ENVIRONMENTAL RESEARCH

RESEARCH AND TECHNOLOGY BRANCH

SEPTAGE SLUDGE DEWATERING FEASIBILITY STUDY

Environment Ontario

ISBN 0-7729-9036-0

SEPTAGE SLUDGE DEWATERING FEASIBILITY STUDY

Report prepared for the:
CETEC North Committee of the
Ontario Ministry of the Environment
and the Ontario Ministry of Northern Development and Mines

Report prepared by:
Blake F. Dawdy, P. Eng., Northland Engineering Limited (1957)

NOVEMBER 1991

PIBS 1659

Acknowledgements

The author of this report wishes to acknowledge the support and input of a number of people who have assisted in the preparation of this report. Mr. Phil Joseph, P. Eng., of the Ontario Ministry of the Environment deserves full credit for the initiation of this project. Mr. Jim Harmar, District Officer of the North Bay District of the Ontario Ministry of the Environment provided key review and sounding board functions. Mr. Willy Brink of the Ontario Ministry of the Environment, Project Engineering Branch, also provided key review functions. Mr. Ray Banach of the North Bay District Office of the Ontario Ministry of the Environment provided key information on septage generation rates in the North Bay Area. Dr. Bill Snodgrass, P. Eng., of Beak Consultants provided key input on the technical content of the report.

Disclaimer

Abstract

Dawdy, B.F., Northland Engineering Limited, 1850 Bond Street, Site #1, Comp.#1, North Bay, Ontario, P1B 8G5, Septage Sludge Dewatering Feasibility Study, a report prepared for the CETEC committee, Ontario Ministry of the Environment, November, 1990.

Over 1.5 million people in Ontario depend on septic tanks and tile beds for disposal of domestic sewage. Increasing awareness of the Impact of septic systems upon lakes, watercourses and the environment in general is promoting more effective management techniques for these systems and modifications to improve their performance. Measures being considered include mandatory pumpout of septic tanks at regular intervals and the incorporation of chemical precipitation systems, for phosphorus removal, into septic systems located adjacent to nutrient sensitive lakes or rivers. It is likely that such measures will double the volumes of septage that must be disposed of in this province within the next decade.

Current conventional methods of septage disposal such as discharge to municipal sewer systems, disposal in exfiltration lagoons and application to agricultural Lands have significant drawbacks. Continued reliance on such methods with the anticipated increase in volumes of septage may result in serious environmental problems.

This study provides an overview of existing septage collection and disposal techniques in the North Bay area, likely future changes in the volumes and nature of the septage, possible nutrient removal techniques for domestic septic tank systems, the suitability of innovative mobile septage sludge dewatering schemes from other jurisdictions for application in the North Bay area, alternative septage disposal techniques and makes recommendations for future action.

Table of Contents

List of Tables

List of Figures

1.0 Introduction

1.1 Authorization

In June of 1989, Northland Engineering (1987) Limited was engaged by the Ontario Ministry of the Environment and the Ministry of Northern Development and Mines to examine the feasibility of introducing various innovative mobile septage collection and disposal systems.

The prime objective of this assignment was to identify a potential septage management system which would minimize adverse environmental impacts from septic tanks and tile beds and the disposal of the residuals from these systems.

In support of the prime objective, the following steps were undertaken:

a) the existing septage management system was identified and evaluated;

b) the existing septage generation rates and changes which could modify these rates were identified; and

c) alternative septage collection and disposal systems currently being successfully operated in other jurisdictions were evaluated with their potential for application in Northern Ontario and in particular the North Bay area.

Because of the extensive research and experience with such systems in other jurisdictions, most information on the systems has been collected from published literature. It was also possible to visit the location of one of these operations at Sainte-Agathe-des-Monts, Quebec.

1.2 Background

Increasing environmental concern and changes in lifestyles associated with rural living have focussed attention on rural sewage disposal systems.

The most widespread type of rural sewage disposal system is the conventional septic tank and tile bed. The popularity of these systems is due both to their low cost, the lack of alternatives and their relative effectiveness.

The basic treatment processes operating in a septic tank and tile bed system are the settling of solids and coagulation of greases within the septic tank, the biologic treatment of organic matter in the liquid in the tile bed, and the dispersion of the treated liquid to the subsurface water table.

For effective operation of these systems solids and grease must be trapped in the septic tank. If solids and grease are allowed to enter the tile bed, the tiles soon become plugged and the tile bed fails.

Although anaerobic digestion reduces the volume of solids within the tank, over a period of time the buildup of grease on the surface and digested solids in the bottom of a septic tank reaches a volume where they must be removed to ensure continued successful operation of the system (see Figure 1). Depending on the size of the septic tank, and the nature of the inflows, this typically is required every 1 to 5 years. (The lower figure applies to large commercial systems).

Nutrient removal by conventional septic tank and tile bed systems is limited to the settling of solids in the tank and adsorption by soil particles down gradient of the tile bed system.

Removal of grease and digested solids from a septic tank is typically undertaken by a vacuum pump into a steel storage tank mounted on a truck. All the contents of the septic tank are removed including the liquid present in the tank at the time of pumping.

The pumped material, known as *septage* is then trucked away for disposal at either a septage lagoon, a municipal sewage treatment plant, or some other approved site.

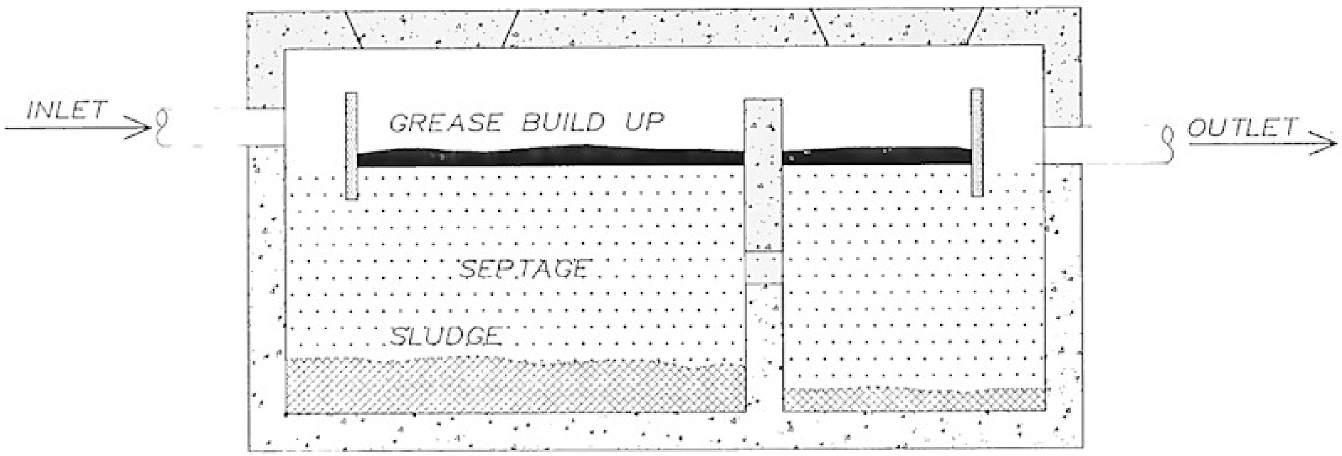

FIG. I. Typical Septic Tank.

Frequent pumping of septic systems is desirable for a number of reasons, including:

- the prevention of grease and solids from reaching the tile bed;
- the reduction of nutrient levels in the liquid entering the tile bed; and
- the effective inspection of system performance.

Because of the cost associated with a pumpout ($80-S85), the widespread lack of knowledge of the need, and the lack of regulatory requirements, the septic tanks of many systems are not pumped as frequently as is desirable. In a recent survey of septic systems on Trout Lake, (ref- 16) 157 of 317 systems five years or older had not been pumped within the last five years.

In other jurisdictions, a compulsory requirement for septic tank pumpout exists. For example in the Province of Quebec, permanent residences are required by law to be pumped out at least every two years while seasonal residences require pumpouts at least every four years. It is reported that compulsory pumpout requirements are not completely effective in ensuring timely pumpouts or proper disposal of the septage.

