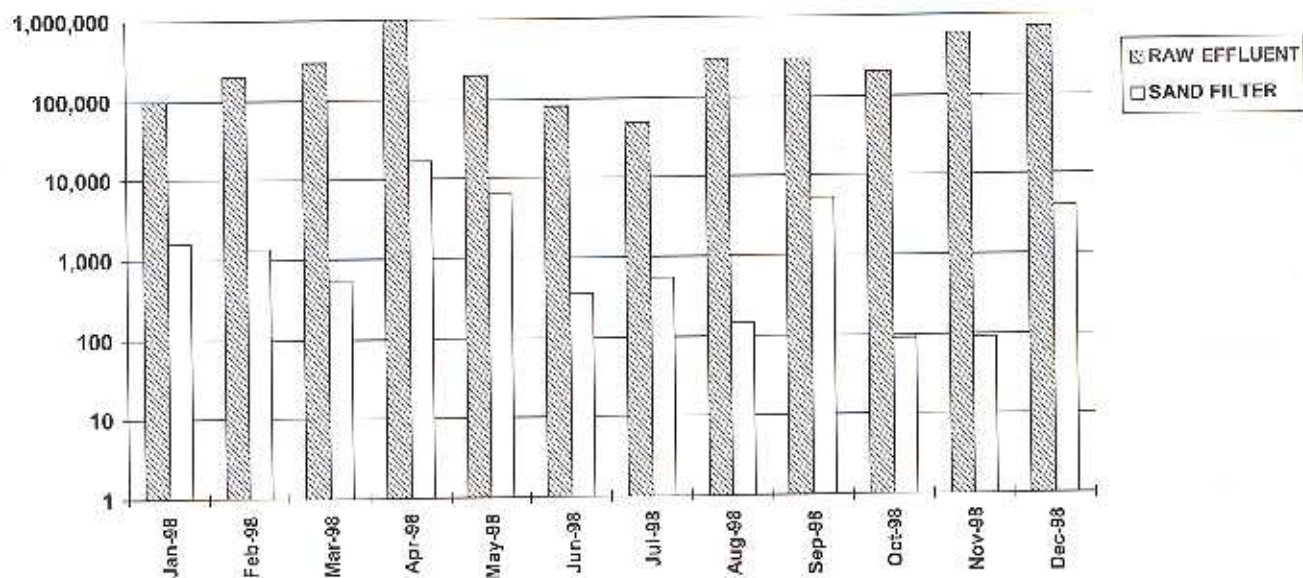


# TECHNOLOGY C: Sand Filter Bank

*FECAL STREP BACTERIA  
GRAVITY SAND FILTER 1998*  
MPN/100 ml



*FECAL STREP BACTERIA  
INTERMITTENT SAND FILTER 1998*  
MPN/100 ml





# Sand Filter Bank

### Monolithic Tank





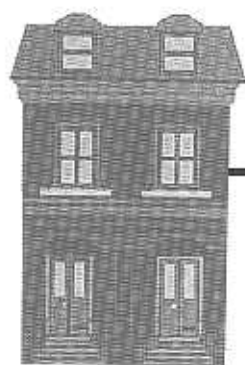


# TECHNOLOGY





TECHNOLOGY



SEPTIC  
TANK

PUMP  
TANK

SAND  
FILTER

PUMP  
TANK

AT GRADE  
PRESSURE  
DISTRIBUTION

Sand Filter Plus At-Grade Bed



## Typical At-Grade System

Item	Quantity	
1000 gallon septic tank	1	
500 gallon septic tank	1	
4" sch. 40 PVC	20 l.f.	
2" sch. 40 PVC	80 l.f.	
1 1/2" sch. 40 PVC	216 l.f.	
1/2 hp sewage pump	1	
Pump controller & alarm	1	
3/4" crushed aggregate	7 tons	
Topsoil cover	110 yds. <sup>3</sup>	
Miscellaneous fittings	varies	
Labor	Time	
Excavation (Backhoe, operator and laborer)	24 hrs.	
At-grade bed construction	16 hrs.	
Electrical (Electrician and laborer)	8 hrs.	
Piping (2 laborers)	10 hrs.	

## Typical Sand Filter Construction Intermittent

Item	Quantity	
Sand filter tank	1	
Sand	5 tons	
Pump tank	1	
1/2 hp sewage pump	1	
Pump controller and alarm	1	
2" sch. 40 PVC	20 l.f.	
4" perforated PVC	12 l.f.	
2" ball valve	1	
4" concrete blocks	12	
Pipe hangers	3	
Access covers (36" square min.)	2	
3/4" clean stone	1/4 ton	
Pea gravel	1/4 ton	
Miscellaneous fittings	varies	
Labor	Time	
Excavation (Backhoe, operator and laborer)	8 hrs.	
Sand filter construction (2 laborers)	8 hrs.	
Electrician	4 hrs.	

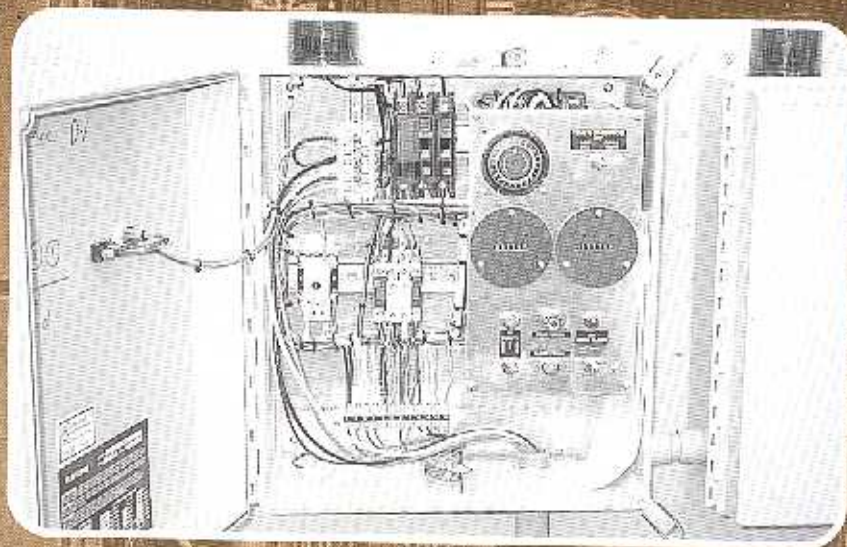


## TECHNOLOGY D: Sand Filter Plus At-Grade Bed

**Effluent was drawn** from the campus sewer system, passed through one of two 3,000 gallon single compartment septic tanks hooked in parallel and through one of 9 single pass intermittent sand filters with uniform (coefficient of uniformity  $< 2$ ) 2mm sand. Effluent was then sent to an at-grade pressure distribution soil absorption area. Each absorption area was dosed four times per day. Initial flow was 400 gpd but was quickly reduced to 250 gpd and eventually down to 75 gpd.

- Limiting zone depth: 13 inches beneath the surface.  
Slope: 3.7 to 3.9%
- Percolation rate: Average 70 to 197 minutes per inch. Range was 10.4 to 240 minutes per inch.
- Hydraulic conductivity: 0.4 to 5.8 cm per day.
- Dosing cycle: Dosed four times each day; flows 250 gpd down to 75 gallons per day
- Breakout of effluent from beds at flow rates greater than 75 gallons per day

**Chalfont series**, somewhat poorly drained; common faint mottles at 8" beneath the surface; common distinct mottles at 13 inches beneath the surface; fragipan at 21 inches beneath the surface.





## Technology D At-Grade Bed Data

Bed:	D1	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	1	60	61	4.96
Avg. Slope:	3.8	2	34.3	106.7	0.33
		3	60	61	
		4	34.3	106.7	
		5	120	30.5	
		6	40	91.5	
		7	240	15.3	
		8	80	45.8	
Average:			83.6	64.8	2.6
Geometric Mean:			66.7	64.9	1.3

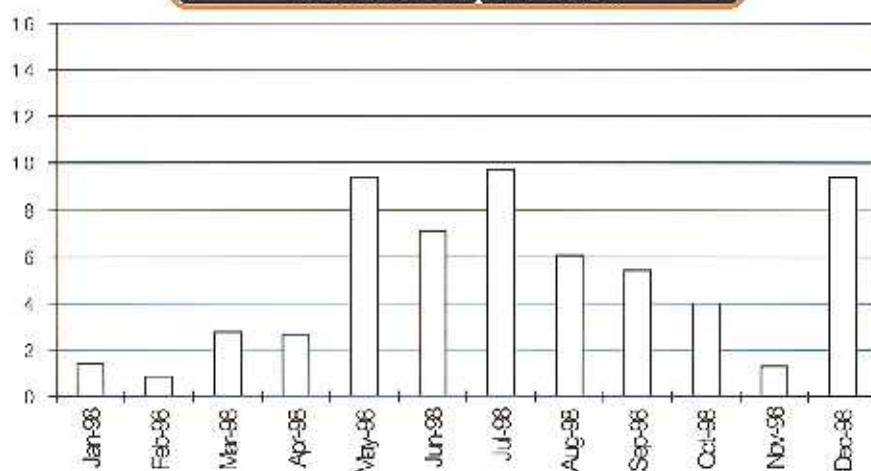
Bed:	D2	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	1	240	15.3	0.75
Avg. Slope:	3.8	2	17.1	214	0.12
		3	120	30.5	
		4	240	15.3	
		5	240	15.3	
		6	240	15.3	
		7	240	15.3	
		8	240	15.3	
Average:			197.1	42	0.4
Geometric Mean:			158.2	23.1	0.3

Bed:	D3	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	1	120	30.5	2.16
Avg. Slope:	3.9	2	60	61	9.42
		3	10.4	351.9	
		4	16	228.8	
		5	40	91.5	
		6	80	45.8	
		7	120	30.5	
		8	120	30.5	
Average:			70.8	108.8	5.8
Geometric Mean:			52.2	70.1	4.5

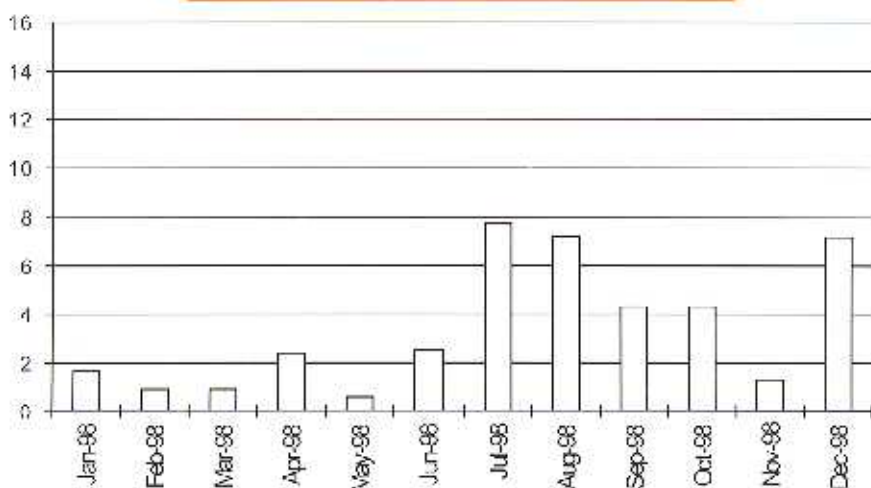


# TECHNOLOGY D: Sand Filter Plus At-Grade Bed

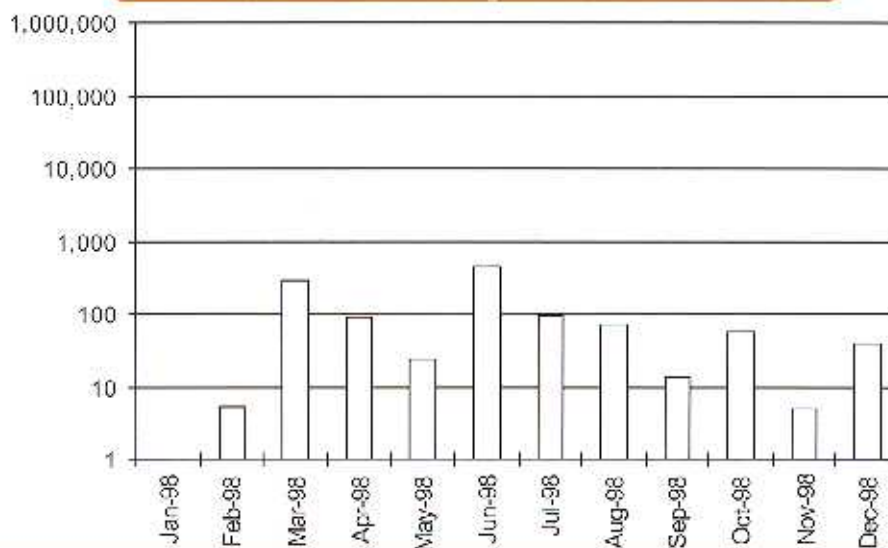
*Average Nitrate Tech. D - mg/l  
One Foot Depth - 1998*



*Average Nitrate Tech. D - mg/l  
Four Foot Depth - 1998*



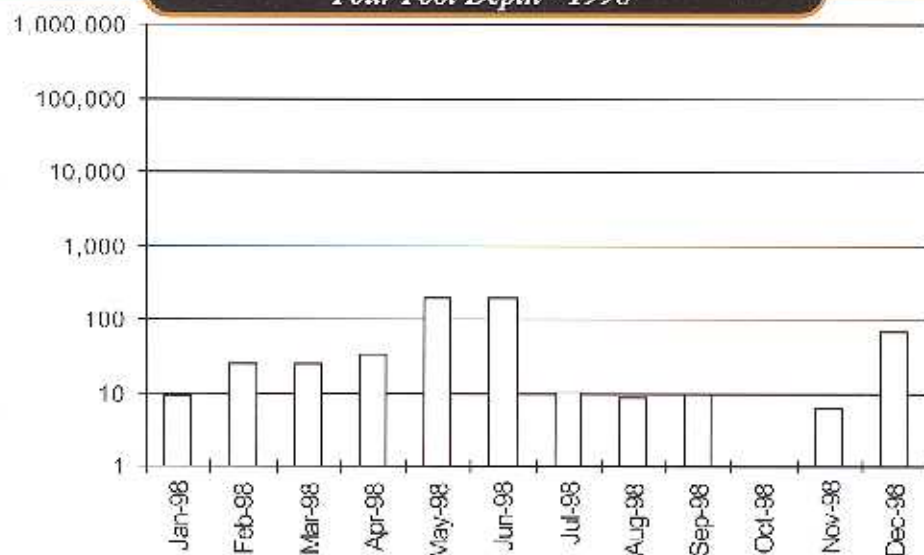
*Geo Mean Fecal Coliform Tech. D - MPN/100ml  
One Foot Depth - 1998*



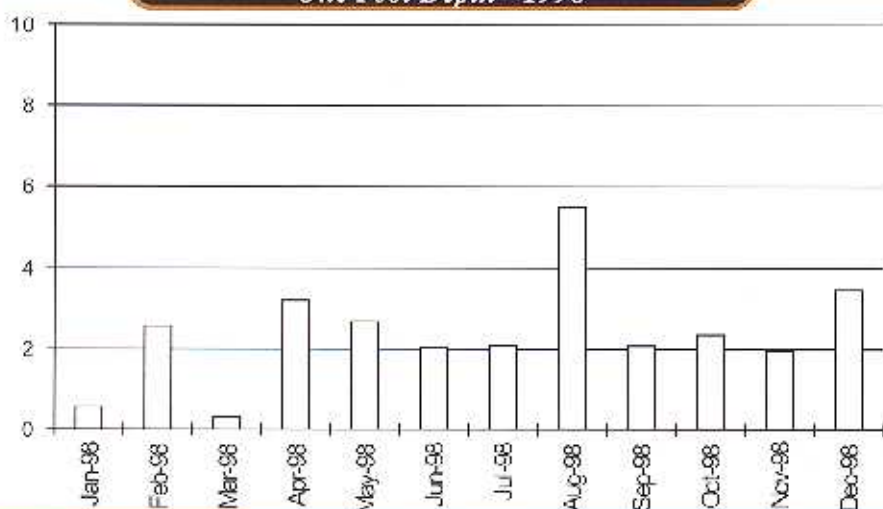


# TECHNOLOGY D: Sand Filter Plus At-Grade Bed

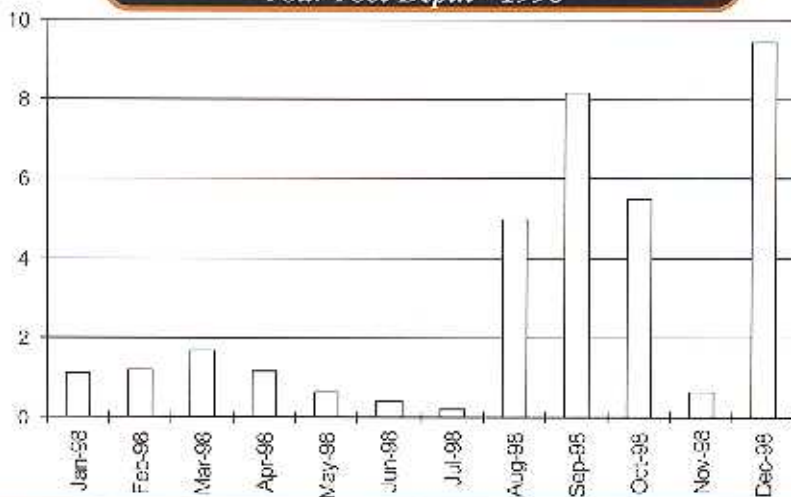
**Geo Mean Fecal Coliform Tech. D - MPN/100ml  
Four Foot Depth - 1998**