The principal destinations of pumped septage in Ontario are:

- Agricultural Land;
- Septage exfiltration lagoons; and
- Municipal sewage treatment systems;

Disposal of septage is a significant and growing problem. The problems associated with current methods of disposal include:

- the upsetting of plant processes particularly in smaller municipal treatment plants caused by its relatively *strong* nature;
- environmental and aesthetic concerns particularly with regards to degradation of groundwater associated with septage disposal lagoons; and

- it's liquid nature, odour, pathogenic nature, possible heavy metal content, and the grit, grease, and pair contained in it which together constitute both a regulatory and practical problem for Land disposal.

This constitutes a classic environmental conundrum in that more frequent pumping is desirable from a number of environmental perspectives but the disposal of the material has significant adverse environmental effects.

Septage is legally described as *hauled sewage* in Ontario. As such its collection and disposal are regulated under Part VII of the Environmental Protection Act. Under Regulation 374/81 septage collection and disposal systems are described as Class 7 sewage disposal systems.

2.0 Mobile Septage Sludge Dewatering

2.1 Concept of Mobile Septage Dewatering

The idea behind mobile septage dewatering is that only the solids and greases contained in the septic tank need to be removed to ensure effective operation of the system.

The solids content of septage is generally estimated to comprise 2% of the total volume of septage in a septic tank- The liquid portions of the septage can in principle be properly treated by tile beds. Therefore mobile septage dewatering is intended to minimize the removal of the liquid fraction of septage while maximizing the removal of the solid fraction of septage.

Obvious benefits of septage dewatering are:

- a reduction in the total volume of waste collected;
- an increase in the number of septic systems that can be pumped on a given trip; and
- a reduction in the cost of septage pumping.

A less obvious but equally important benefit is that dewatered sludge is easier to handle and allows consideration of alternative disposal schemes.

2.2 Description of Mobile Septage Sludge Dewatering Systems

2.2.1 Fossetic system

The Fossetic system was developed by Maurice Poulin, P. Eng. of Envirosol, Sainte-Agathe-des-Montes, Quebec in the early 1980's. (ref. 7, 8, & 9)

Three different layers or phases of material occur in a septic tank. The bottom layer consists of the settled *solids.* Above this layer is the liquid which is discharged to the tile bed. Finally on the top is a layer of grease and scum. Of these materials only the settled solids and the grease layer need to be removed during pumpouts to ensure continuing satisfactory performance of the system. When a tank is ready to be pumped, the settled solids and grease occupy about 30 to 35% of the total tank volume.

The Fossetic system is described aptly as *the selective pumping technique.* The pumpout truck is modified so that a baffle separates the tank into two chambers. The operator uses a transparent hose to suck the separate fractions of the septage into their respective chambers. Initially the crust formed by the scum and grease is broken and the largely liquid fraction is pumped. Because the hose is transparent, the operator can easily determine when the largely solid fraction is being pumped and switches to the second compartment of the truck (see figure 2). Because the liquid is removed, the surface layer of grease and scum has settled on the solids. Once the solids and grease fractions are removed, the liquid portion is returned to the septic tank.

The volume of septage removed from the system thus comprises only 30-35% of the total volume of septage contained in the tank unlike the 100% volume removal of the conventional system.

The modifications required to an existing truck consist of:

a) the installation of a plate in the tank of the truck to form two isolated compartments (a front compartment of approximately 4000 litres for the temporary storage of liquid and a rear compartment for retaining the solid fraction);

b) the installation of piping and valving allowing switching of intake and discharge between the two compartments; and

c) the installation of a high capacity vacuum pump if not already installed (minimum of 500 C.F.M., 600 C.F.M. recommended).

This system is patented in Canada and the United States. Because of funding provided by Environment Canada, the royalties are quite modest. Existing arrangements in Quebec are for a franchisee to be granted an exclusive license for an area for a royalty fee of $1-00 per septic tank in the area.

The costs of retrofitting existing trucks for *selective pumping* reported by two independent franchisees were between $2,000 and $2,500 for the plate and piping with an additional 57,500 required to retrofit one of the trucks with adequate vacuum pumps. For comparison purposes the estimated capital cost of a new system is $60,000 plus a suitable truck chassis. For comparison purposes a new conventional tank and related equipment costs about $45,000.

The septage obtained from *selective pumping* is being composted with sawmill wastes to create a topsoil additive. More details of this procedure are described in the section an septage disposal options.

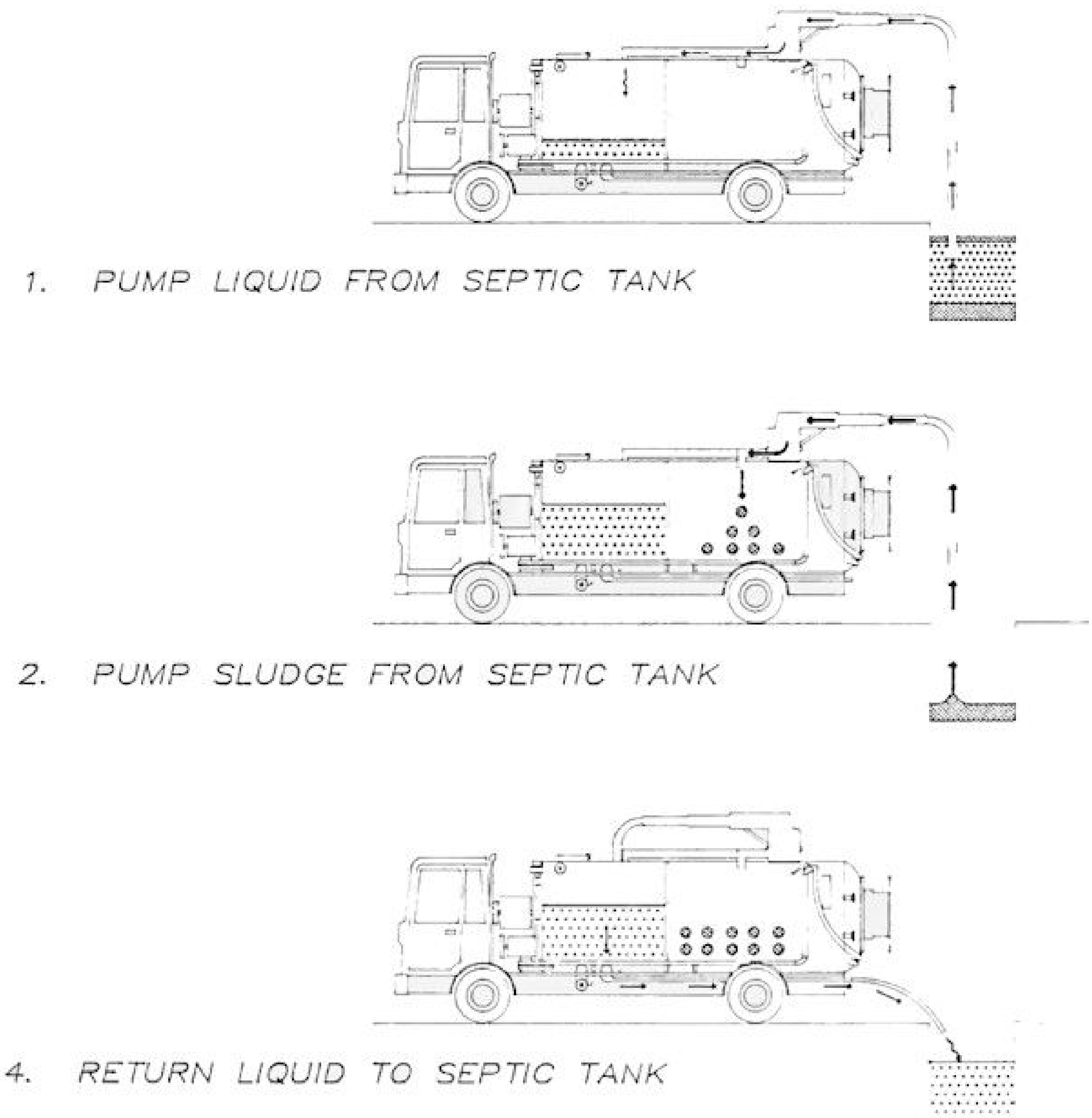

Fig 2. Fossetic Selective Pumping System.

2.2.2 Hamstern

The Hamstern system was developed by Marstrands Vatten-och Avloppstekniska AB, of Marstrand, Sweden in the late 1970's. (ref. 3, 4, 5 & 10).

The process consists of pumping the raw septage from a septic tank into a receiving tank. Filtered liquid from the previously pumped septic tank is discharged to the just pumped septic tank (see figure 3).

The septage is then dosed with lime and transferred to a vacuum/mechanical filtration dewatering system. The dewatered sludge is transferred to a sludge cake container, while the filtered liquid is transferred to a holding tank for discharge to the next septic tank.

Dosage rates with lime are approximately 4 kg of $Ca(OH)_2$ per cubic metre of septage.

The solids content of the dewatered sludge cake is estimated at 20%. Only about 10% of the original volume of septage is removed from the tank to be trucked away for disposal.

Capital costs of the dewatering unit are not available from the manufacturer but reference to a previous evaluation indicates a capital cost of approximately $400,000 plus the cost of an appropriate truck chassis.

Dewatered sludge after being stabilized by lime is generally disposed of to agricultural land. Because the pH of the sludge is temporarily raised to 12 by the addition of lime virtually all pathogenic bacteria and viruses are destroyed.

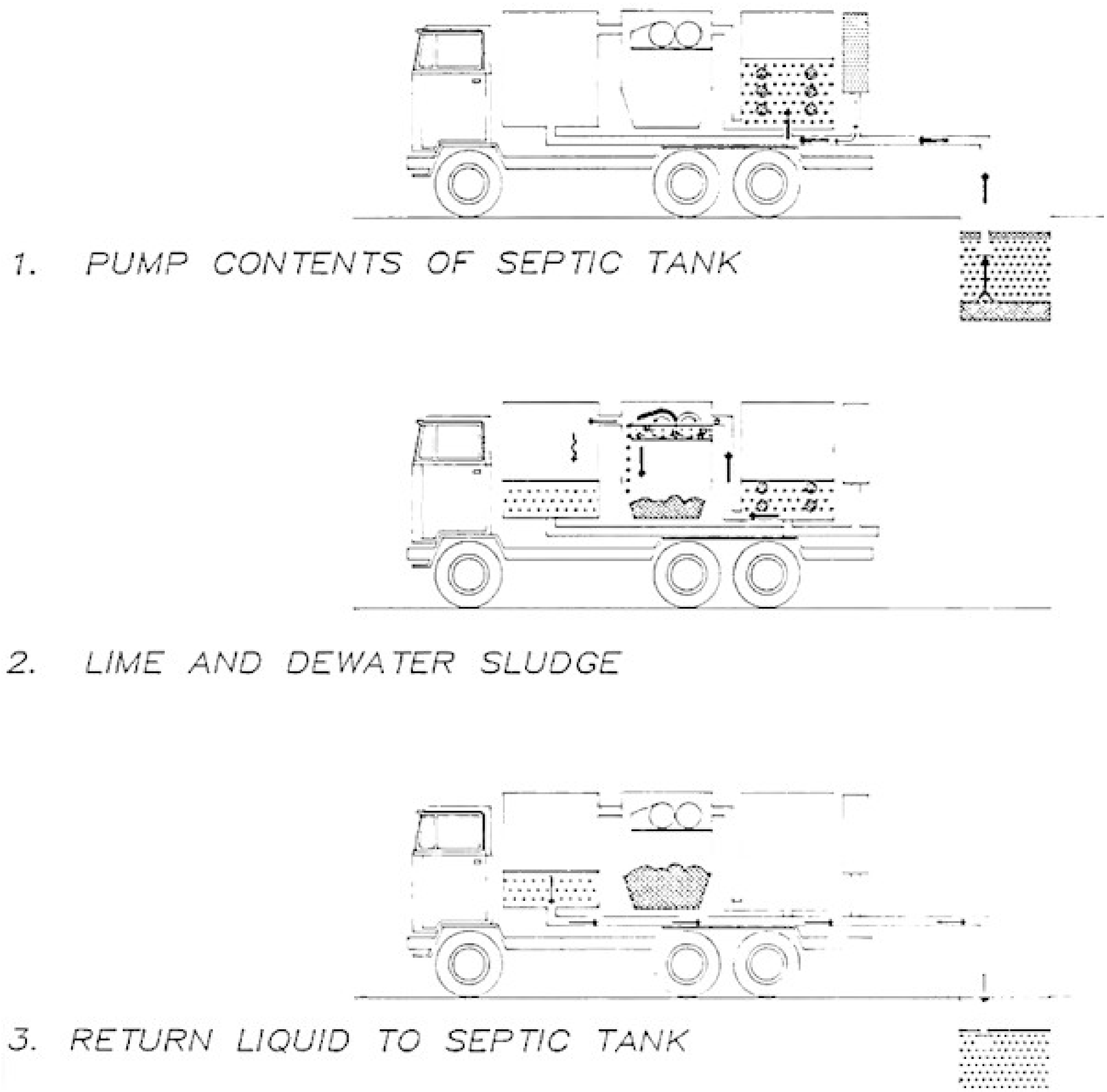

FIG. 3. Hamstern System.

2.2.3 Moos KSA

The Moos KSA system was developed by Simon Moos Maskinfabrik ApS of Sonderborg, Denmark in the early 1980's. (ref. 4, 10, & 14).

The process consists of pumping all of the septage from a given septic tank into a receiving tank. The filtered liquid from a previously pumped tank is discharged to the just pumped septic tank as in the Hamstern system.

The septage is then conditioned with a commercial polymer. The polymer conditioned septage is pumped into the dewatering tank and assists the settling of solids. This tank consists of a side wall drainage system covered by filter fabric. The supernatant liquid is filtered by gravity through the side walls (see figure 4).

The required dosage rate of polymer is approximately 150 g/m^3 of raw septage.

The solids content of the dewatered cake is approximately 15%. Only 13% of the original volume of the septage in the septic tank needs to be taken offsite for disposal.

Costs quoted for this equipment by the manufacturer were approximately $175,000 Canadian depending on currency exchange rates. In addition to this, a suitable truck chassis would be required.

Dewatered sludge from this process is generally disposed of on agricultural land either with or without lime stabilization.