**Average Total Phosphorous Tech. D - mg/l  
One Foot Depth - 1998**



**Average Total Phosphorous Tech. D - mg/l  
Four Foot Depth - 1998**



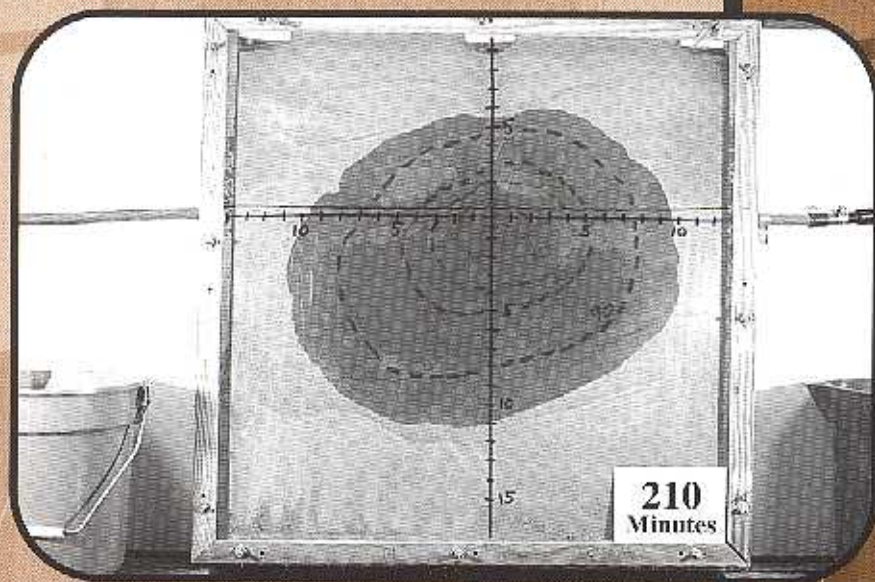
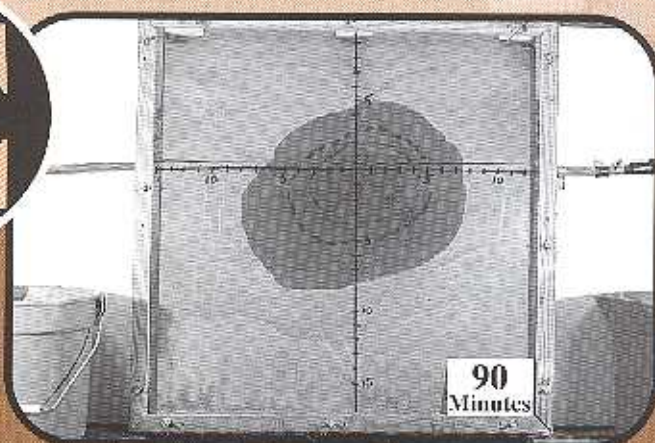
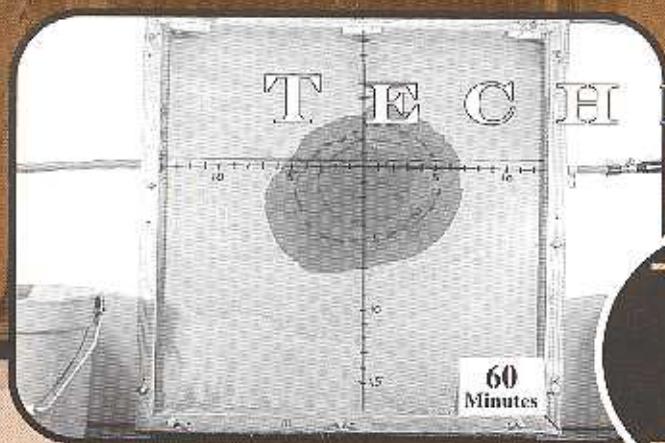
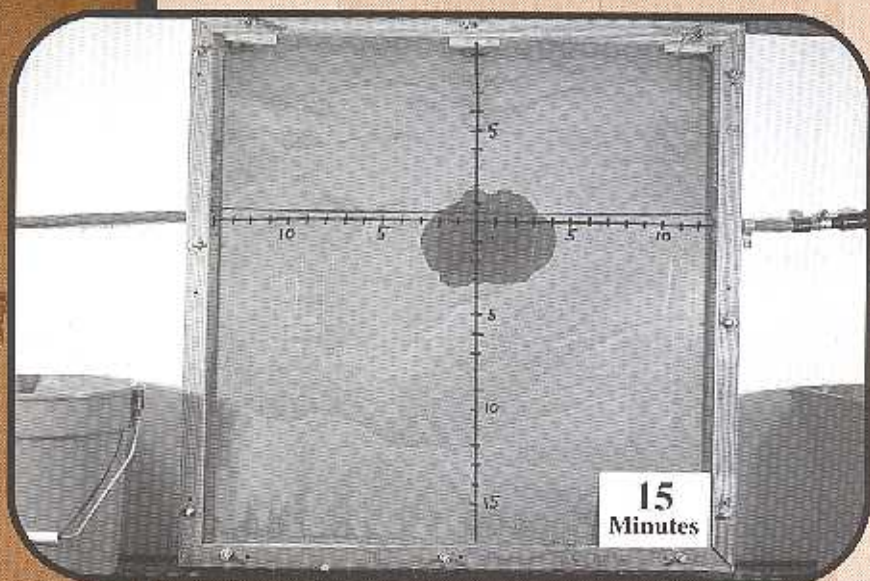






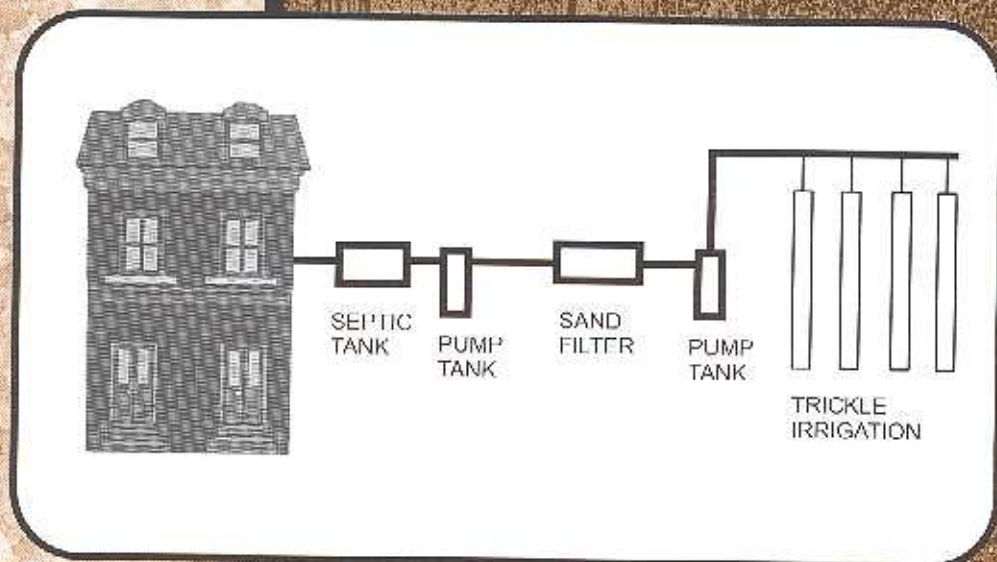
# Wetting Front Movement

*(Through Soil, Away From Emitter)*





TECHNOLOGY



Drip/Trickle Irrigation



# TECHNOLOGY E: Drip/Trickle Irrigation

*Single pass, sand filter* treated effluent is sent to trickle irrigation systems. Each trickle irrigation system doses two 600 lineal foot zones 5 times per day with disc filtered effluent. After 20 doses the system automatically flushes the lines. Prior to each dose, the disc filters are backwashed.

- Limiting zone: 25 inches, mottles.
- Slope: 18.4 to 24.3%
- Percolation rate: Average 20.1 to 58.4 minutes per inch. Range was 2.8 minutes per inch to 120 minutes per inch.
- Hydraulic conductivity: 9.9 to 17.6 cm/day..
- Dosing cycle: Each zone is dosed five time per day; each system has two zones.
- Each system received approximately 400 gallons per day.