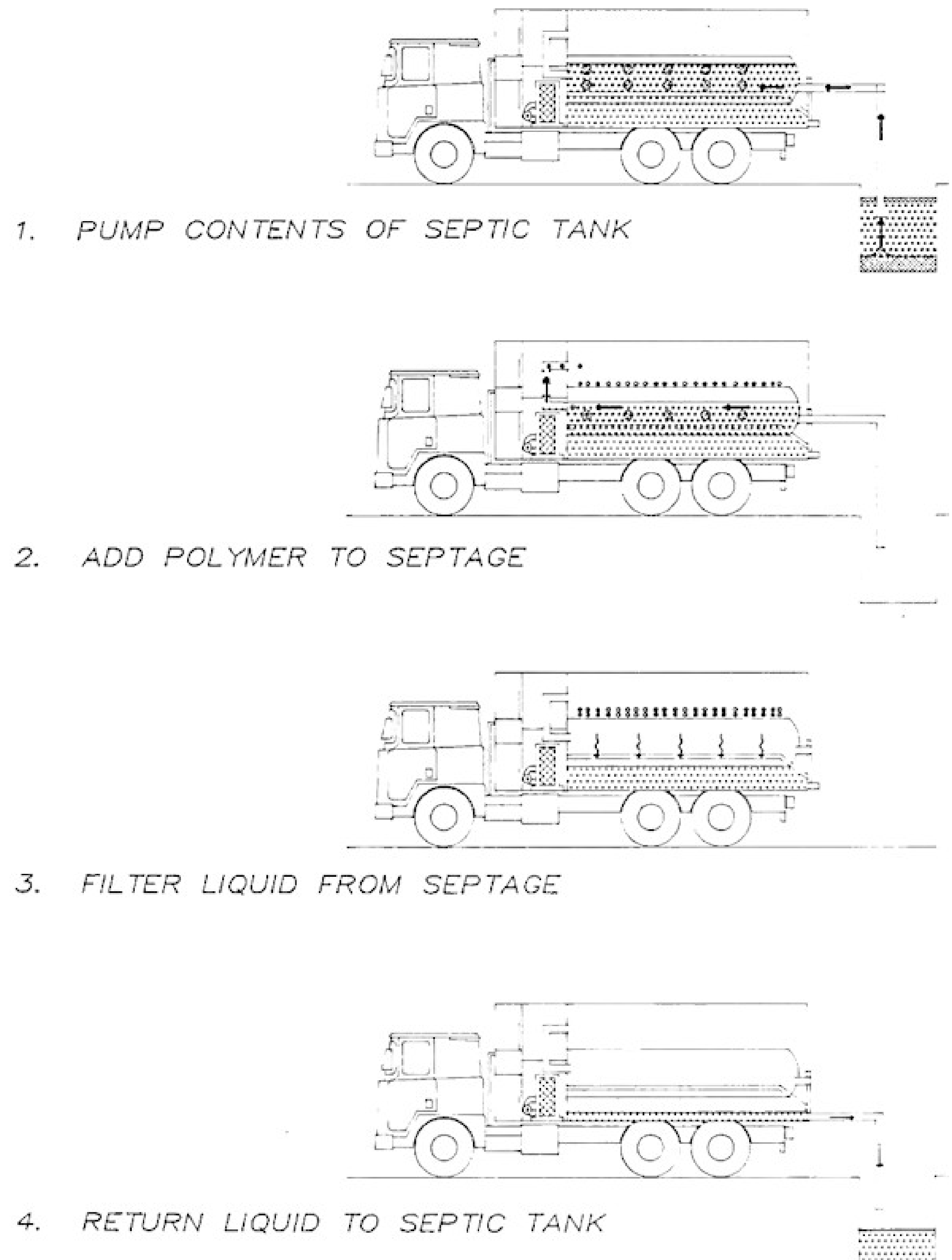

FIG. 4. Moos KSA System.

2.3 Comparison of Systems

2.3.1 Impacts of Disposal Options on Comparison

In comparing the relative merits of these systems it is important to realize that the intended means of disposal is critical. In view of the waste management problems currently being experienced throughout Ontario, the means of disposal may be the overwhelming criteria for selection of a system. All three systems reduce the total volume of waste to be treated offsite.

If current disposal practises remain the only viable disposal options then there is little point in examining either of the Scandinavian systems since the dewatered sludge is unsuitable for disposal either at a septage lagoon or a municipal waste water treatment plant. The dewatered sludge from the Fossetic system might be suitable for conventional disposal techniques.

Conversely if land application for agricultural purposes is the preferred disposal option, then the Scandinavian systems appear to be the best alternatives. It is anticipated, that in the future, disposal of untreated septage on agricultural Land will no longer be permitted and in many areas of the province disposal at a municipal treatment plant is not feasible or viable.

If a form of composting with sawmill wastes or other material is the preferred disposal option, then the Fossetic system is the preferred system.

2.3.2 Reduction of Nutrients

Under conventional operations little nutrient reduction can be anticipated for any of the alternatives considered. Paulsrud and Eikum (ref. 4) report that the residual lime from the Hamstern process may improve the phosphorus removal efficiency of the septic tank system during a period after filtrate return.

Measurements made by Brandes (ref. 6), indicate that only 4.3% of the phosphorus input to a conventional system over a 16 month period was retained in the sludge. This suggests that even very frequent pumping of conventional septic tank systems can have only a very modest effect an nutrient levels.

One proposal, under active consideration in the Trout Lake Pollution Control Planning Study (ref. 16), is to retrofit existing septic systems with a chemical precipitation system. Measurements by Brandes (ref.6), indicate a range of 70% - 85% of all phosphorus entering a septic tank was precipitated by alum injection. This same study measured a 2.3 times increase in the rate of sludge generation. Details of this proposal are described elsewhere in this report.

If the favourable findings with regard to phosphorus reduction are borne out by further work, mobile septage dewatering systems may play an important role in handling the increased sludge generation due to adoption of the chemical injection phosphorus management technique.

2.3.3 Effect on existing systems

In reviewing the potential impact of the dewatering systems on the septic system, our original concern was that the pumping process might result in the resuspension of previously settled solids and a resulting shock load of suspended solids to the tile bed. This shock load could significantly shorten the tile bed's service life by clogging the tiles with solids. Review of the available information indicated that this was not found to be a significant problem for any of the three systems examined.

Specific comments relative to each system are:

The Fossetic system by reducing the total volume of septage in the septic tank by 30-35% provides a buffer period, during which no effluent discharges to the tile bed, while this volume is replenished by inflow. During this buffer period, typically at least three hours, resuspended solids have an opportunity to settle out. Measurements undertaken by Poulin indicated that after 3 hours the suspended solids concentration of the liquid in the septic tank was within 15% of the original concentration prior to pumping (230 mg/L versus 200 mg/L originally).

The suspended solids of the filtrate from the MOOS KSA system is reported to be in the range of 200-300 mg/L (ref. 4 & 10). As much as 87% of the original septage volume is returned to the septic tank. This means that little time is available for the settling out of resuspended solids, while the tank refills to the level where it will discharge to the tile bed, Because of the suspended solids level of the returned liquid, this should not cause a significant problem for the tile bed.

The filtrate from the Hamstern system is reported as averaging a suspended solids level concentration of 1000 mg/L (Paulsrud & Eikum) significantly higher than the other two systems. The authors state:

> *"no negative effect so far has been reported, and investigations in Sweden have shown only a minor increase in suspended solids out of the septic tank 1-3 days after filtrate addition. "* (ref. 4)

Despite this statement, there is some potential concern. Since 90% of the original septage volume is returned to the septic tank with the Hamstern system, little time exists for settling of the resuspended solids before the liquid from the tank discharges to the tile bed. Consequently, there is the potential for a short term impact on the tile bed.

Both the MOOS KSA system and the Hamstern system return the filtered liquid from a previously pumped system to the system that has been just pumped. The potential therefore exists for passing contaminants from one system to another. A hypothetical scenario is that surplus medicine is poured down the drain of one house killing the digesting bacteria in the septic tank and the contaminated liquid is passed on to the next house to repeat the kill off. While not a likely occurrence, this is an example of the sort of problem that may arise.

Although the filtration time of the Hamstern system (approximately 15 minutes) would be sufficiently short to allow return of a given tanks liquid, the MOOS KSA system because of its gravity filtration method would require too Jong a period (in excess of an hour) to allow return of the liquid to the tank from which the septage has been pumped.

The Fossetic process intrinsically treats each system's liquid individually.

2.3.4 Cost Analysis

The following cost analysis (Table I) of the various systems was undertaken using the best information available.

Table I. Cost Analysis of Various Septage Collection Systems.

	Unit	Hamstern	Moos KSA	Fossetic	Conventional Vehicle
Capacity	m^3/day	45	35	35	25
Volume of tank	m^3			13.5	13.5
Unit Costs					
Labour Cost	$/day	$160	$160	$160	$160
Chemicals	$/$m^3$	$0.75	$1.00	$0.00	$0.00
Fuel, vehicle	$/km	$0.23	$0.23	$0.23	$0.23
Fuel, dewatering	$/day	$35	$5	$0	$0
Servicing vehicle	$/km	$0.12	$0.12	$0.12	$0.12
Maintenance	$/day	$30	$22.50	$12	$12
Insurance	$/yr	$5,000	$5,000	$4,000	$3,750
Capital Costs					
vehicle chassis	$	$45,000	$45,000	$45,000	$45,000
&watering unit or tank	$	$400,000	$175,000	$60,000	$45,000
Depreciation vehicle	years	5	5	5	5
dewatering unit or tank	years	10	10	10	10
Unit Quantities					
working days	#	48	60	60	80
units per day	#/day	10	8	8	6
disposal trips	#/day	1	1	1	2
disposal mileage	km	120	120	80	50
mileage per call	km	3	3	3	3
annual mileage	km	7200	8640	6240	9440
Cost Analysis Breakdown - Collection and Haulage					
fuel/maint.	$	$5,617	$4,644	$2,904	$4,264
chemical cost	$	$1,620	$2,100	$0	$0
labour cost	$	$7,680	$9,600	$9,600	$12,800
capital cost	$	$66,425	$35,075	$19,052	$16,963
insurance	$	$5,000	$5,000	$4,000	$3,750
royalties	$	0	0	$480	0
Total Cost	$	$86,342	$56,420	$36,036	$37,777
Per Unit Cost	$	$180	$118	$75	$79
units per year	#	480	480	480	480

*** Note: Disposal charges and/or costs are not included

A number of costs such as labour rates, vehicle mileage, actual distance travelled, and depreciation rates can only be assumed. Key assumptions include a labour rate of $20 per hr., mileage of 38 litres per 100 km., and a real interest rate of 7%. These estimates appear to be fairly realistic as the cost per unit for a conventional vehicle is $79, compared to the $80 currently charged by haulers.

Controversial estimates include the distance of travel for disposal and distance between calls. Because of the lack of availability of agricultural land for disposal in much of the watershed, an arbitrarily high disposal mileage has been assigned to the systems relying an sludge disposal. Disposal to the municipal system is central to this area and has the lowest arbitrary mileage. It is assumed that a central composting facility would be required and that the location would not be as central as the North Bay municipal system because of siting constraints.

2.3.5 Summary of Comparisons

Table II summarizes the key features of each of these systems.

Table II. Comparison of Alternative Septage Collection Systems.

	Fossetic	Hamstern	Simon Moos
% Reduction in Septage Collected	70.0%	90.0%	87.0%
Solids Content of Sludge	6.7%	20.0%	15.0%
Nutrient Removal	No	Some	No
Destruction of Pathogens	No	Yes	No
Suitability of Sludge for Agricultural Use	somewhat suitable	quite suitable	quite suitable with lime stabilization
Suitability of Sludge for Composting	quite suitable	not suitable	not suitable
Potential impact on Tile Bed	No	Yes	No
Transfer of Liquid Between Systems	No	Yes	Yes
Chemicals Required	None	Lime	Polymer
Estimated Capital Cost	$105,000	$445,000	$220,000
Estimated Operating Cost	$75	$180	$118

2.4 Required System Modifications

Currently septic tank access hatches are generally buried about 150 mm below the ground surface. The reasons for this practice are probably threefold.

1) safety against unauthorized access;

2) to prevent odours from escaping from the tank; and

3) for aesthetic reasons.

The disadvantages of this practice are:

1) additional effort is required at pumpout time to locate and excavate the access hatches as well as the need to backfill and restore the ground cover after pumping; and

2) new owners may be unsure of the septic tank location or even unaware of its existence.

If more frequent pumpouts of a septic system are to be undertaken, it would be advantageous to facilitate access. The major improvement would be to provide access to the hatches at grade rather than the typical practise of burying the access hatches. An added advantage of a readily removable cover is that septic systems can be inspected in a much easier manner.

Improved septic tank access must conform to CSA 3.3.1.2 (i.e. maximum 200 mm opening) with a locking device. The risk of unauthorized entry and potential accidents is to be minimal.

While some homeowner resistance might be encountered to a visible access to the tank, the disruption to lawns from an annual excavation of the access hatches should persuade most that this is a desirable change.

The cost of such modifications to an existing or a proposed system is estimated to he approximately $500.

2.5 Nutrient Removal Systems

A major concern associated with lakefront properties on septic tanks and tile beds is the introduction of phosphorus to the lake. The biological activity or trophic status of most lakes in Ontario is determined by the concentration of phosphorus in the waters. High phosphorus levels lead to a lower water quality.

Phosphorus is relatively rare in natural settings and it is common for lakes with significant shoreline development to have more than half of the phosphorus introduced to the lake originating from septic systems.

Conventional septic systems and tile beds are not effective treatment techniques for phosphorus removal. Some phosphorus removal occurs from the settling of solids in the septic tank and their consequent removal by pumping. Measurements by Brandes (ref. 6) indicated 4.7% removal by this method on a test conventional system.

The other process which slows phosphorus from reaching the lake is the adsorption of phosphorus to fine particles in the soil from the liquid discharging from the tile bed to the lake, In sandy or rocky soils with little fine soil particles or a thin layer of water saturated soil above bedrock, the capacity of the soil to adsorb phosphorus is quickly exhausted. Even on better sites the ability of soils to adsorb phosphorus is limited and within a matter of decades no phosphorus retention occurs.

A potential solution to this problem is the incorporation of chemical precipitation systems in the plumbing of residences relying on septic systems for disposal of waste water. this solution was first investigated by Brandes (ref. 6). The basic technique. explored by Brandes, is to inject aluminum sulfate (alum) into the waste water stream on a flow proportional basis. The alum chemically bonds with the phosphorus to form the low solubility solid Aluminum Phosphate.

The aluminum phosphate precipitates out of solution and settles to the solids in bottom of the septic tank. Consistent results of 80-85% removal were reported by Brandes.

The stochiometric equation for this process is as follows:

$$Al_2\ (SO_4)_3 + 2PO_4^{-3} \rightarrow 2AlPO_4 + 3SO_4^{-2}$$

The pilot system installed by Brandes for his investigations used a mercury float switch similar to that used on thermostats to sense movement on the flushing handle of the toilet in the residence and introduce a fixed amount of alum into the system. Since the alum was injected at the same time as the waste water, good mixing occurred within the plumbing prior to reaching the septic tank.

Toilet wastes are currently estimated to contribute 0.6 kg/cap/yr to a septic system, miscellaneous household uses an additional 0.2 kg/cap/yr and automatic dishwater detergent in houses so equipped an additional 0.6 kg/cap/yr. In view of the multiplicity of sources of phosphorus discharging to a household's plumbing, a flow sensor installed on the main discharge pipe appears to be more suitable as an activating device.

The proposed system would consist of a flow sensor on the main drain pipe activating a chemical dosing pump mounted on a small drum of chemical concentrate located in the basement of the residence.

Brandes reported maximum phosphorus removal at an aluminum to phosphorus ratio of 2:1. Based on a per capita Phosphorus loading to the septic system of 1.4 kg/cap/yr (ref. 16), approximately 18 kg of alum per year per person would be required. Alum can be obtained in 45.5 litre containers of liquid alum containing 29.58 kg of dry alum.

Thus two containers would be sufficient for a 3 person residence per year.

The estimated cost of the alum on an annual basis is 75$ per household while the cost of the flow sensor and chemical feed pump is estimated at $500 per household.

One possible scenario for the operation would be for a municipally operated system, where the containers, with a chemical feed pump integral in their lids, would be replaced on a regularly scheduled basis, allowing shop servicing and inspection of the chemical feed pump.

Brandes reported that sludge accumulation was 2.35 times greater with the alum precipitation system. Consequently there is a need for more frequent septage pumpouts with this system as well as a greater volume of septage to be disposed of.

Other chemicals such as Lime (Calcium Hydroxide), Ferric Chloride and Ferric Sulphite might also be worthy of exploration.

Potential issues which need to be resolved before a chemical precipitation system is implemented on a large scale include:

- how are the greater volumes of septage to be handled? (i.e. are mobile septage dewatering and related disposal options appropriate?)
- what is the potential impact of the residual chemicals, such as aluminum and sulfates, on soils, aquatic life, terrestrial plant life, and humans?
- what precipitating agent is most effective and causes the least adverse environmental affects?
- what are the best mechanical and operating arrangements for such a system?
- are there any potential problems with the use of the dewatered septage sludge as a constituent in compost?