**R***eadington series, moderately well drained; common distinct mottles at 25 inches, with fragipan.*





# TECHNOLOGY E: Drip/Trickle Irrigation

Bed:	E1	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	3	48	76.3	5.94
Avg. Slope:	18.39	4	5	732	13.82
		5	24	152.5	
		6	10.4	351.9	
		7	3.8	963.2	
		8	26.7	137.1	
		9	34.3	106.7	
		10	2.8	1307.1	
		11	21.8	167.9	
		12	24	152.5	
Average:			20.1	414.7	9.9
Geometric Mean:			14.1	260	9.1

Bed:	E2	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	28	120	30.5	17.63
Avg. Slope:	20.39	29	40	91.5	
		30	17.1	214	
		1	16	228.8	
		2	2.9	1262.1	
		13	120	30.5	
		14	120	30.5	
		15	20	183	
		16	48	76.3	
		17	80	45.8	
Average:			58.4	219.3	17.63
Geometric Mean:			36.5	100.2	

Bed:	E3	Hole #	Perk Rate (MPI)	cm/day	Guelph Rate cm/day
Bed Size:	15x60	23	48	76.3	
Avg. Slope:	24.25	24	4.4	831.8	13.82
		25	6.7	546	
		26	18.5	197.8	
		27	48	76.3	
		18	120	30.5	
		19	120	30.5	
		21	60	61	
		22	40	91.5	
Average:			51.7	215.8	13.82
Geometric Mean:			32.8	111.7	

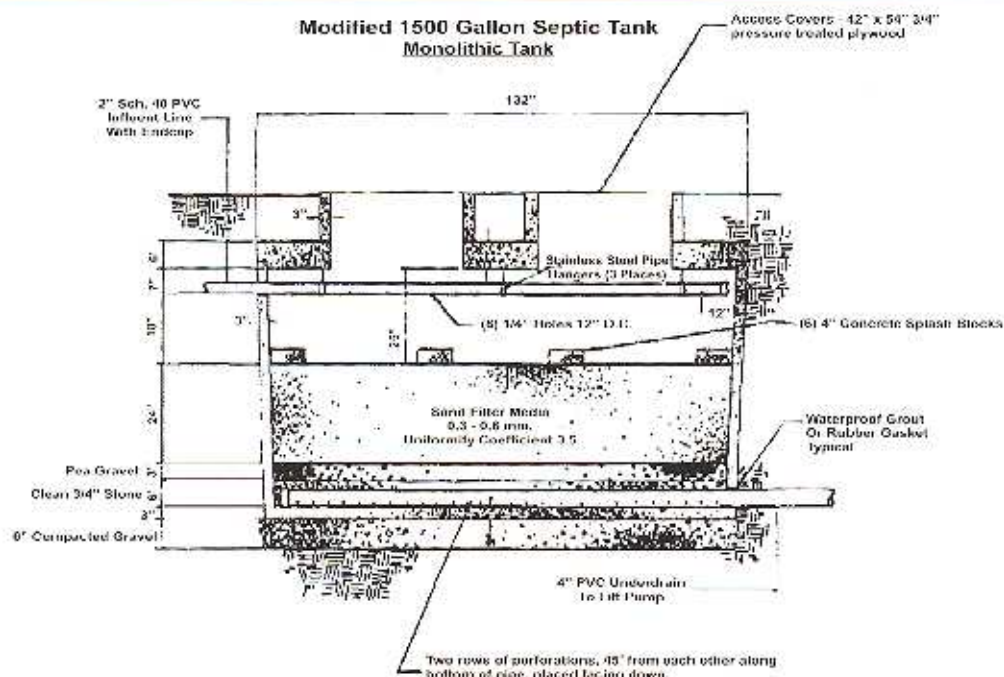


## Typical Drip Irrigation System Materials and Labor

ITEM	QUANTITY
1,000 gallon septic tank .....	1
500 gallon pump tank .....	1
Sand filter tank .....	2
1,000 gallon pump tank .....	1
4" sch. 40 PVC .....	100 l.f.
2" sch. 40 PVC .....	30 l.f.
1 1/2" sch. 40 PVC .....	150 l.f.
1" sch. 40 PVC .....	100 l.f.
6" sch. 40 PVC .....	12 l.f.
American On-Site 2 Zone Drip System .....	1 lot
<i>Includes: Controller, hydraulic control unit, valve box, float tree, pump, 2,000 l.f. of tubing, black flexible PVC, specialty fittings.</i>	
1/2 hp sewage pump .....	1
Sand filter media .....	10 tons
Miscellaneous fittings .....	varies

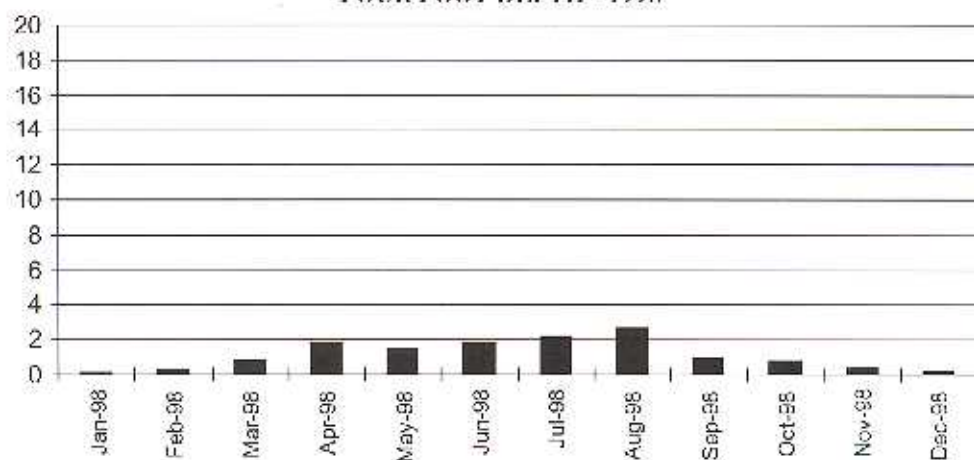
*Note: Sand filters & 500 gallon pump tank can be replaced with peat filter in some instances.*

LABOR	TIME
Excavation (Backhoe, operator and laborer) .....	28 hrs.
Dripper line installation (2 laborers & cable plow) .....	32 hrs.
Electrical (Electrician and laborer) .....	16 hrs.
Piping (2 laborers) .....	32 hrs.