3.0 Septage Disposal

3.1 Septage Volumes

Septage volumes and means of disposal within the North Bay District and Parry Sound Subdistrict of the Ministry of the Environment have recently been reviewed by district staff. The preliminary findings of this review (ref. 15) are presented in the following table.

Table III. Septage Haulage Survey - 1989 North Bay Area Haulers.

Volume of Liquid Hauled and Method of Disposal

Hauler	Locale	North Bay Sewage Treatment Plant	Exfiltration Lagoons	Farm Fields	Subtotals
Becker	Trout Creek			3,000	3,000
Carriere	East Ferris	112,500	337,500		450,000
Dutrisac	Springer			20,000	20,000
Charpentier	Lavigne		400,000		400,000
Lafreniere	Springer		600,000		600,000
Seguin	North Bay	2,069,000	11,000		2,080,000
Phippen	North Bay	200,000			200,000
Trottier	Callander	749,860			749,860
	subtotals	3,131,360	1,348,500	23,000	
		69.54%	29.95%	0.51%	4,502,860

Note: All figures are given in imperial gallons

Approximately 50% of the waste liquid disposed of is assumed to be the contents of holding tanks and comprises few special handling or disposal problems. Holding tank waste is not suitable for septage dewatering. The balance of the waste liquid (some 2.25 million gallons or 10,250 cubic metres) comprises septage. Assuming that the same proportion of septic tanks are pumped on an annual basis, this can be taken to be the current septage generation rate within the area.

Provincially the installed capacity of Class IV systems (ie. septic tanks and tile beds) is approximately 3.25 times greater than the installed capacity of Class VI systems (i.e. holding tanks). Although holding tanks require approximately 15 to 30 times as many pumpouts as septic systems for equal volumes of sewage treated, it is assumed that water conservation measures and their predominant use of holding tanks as seasonal systems reduce the volumes of septage generated so that total volumes of septage generated are approximately equal.

Within the area serviced by these haulers reside some 21,000 permanent residents who are not serviced by a municipal sewer system. Typical per capita septage generation rates used in the United States (ref. 1) vary from 190 to 380 litres per capita of septage per year as compared to the 490 litres reported for the North Bay Area. The discrepancy is likely accounted for by the large number of seasonal residents and visitors to this area.

Based on the findings of the Trout Lake Pollution Control Plan (ref. 16), average septic tank pumpout frequency can be estimated currently to be about once every five years. In the future, pumpout frequency is likely to increase either by regulation or because of the increased environmental consciousness of residents.

The Trout Lake Pollution Control Plan recommends municipally enforced annual pumpouts of all septic systems within the watershed. If such pumping frequency were undertaken in the entire North Bay area, annual septage generation rates will increase five fold.

Another key recommendation of the Trout Pollution Control Plan is that alum precipitation units to reduce phosphorus in the effluent be retrofitted to all septic systems in the watershed. This is anticipated to increase septage sludge generation rates to 2.5 times current rates.

Population in the North Bay Area over the past decade has shown a slight decline.

Although recent economic conditions have stabilized population, little or no growth is anticipated in the near future. Taking into account all of the foregoing, it is anticipated that raw septage volumes generated within the North Bay Area could increase to between 30,000 and 50,000 cubic metres annually within the next five years.

3.2 Nature of Septage

As described earlier, septage is a difficult material to handle. Septage contains significant amounts of pathogenic organisms, nutrients, oxygen-demanding materials, grit, grease and hair- The characteristics of raw undewatered septage are summarized in Table IV.

Table IV. Comparison of Septage and Domestic Sewage.

	Design Septage Values	Design Domestic Sewage Values	Ratio Septage to Domestic Sewage
Total Solids	40,000	700 - 1,000	40 - 57
Total Suspended Solids	15,000	180 -300	63 - 83
BOD_5	7,000	160 -280	32 - 44
Chemical Oxygen Demand	15,000	550 -700	24 - 27
Total Kjeldahl Nitrogen	700	40 -50	16 - 18
Ammonium-Nitrate	150	25 -30	5 - 6
Total Phosphorus	250	10 -15	20 - 25
Alkalinity	1,000	100 -125	9 - 10
Grease	8,000	90 -110	80 - 89

1. All values expressed in mg/L
2. Design Septage Values from U.S. EPA "Manual of Septage Practise" (ref. 1)
3. Design Domestic Sewage Values from U.S. EPA "Wastewater Treatment Facilities for Sewered Small Communities" (ref. 12)

3.3 Current Septage Disposal Practises

The principal means currently employed for disposal of septage in the North Bay Area are either discharge to the Municipal Sewer System at North Bay (70%), or to privately operated septage lagoons (29.5%). Additionally small quantities (0.5%) are disposed of to agricultural fields. (ref. 15).

While each of these methods have been practiced successfully in a number of jurisdictions, without proper techniques, facilities, and controls, each method can have serious environmental impacts.

3.3.1 Disposal to Municipal Sewer System

Hauled sewage including septage is discharged to the North Bay sewer system approximately 1 kilometre upstream of the sewage treatment plant at a designated manhole. This manhole is located on a trunk sewer servicing approximately 8,000 people in the northwest corner of the city. In 1989, approximately 7,100 cubic metres of septage was discharged to the City sewer system.

Because of climatic conditions, virtually all pumping of septage except for emergency situations is undertaken during the months of May through October. Average daily flows for the North Bay Sewage Treatment Plant for the months of May through October in 1987 and 1988 averaged 25,360 cubic metes (ref. 13). A summary of the impact of septage discharge on the plant is as follows:

Table V. Impact of Septage Disposal on the North Bay Sewage Treatment Plant.

Parameter	Increase	Impact on Operating Costs
Flow	0.15%	nominal
Suspended Solids	9.7-12.8%	additional sludge handling costs
BOD_5	4.9-6.8%	increased energy consumption
Total Phosphorus	3.1-3.8%	increased chemical and sludge handling costs
Grease	12.3-13.8%	increased maintenance and sludge handling costs

Note: Increases are expressed as a percentage of total loading to the plant.

The average daily discharge of septage may at times exceed these increases by as much as 4 times. The result is potential disruption of the activated sludge process.

The application of German guidelines (ref. 1) to the North Bay S.T.P. suggest that 20 cubic metres of septage per day can be accommodated. Other published guidelines (ref. 1) suggest that approximately 168 cubic metres of septage can be accommodated without adverse affects on the treatment process. Estimated average daily septage inputs, during the period of May through October, for the North Bay area are 39 cubic metres or approximately 4 haulage trucks. Peak discharges are estimated at 156 cubic metres per day or some 16 haulage truck loads. The wide range in accepted values for amounts of septage that can be safely discharged to a municipal system reflect the prevailing uncertainty on the potential impact. Generally throughout the 1987-1988 period, the North Bay S.T.P. was found to comply with the provincial effluent requirements for suspended solids and BOD_5 while slightly exceeding the objective for phosphorus in effluent (ref. 13). Consequently, the plant can be assumed to be accepting existing septage loads satisfactorily.

However, the potential increase in septage discharge volumes by a factor of 3 to 5 is likely to result in considerable disruption to the plant process and associated problems with meeting provincial discharge criteria.

3.3.2 Septage Lagoons

Septage Lagoons, in the North Bay area, receive approximately 29.5% or 3100 cubic metres of septage annually with an additional 3100 cubic metres of holding tank contents.

Many septage lagoons are designed to act as exfiltration ponds with the liquid infiltrating to the soil. The principal water quality concern associated with the operation of lagoons therefore, is the potential impact on groundwater resources and in particular nitrates. In practise, nitrates concentration is the governing criteria in evaluating the impact of septage lagoons on groundwater.

The provincial water quality objectives require a maximum concentration in groundwater of 10 mg/L for nitrates. Allowance for background nitrate concentrations, and the rights of downstream property owners to use the groundwater for disposal, under the Ministry of the Environment's *reasonable use policy,* mean that only a portion of this 10 mg/L is available for dilution.