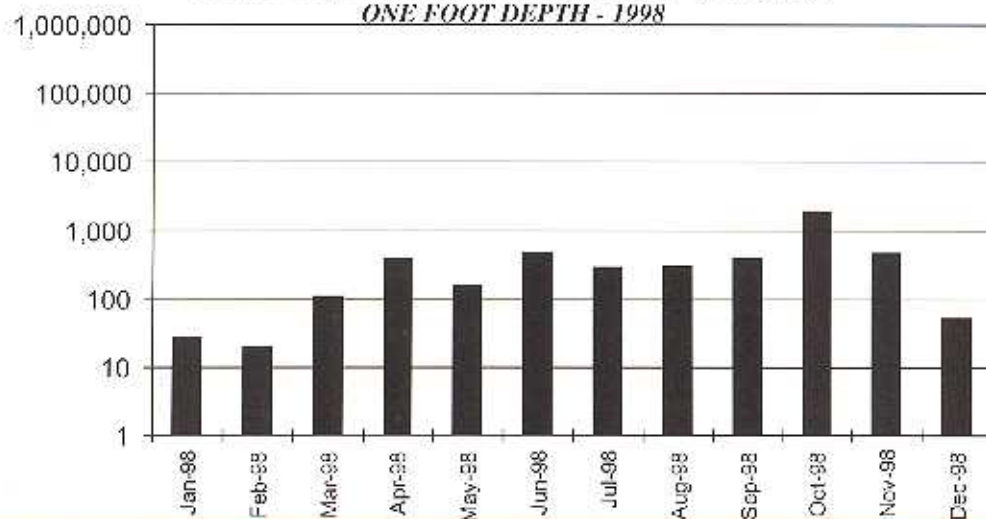




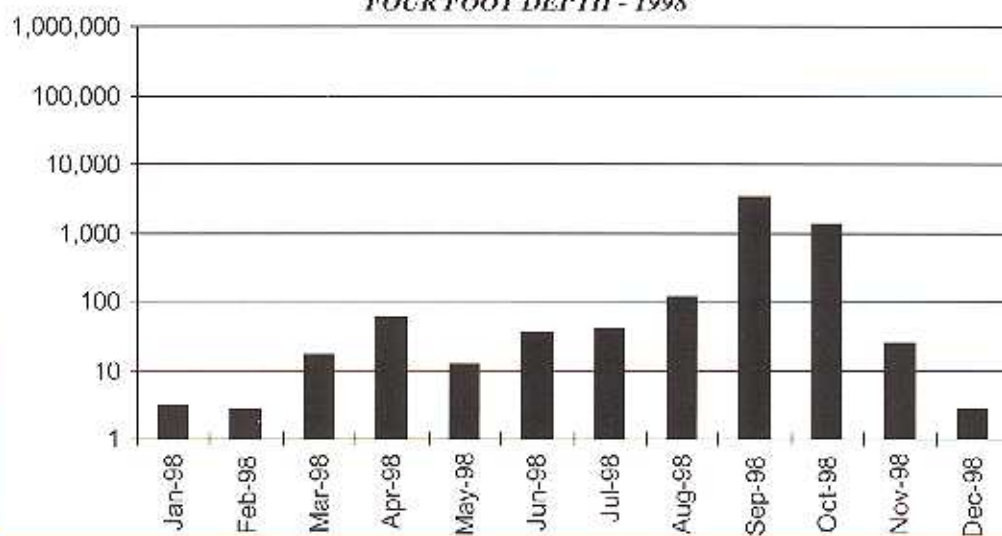
**AVERAGE TOTAL PHOSPHOROUS TECH E -mg/l  
FOUR FOOT DEPTH - 1998**



**GEO MEAN FECAL COLIFORM TECH E - MPN/100ml  
ONE FOOT DEPTH - 1998**



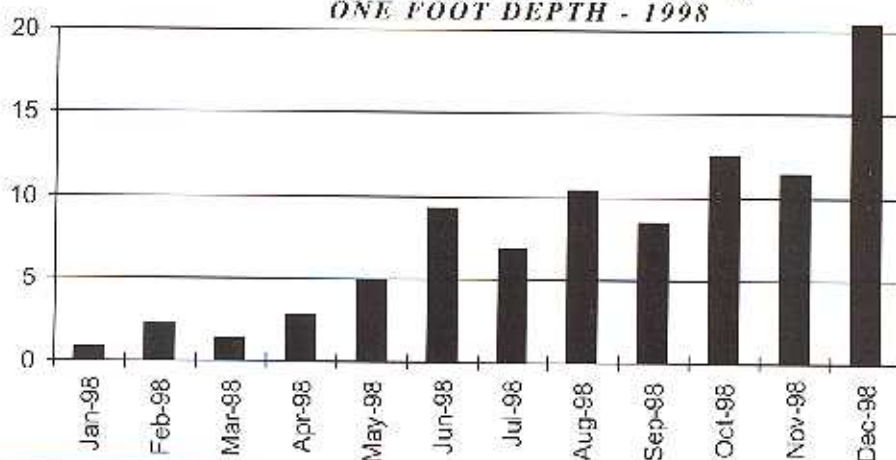
**GEO MEAN FECAL COLIFORM TECH E - MPN/100ml  
FOUR FOOT DEPTH - 1998**



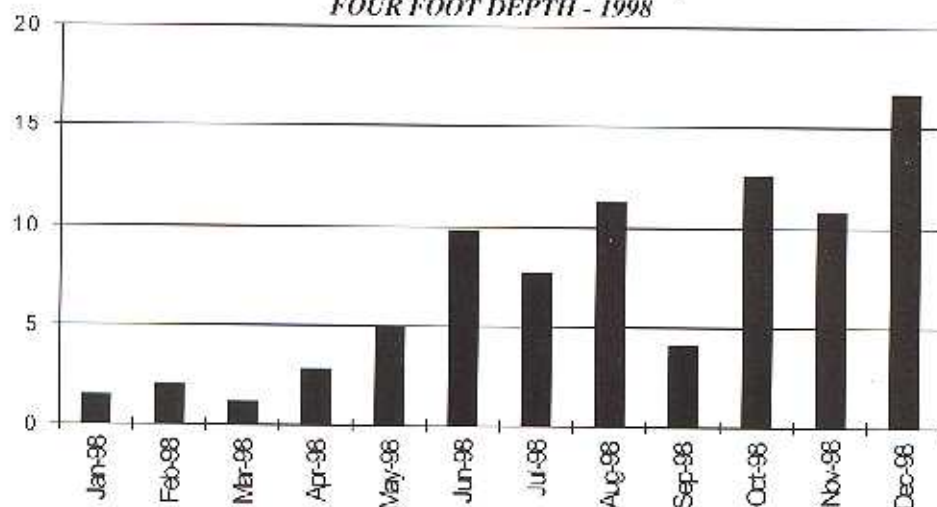


# TECHNOLOGY E: Drip/Trickle Irrigation

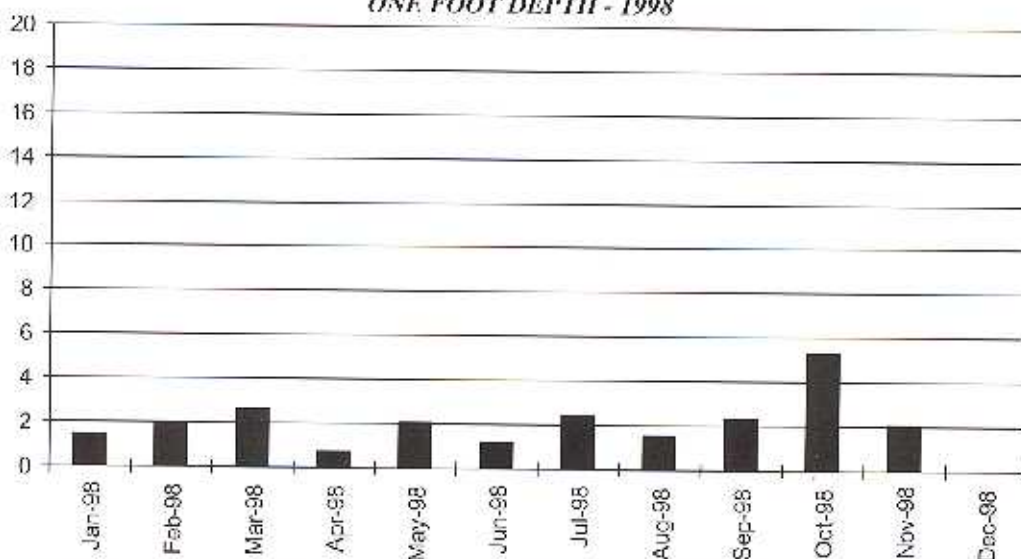
*AVERAGE NITRATE TECH. E - mg/l  
ONE FOOT DEPTH - 1998*



*AVERAGE NITRATE TECH. E - mg/l  
FOUR FOOT DEPTH - 1998*

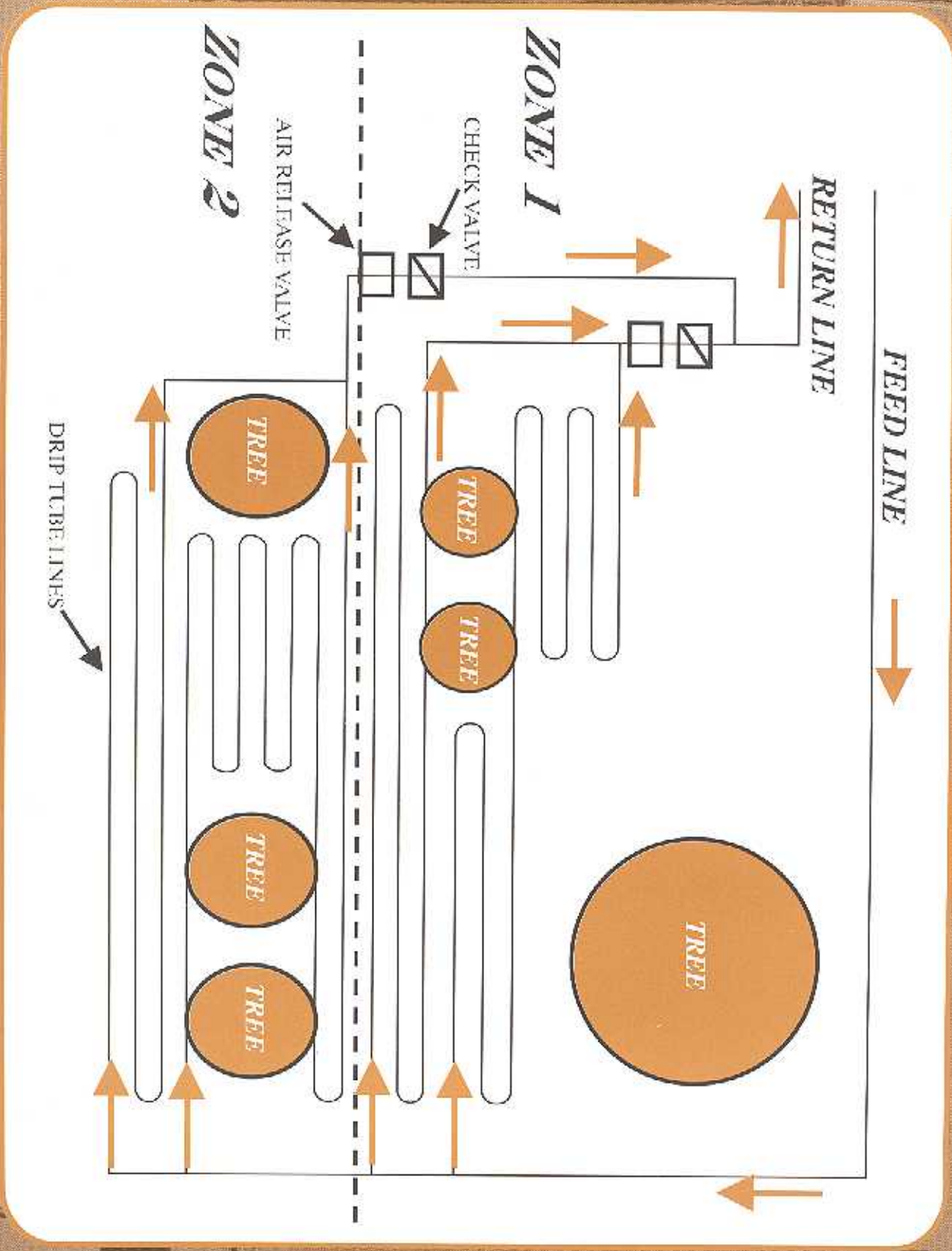


*AVERAGE TOTAL PHOSPHOROUS TECH. E - mg/l  
ONE FOOT DEPTH - 1998*

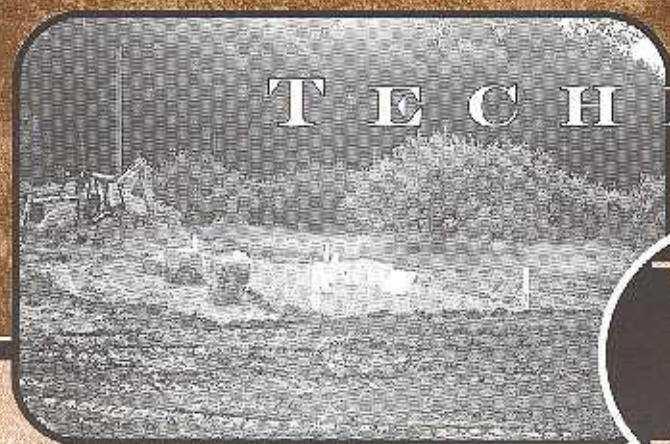
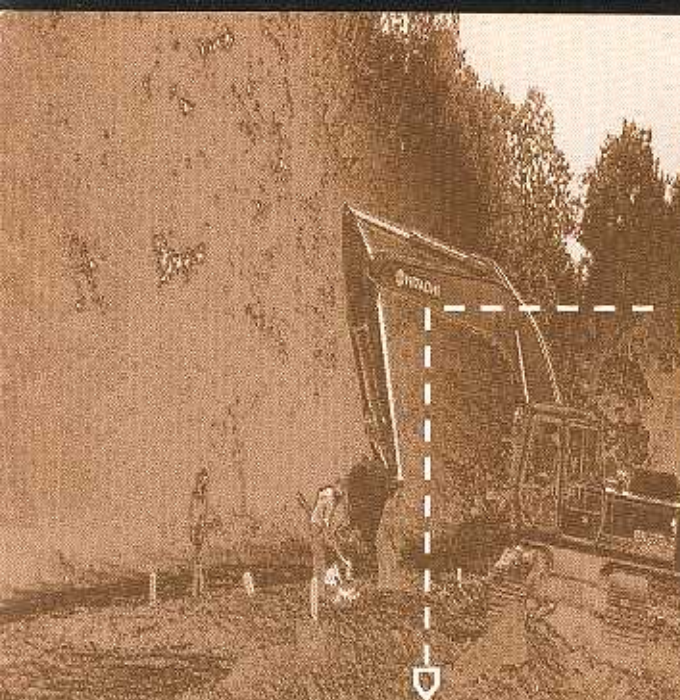




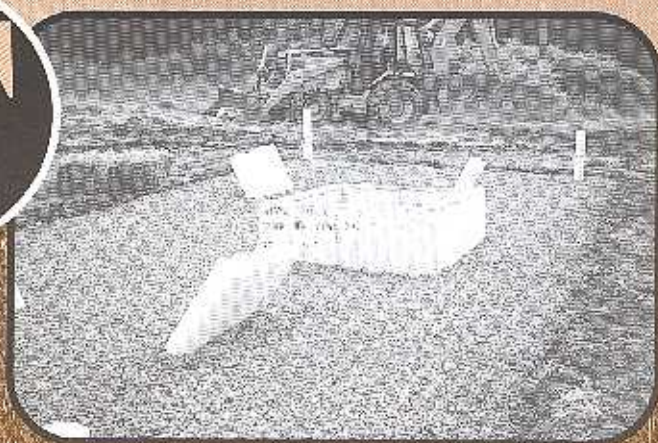
# Drip/Trickle Irrigation





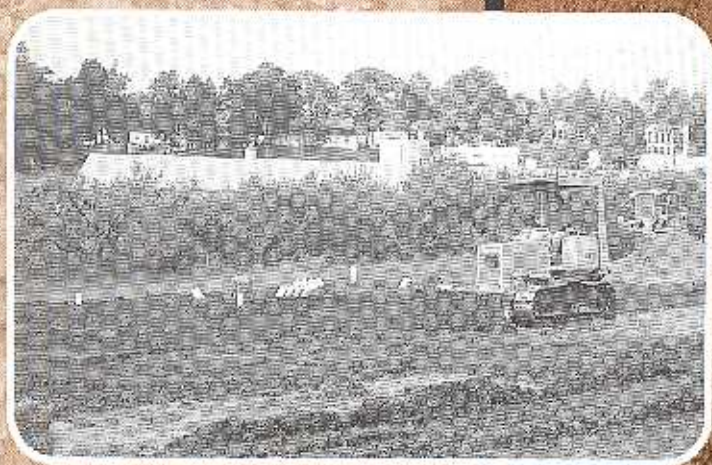
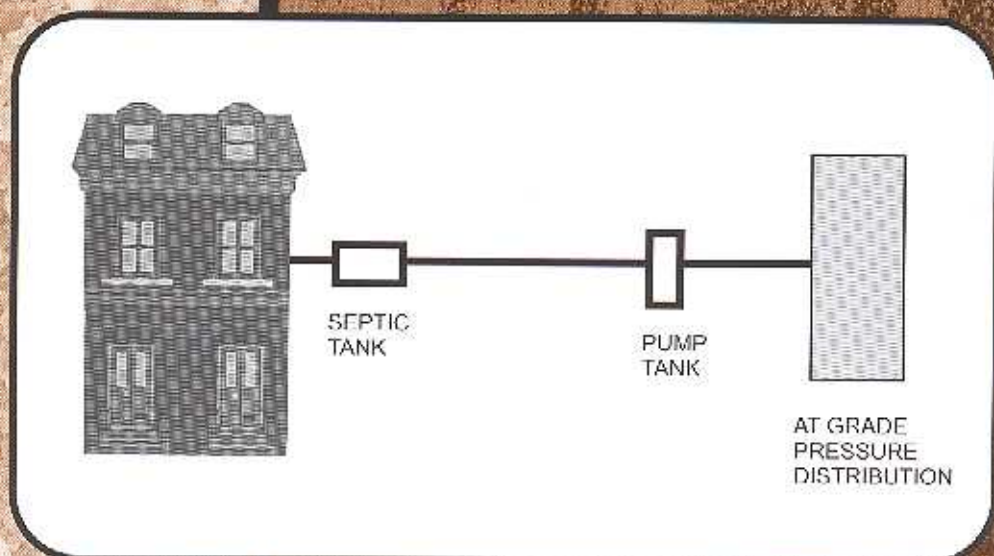


# TECHNOLOGY





TECHNOLOGY



Renovative Thickness



*Three at-grade* pressure distribution systems received septic tank quality effluent. Effluent from the campus sewer system was sent through two parallel 3,000-gallon single compartment septic tanks. Effluent was then sent to a common pump chamber and dosed four times per day to each of three at-grade pressure absorption areas.