Assuming that all forms of nitrogen in septage are oxidized to nitrates, approximately typical potential nitrates concentrations are 700 mg/L (measured as N). Assuming that 2.5 mg/L of nitrates is the allowable discharge and neglecting the attenuation mechanisms of soils and nitrogen uptake by intervening vegetation, a dilution ratio of 280:1 is required for the long term compliance of lagoons.

Using an infiltration rate of 200 mm/yr of precipitation into the soil (typical of the North Bay Area), approximately 1400 (1/0.2 x 280) square metres of land area is required for the dilution of 1 cubic metre of septage. On an annual basis, therefore, approximately 3100 x 1400 or 434 hectares of land is required for current septage generation rates and disposal in the North Bay area.

Other problems associated with septage lagoons are odours, visual aesthetics and insects.

In summary, although lagoon operations can be controlled in such a manner as to minimize environmental impacts outside property limits, exfiltration lagoons are generally a relatively inefficient means of septage disposal for reasons including:

- the neutralization of land due to contamination;
- potential impacts on groundwater; and
- objectionable odours and visual aesthetics.

3.3.3 Disposal of Septage to Agricultural Lands

The disposal of septage to agricultural lands attempts to utilize the nutrients in septage as a fertilizer. Septage is quite similar to sewage treatment plant sludge in many of its characteristics although much lower in heavy metals. In the North Bay area, septage sludge is generally applied to fields used for hay and haylage.

Ontario's Guidelines for Sewage Sludge Utilization on Agricultural Lands (ref. 2) have been adopted as the basis for examining the suitability of raw septage for agricultural land application. Although hauled sewage is explicitly exempt from these guidelines, the have been selected because of the detailed guidelines with respect to heavy metal loadings and thus can be considered a more technically conservative approach. For this purpose, raw septage is judged to be a fluid anaerobically digested sludge.

Key rationale behind these guidelines are:

a. Ammonia nitrogen application rates should not exceed the potential plant requirements for nitrogen in order to minimize the potential for nitrate contamination of groundwater; and

b. The heavy metals contents of the soils should not be allowed to exceed recommended levels in order to prevent the entrance of heavy metals into the food chain.

As a consequence, the ratio of ammonia-nitrogen to a heavy metal governs the suitability of a given septage for application to agricultural land.

The following table examines the general suitability of septage using United States Environmental Protection Agency design values (ref. 1) for heavy metals concentrations in septage for application to agricultural lands.

Table VI. Suitability of Septage for Agricultural Land.

	Raw Septage Metals Contents Design Concentrations (mg/L) (ref.1)	Ratios Ammonia-Nitrogen / Metals	
		Design	Guideline (ref.2)
Arsenic	0.20	750	> 100
Cadmium	0.70	214	> 500*
Cobalt	no data		> 50
Chromium	1.0	150	> 6
Copper	8	19	> 10
Mercury	0.25	600	> 1,500*
Molybdenum	no data		> 180
Nickel	1	150	> 40
Lead	10	15	> 15
Selenium	0.1	1,500	>500
Zinc	40.0	3.8	> 4*

Note: * indicates a violation of the provincial criteria

From this table it is apparent that a design raw septage exceeds the sludge utilization criteria for several critical heavy metals including Cadmium, Mercury, and Zinc. The contents of septage can vary significantly from locale to locale. It is suspected (ref. 17) that levels of heavy metals in Ontario septage are lower than the EPA values. However, the potential exists for violation of these criteria particularly in the case of Mercury.

Pathogenic viruses and bacteria are also present in abundance in raw septage (ref. 2) a significant health hazard to any persons coming in contact with the septage.

Direct disposal of raw septage on agricultural land, therefore, has the potential to introduce undesirable quantities of heavy metals to the food chain and pose health hazards to persons.

3.4 Alternative Septage Disposal Schemes

In the course of this study two alternative septage disposal schemes have been considered:

a) disposal of dewatered stabilized sludge to agricultural lands; and

b) composting of septage with wood waste.

Both of these schemes require special collection techniques to reduce the volume of septage handled and to render the septage suitable for disposal. The associated collection techniques have been discussed previously and are respectively the Hamstern and Simon Moos systems for agricultural disposal and the Fossetic system for composting. The following sections deal specifically with each system.

3.4.1 Dewatering and Stabilization of Sludge for Agricultural Land Disposal

As discussed previously raw septage has undesirable characteristics for direct application to agricultural lands. These characteristics include the potential heavy metal contamination of lands and the potential health hazards to persons from pathogenic bacteria and viruses.

The Scandinavian systems dewater the septage to minimize handling problems and use lime stabilization to raise the pH to approximately 12 in order to eradicate all pathogenic bacteria and viruses. The resulting sludge can be regarded as a Dried and Dewatered Anaerobic Sludge.

Information on the metals content of the Hamstern sludge along with the appropriate Ontario criteria are presented in the following table.

Table VII. Hamstern Sludge Analysis (ref.3).

Dry Solids	25.60% by mass	
Ammonium Nitrogen	0.11% DS	
Nitrate	<0.01% DS	
Total Phosphorus	0.70% DS	
Potassium	0.02% DS	
Calcium	18.80% DS	
	Measured Concentrations	Provincial Objectives (ref.2)
Mercury	0.4 mg/kg DS	11 mg/kg
Cadmium	1.2 mg/kg DS	34 mg/kg
Lead	1.6 mg/kg DS	1100 mg/kg
Chromium	7.4 mg/kg DS	2800 mg/kg
Cobalt	<3 mg/kg DS	340 mg/kg
Nickel	5.9 mg/kg DS	420 mg/kg
Copper	105 mg/kg DS	1700 mg/kg
Zinc	390 mg/kg DS	4200 mg/kg

However provincial criteria also require that a dried or dewatered anaerobically digested sludge also conform to the criteria given in Table VI. Depending on specific metals content this sludge or may not be suitable for disposal on agricultural land.

The lime stabilization process eliminates the health hazards associated with viruses and bacteria in raw septage.

No information on the content of the Simon Moos Sludge was available.

Both sludges are described as being suitable for application by a conventional manure spreader. In addition during inclement weather the material can be stockpiled for later application to a field since it has stabilized. (ref. 4 &10)

Although this product has a number of merits, its suitability for application in the North Bay area is questionable for the following reasons:

a) the high capital costs associated with the equipment;

b) the limited agricultural activity in the North Bay area; and

c) the long haulage distances required for agricultural disposal.

In areas of the province with extensive agricultural activity, the high capital cost of the system could discourage its use. However, the lack of reasonable alternatives suggests that these options should be re-appraised if direct application of untreated septage to agricultural land is prohibited.

3.4.2 Composting

Previous efforts to compost septage have encountered difficulties because of the low solids content of raw septage, approximately 2% (ref.1). The dewatering technique utilized in the Fossetic system increases the concentration of solids to 5.5 - 6.0% (ref. 7, 8, & 9). This material is much more amenable to composting.

The principal bulking material utilized is wood waste. The technique utilized is to discharge the dewatered septage to a filter bed consisting of wood waste and sand. The filters consist of approximately 60 cm of wood waste an top of 30 cm of sand material. The required ratio of wood waste to septage is approximately 3 or 4 to 1 (ref. 7 & 8).

The filter has an average capacity of 0.04 cubic meters of septage per square meter per day. The filter is saturated after 3 cycles. The leachate from the filter is a fairly low strength sewage suitable for conventional treatment either by a tile bed or conventional lagoon (ref. 7 & 8).

Once the filter bed is saturated with septage it is deposited in piles by a front end loader. The material is then periodically turned using the front end loader to ensure maintenance of aerobic conditions. The mixing intervals are as follows:

- every 15 days for the first three months; and
- monthly for the balance of the first year.

The material is then allowed to mature under an opaque plastic cover for a further period of two years until it is ready for sale.