- Limiting zone: None to 72 inches.
- Slope: 1.6% to 8.5%
- Percolation rate: Average 11.5 to 18.3 minutes per inch. Range was 3.3 to 40 minutes per inch.
- Hydraulic conductivity: 26.4 to 103.3 cm/day.
- Dosing cycle: 4 doses per day per system; 300 gallons per day per system loading rate.

**L***ansdale series*, deep, well drained soil; bedrock greater than 72 inches beneath the surface.

<u>Bed I</u> <u>(cm/day)</u>	<u>Hole #</u>	<u>Perk MPI</u>	<u>cm/Day</u>	<u>Guelph Rate</u>
Size: 15x40 Ave. Slope: 7.8%	1	8.0	450	3.76
	2	7.3	493.15	48.98
	3	21.8	165.138	
	4	15	240	
	5	40	90	
	6	16	225	
	7	20	180	
	8	18.5	194.59	
Average Geometric Mean		18.325	196.45	
		16.1	233.56	



<u>Bed II</u> <u>(cm/day)</u>	<u>Hole #</u>	<u>Perk MPI</u>	<u>cm/Day</u>	<u>Guelph Rate</u>
Size: 15x40 Ave. Slope: 7.1%	1	12.6	285.71	43.02
	2	9.6	375.0	35.42
	3	24.0	150.0	
	4	13.3	270.68	
	5	20.0	180.0	
	6	9.6	375.0	
	7	21.8	165.14	
	8	12.0	300.0	
Average Geometric Mean		15.363	234.33	
		14.49	248.51	

<u>Bed III</u> <u>(cm/day)</u>	<u>Hole #</u>	<u>Perk MPI</u>	<u>cm/Day</u>	<u>Guelph Rate</u>
Size: 15x40 Ave. Slope: 3.95%	1	9.2	391.3	28.68
	2	8.9	404.49	177.98
	3	13.3	270.68	
	4	9.2	391.31	
	5	7.5	480.0	
	6	10.4	346.15	
	7	3.3	1090.91	
	8	30	120	
Average Geometric Mean		8.1	444.44	
		9.68	371.74	



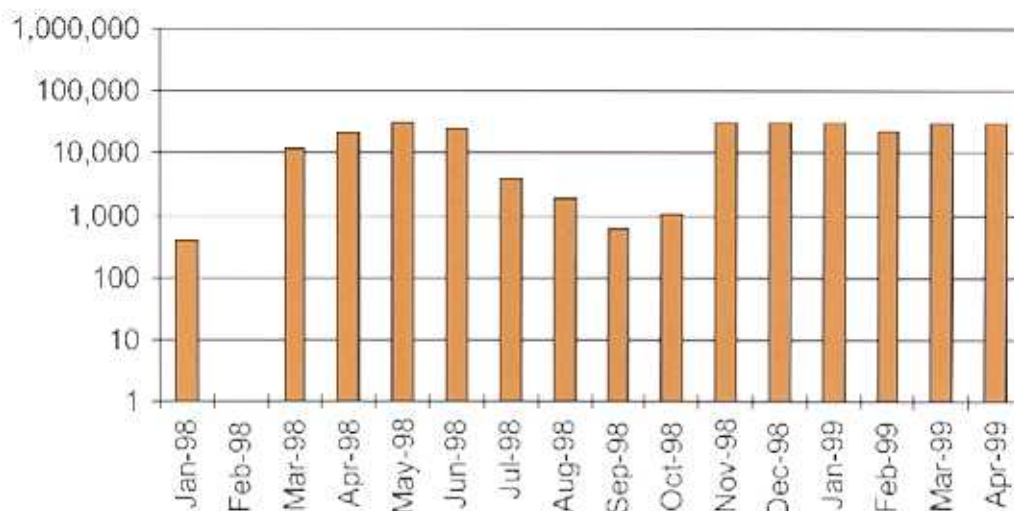
## Lansdale Series

- Ap1 0-6"** 7.5YR 3/2 dark brown loam; moderate fine granular structure; 5% coarse fragments; clear wavy boundary.
- Ap2 6-11"** 7.5YR 3/2 dark brown loam; moderate fine to medium subangular blocky structure; 5% coarse fragments.
- Bw 11-16"** 10YR 4/3 brown and 10YR 4/2 dark grayish brown channery sandy loam; weak medium subangular blocky structure; 30% coarse fragments.
- Bt1 16-22"** 10YR 4/2 dark grayish brown channery loam; weak medium subangular blocky structure; 15% coarse fragments.
- Bt2 22-30"** 5YR 4/2 dark reddish gray and 7.5YR 5/4 brown channery loam with few fine 7.5YR 4/1 dark gray and 7.5YR 5/4 brown mottles; weak coarse subangular blocky structure; 20% coarse fragments. *(Discussion on mottles was that they were few and faint and probably caused by wet conditions without free water due to structural differences. Data on percolation and hydraulic conductivity testing done in this horizon shown in permeability section of this report. Rapid rates appear to validate this observation.)*
- Bt3 30-47"** 7.5YR 4/2 brown and 7.5YR 5/4 brown very channery loam with few fine 7.5YR 4/1 dark gray and 7.5YR 5/4 brown mottles; weak coarse subangular blocky structure; 40% coarse fragments. *(Discussion on mottles was that they were few and faint and probably caused by wet conditions without free water due to structural differences. Subsequent percolation testing in this horizon was 10 to 15 minutes per inch which appears to support this observation.)*
- Bt4 47-60"** 5YR 5/2 reddish gray and 7.5YR brown very channery loam structureless massive; 40% coarse fragments.

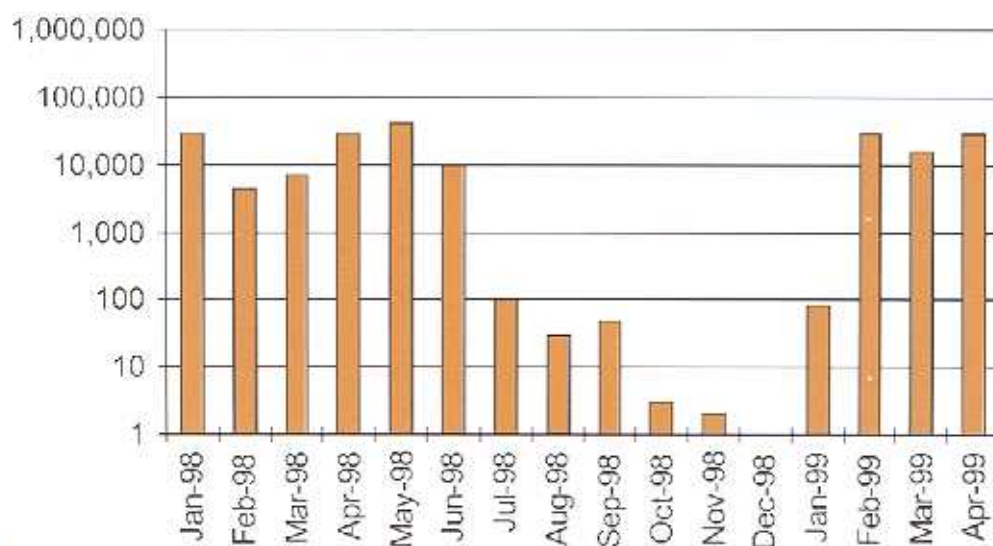




*GEO MEAN FECAL COLIFORM TECH.F.- MPN/100ml  
ONE FOOT DEPTH - 1998-1999*



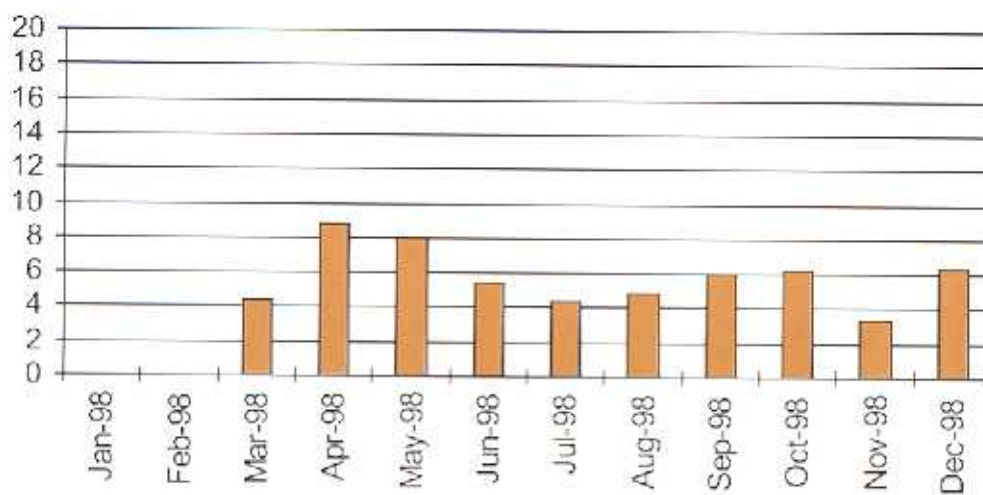
*GEO MEAN FECAL COLIFORM TECH.F.- MPN/100ml  
FOUR FOOT DEPTH - 1998-1999*



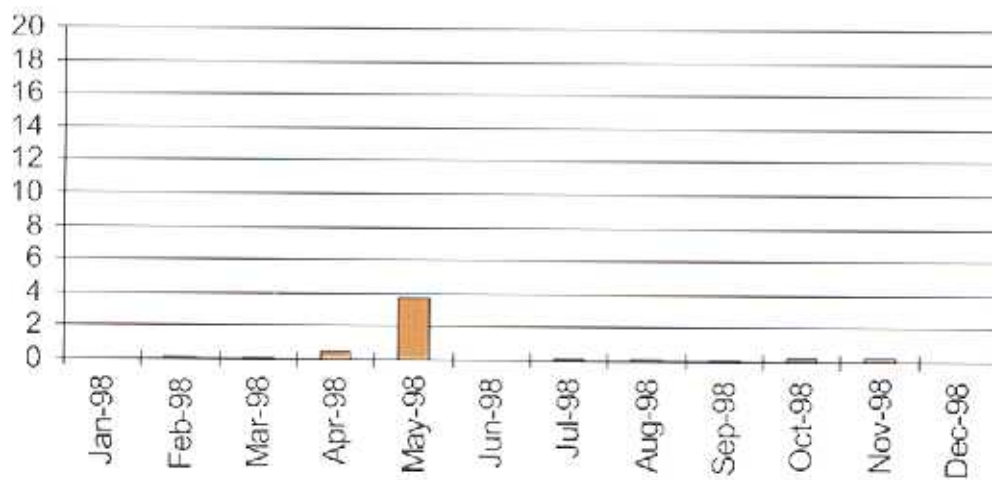


# TECHNOLOGY F: Renovative Thickness

*AVERAGE TOTAL PHOSPHOROUS TECH.F - mg/l  
ONE FOOT DEPTH - 1998*



*AVERAGE TOTAL PHOSPHOROUS TECH.F - mg/l  
FOUR FOOT DEPTH - 1998*



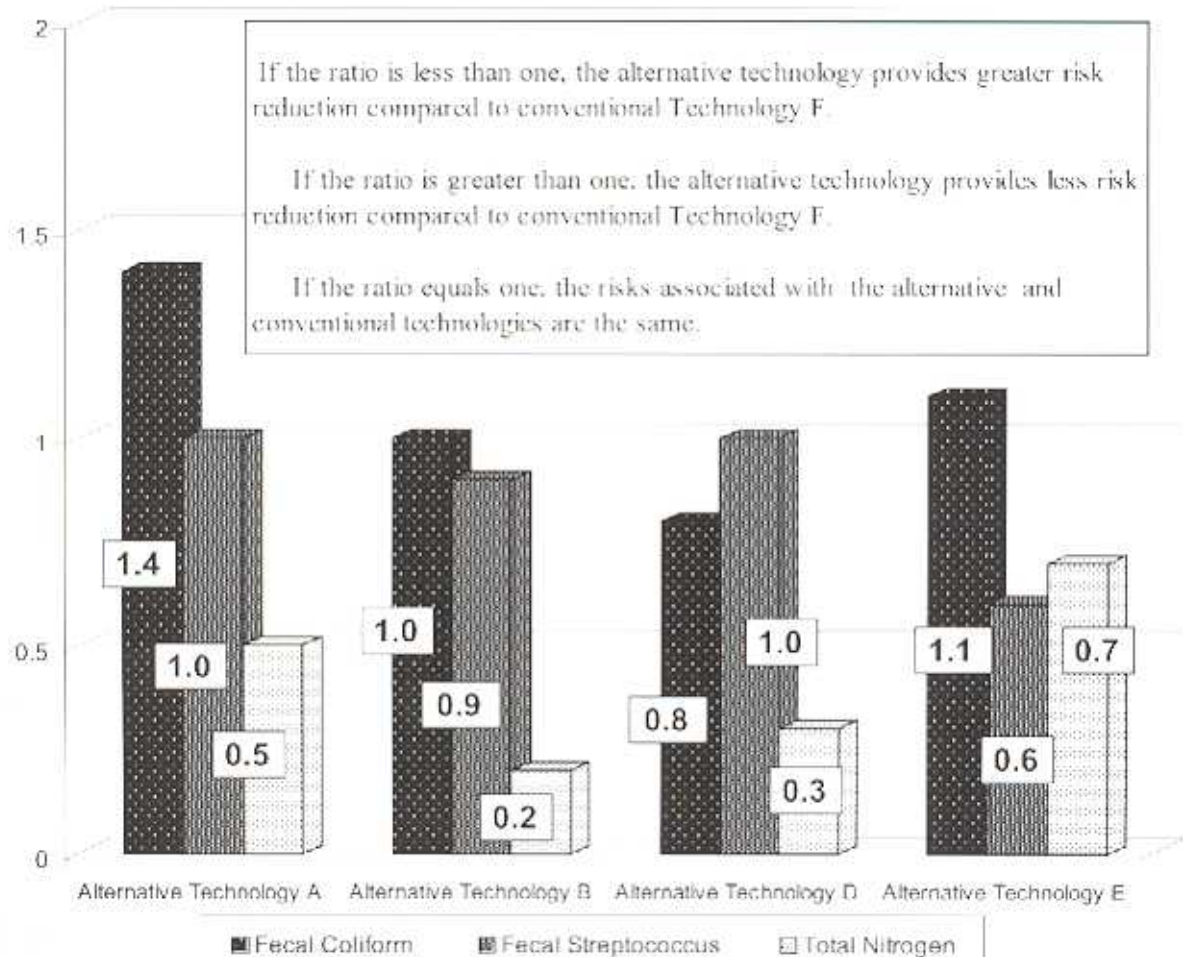


## PROJECT CONCLUSIONS

- **A**ll systems tested showed statistically significant reduction in concentrations in most parameters tested.
- **T**he question becomes: *"Is a statistically significant reduction in a potential pollutant enough to protect public health?"* A comparative risk assessment evaluation (see graph on following page) supports a conclusion that the technologies tested pose no more additional risk than currently approved conventional type bed systems.
- **N**either the statistically significant reduction in potential pollutants nor the comparative risk assessment on their own should be used as a basis for approval. The testing does, however, provide some level of confidence in these systems and serves as a basis for comparison. Alternative technologies are not without risk, and approval should be based on sound judgement from regulators and the private sector.
- **I**t is clear that an increased level of supervision and management for alternative technologies will be required. In addition to normal maintenance such as pumping septic tanks and repair of pumps, such tasks as raking of sand filters, maintenance of hydraulic units on drip irrigation systems, managing of plants on wetland systems and visual observation of distribution areas for wetness will need to be performed. This additional level of management must be provided or systems will not function properly. As part of their guidance documents, DEP will be indicating maintenance requirements specific for the technology released.



## Relative Hazard Ratios for Biological and Chemical Parameters Technologies A, B, D, E, & F



### Benchmarks

Fecal coliform > 200 mpn/100mL  
 Fecal streptococcus > 200 mpn/100mL  
 Total Nitrogen > 24mg/L  
 Total Phosphorous > 1 mg/L

A relative hazard ratio for comparative risk evaluation of five of the on-lot systems was computed. Data from Technology A and from the four foot lysimeters installed in Technologies B, D, E, and F are used for comparison.

Exceedence frequencies for fecal coliform and fecal strep bacteria, using 200 bacteria/100mL as the reference base, were computed for each system. Exceedence frequencies for total nitrogen, using 24mg/l (level of Technology F), were computed for each system.

Exceedence frequencies are calculated by computing the number of months the baseline (200 bacteria or 24mg/l TN) is exceeded, and dividing by the total number of months with available data. Exceedence frequency of experimental technologies A, B, D, or E is then divided by the exceedence frequency of the conventional technology (Technology F) to calculate a relative hazard ratio.



***On-Lot Systems and Small Flows  
Research and Development***

***This CD-ROM*** has been developed for use with the Project Final Report. The data represented by the graphs was collected from March, 1997 through August, 1999. To run: place disk in CD-ROM drive. If presentation does not automatically run, choose RUN from the START menu in Windows 95 or higher, and type: D:\Autorun.exe. (Replace "D" with the drive letter of your CD-ROM.)





# WORKING WITH NATURE

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Or

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