The resulting compost is an excellent growth media. Because of the high temperatures reached during the composting (60°C for the first ten days and 45°C for the following 8 to 10 months), it is claimed that all pathogenic viruses and bacteria are eradicated. The contents of the compost are summarized as follows:

Table VIII. Contents of Fossetic Compost (ref. 7).

pH	5.6
moisture content	120 %
Organic content	38 %
Unit Dry Mass	199 kg/m^3
Nitrogen	2.71 kg/tonne
Phosphorus	0.03 kg/tonne (see Note)
Potassium	0.2 kg/tonne
Calcium	1.67 kg/tonne
Magnesium	0.65 kg/tonne

Note: Phosphorus content would be considerably increased by chemical precipitation.

The high organic content of the compost makes this an excellent soil conditioner. Although the nutrient content of the compost is relatively low compared to chemical fertilizers, it is available to vegetation over an extended period. In general this may regarded as an "environmentally friendly" soil additive.

The economics of the Fossetic operation were described as follows for the summer of 1985. (ref. 7)

- cost of treatment of septage \$8.36 per m^3 of septage collected

- revenue from sale of compost \$3.36 per m^3 of septage collected

- net cost of treatment \$5.00 per m^3 of septage collected

One particularly suitable and readily available source of wood waste is the digester sludge from the wood products plant operated by MacMillan Bloedel in Sturgeon Falls. The volume of production of this waste is estimated at 3750 cubic metres per year and it is currently landfilled. Based on a ratio of 3.5:1 of wood waste to septage this is sufficient to compost approximately 1000 cubic metres of septage annually.

Typical wood waste production at the Field Lumber Company in Field, Ontario is estimated at 40,000 cubic metres per year. Although much of this waste has a commercial market a residuum of bark and slashings is also available for composting although they may require mulching before being suitable for composting. Similarly, other mills in the North Bay Area, have suitable waste materials available.

Another potential source of wood waste for composting is abandoned wood waste disposal sites which currently constitute a significant environmental concern in this area. Generally sufficient wood waste is available to supply a composting operation for a considerable period of time. Other nuisance vegetative materials such as the decayed plant matter washing up on the shores of Lake Nipissing could also be suitable composting materials.

Key technical questions remaining with this process include:

- what are the heavy metal concentrations in the composted material?

- what would be the impact of alum precipitated phosphorus sludge on the compost?

- can municipal sludge be successfully composted given its typically higher heavy metal concentrations?

The major economic concerns associated with application of this scheme in the North Bay area are as follows:

- what markets are available for the compost? and

- what are the costs of existing disposal practises and how can they he reflected in disposal charges?

The last question is particularly relevant as no charge is levied for discharge of septage to the North Bay Sewage Treatment Plant at this time despite a considerable load an plant facilities.

Other questions to be resolved are:

- where will the composting site(s) be located and how many are required?

- what are the costs associated with the setting up and Operation of a composting site? (i.e. labour, equipment, wood waste acquisition, site maintenance and monitoring)

- how will the compost be marketed? and;

- what testing is required for the compost to ensure that the levels of pathogens are acceptable?

Even if markets are not readily available for the compost, the relative simplicity and potential for significantly reduced environmental problems make this an attractive option even if the composted material is simply landfilled and or disposed of.

3.5 Relative Costs of Septage Treatment

Estimates of treatment costs per cubic metre of septage are summarized in the following table.

Table IX. Unit Treatment Cost Estimates for Various Methods of Septage Disposal.

Method	Unit Cost per cubic metre of septage
North Bay Sewage Treatment Plant	$4.05 does not include a fee for landfilling of sludge
Septage Lagoons	$19.60
Agricultural Land Disposal	$0.00 assumes no charge by landowner
Composting with sale of compost	$2.40 unit costs have been modified to reflect reduced septage volume
Composting with landfilling of compost	$3.60 unit costs have been modified to reflect reduced septage volume

The per unit cost for the North Bay Sewage Treatment Plant is based on assuming a relative overall loading of 7.5 % of the total annual loading and a reported operation cost of $1,054,000 for 1990. This neglects several key costs such as the capital cost of the facility and a tipping fee for disposal of the sludge from the plant at the municipal landfill.

The costs of septage lagoons are based on amortization of the capital costs for land acquisition, lagoon construction and site works such as roads and fences, and engineering costs for site approval as well as an annual operation allowance.

It is assumed that no charge is levied by landowners for disposal on agricultural land as septage has significant fertilization value.

Costs of composting are based on the figures quoted by Fossetic Inc. (ref. 7 & 8) with an allowance for inflation. It is assumed that if disposed of at a landfill there would be no charge as this would be a suitable substitute or supplement to the final topsoil required for capping the landfill. Because only 30% of the volume of the septic tank need he disposed of with die Fossetic process unit disposal costs have been adjusted accordingly.

4.0 Conclusions and Recommendations

4.1 Conclusions

1. The existing techniques for septage disposal in the North Bay area have significant existing and potential problems associated with them.

2. Existing disposal charges do not necessarily reflect *true* disposal costs-

3. The potential exists for a major increase in the volumes of septage pumped and requiring disposal.

4. Chemical precipitation of phosphorus is an attractive potential option for reducing nutrient loading to lakes and could potentially double the production of septage.

5. Septage sludge dewatering has the potential to reduce the volume of septage to be disposed of and condition it for more environmentally sound disposal techniques.

6. The *Fossetic* selective pumping system enjoys a number of advantages over the other systems reviewed including cost, simplicity, ready adaptation to existing equipment, and the potential disposal options it allows.

7. Composting of septage sludge with wood waste and other organic material appears to be a particularly attractive solution for final disposal of septage.

8. Both of the Scandinavian systems examined show some promise for application in areas where disposal to agricultural land is likely to remain the primary septage disposal option.

9. Despite significant promise, a variety of social and environmental concerns remain to be resolved before either a chemical nutrient precipitation system for septic tanks or composting of septage can prudently be implemented.

4.2 Recommended Programs

Three different programs are recommended for further consideration:

a) further investigation of chemical precipitation phosphorus removal systems:

b) a pilot project to examine the suitability of local septage and municipal sludge for composting; and

c) a technology transfer assistance program to inform local septage contractors of the technique and merits of selective pumping and to assist in its implementation.

4.2.1 Chemical Precipitation for Phosphorus Removal

The prime objective of this investigation is to establish whether chemical precipitation of phosphorus is a suitable technique for reducing phosphorus loadings from septic tank / tile bed systems to surface waters.

Major questions to be answered are:

- Which precipitation agent (including Alum, Lime, Ferrous Chloride and Ferrous Sulphate) is most suitable for this application from the perspectives of effectiveness, cost, handling safety, and potential environmental side effects?

- What is the most suitable method for introducing the precipitation aunt to a domestic septic system?

- What are the significant characteristics of the sludge generated by the precipitation and normal septic tank mechanisms with respect to its suitability for composting and general use?

A possible work program could consist of:

- bench scale testing of various precipitation agents with samples of sewage obtained from functioning residential septic systems to determine the appropriate dosing for various precipitation agents, effectiveness of the various precipitation agents and the chemical composition of the sludge and liquid after precipitation occurs;

- a literature review of handling hazards associated with the various agents;

- a review and screening of proposed dosing techniques; and

- demonstration projects on functioning residential septic systems with a detailed monitoring program (a minimum of 6 systems including 3 systems for control is recommended).

The required time frame for such a project is estimated at 18 months.

4.2.2 Composting

The primary objective of this program is to establish whether septage sludge composting is a safe, economical, means of managing septage. Because much of the potential success of this project depends on the marketability of the resulting compost, it is felt that the private sector rather than a public agency would be the most suitable operator for this project.

Because of the extensive risk, relatively long lead time before a financial return might be expected, the lack of maturity of the technology, and the potential public benefit of this project, it is felt that significant public assistance could be justified for such an operation.

Such assistance might include provision of technical assistance for designing and obtaining approval of the proposed composting site, provision of technical services to collect and analyze samples and review results, as well as a low interest forgivable loan (i.e. forgivable if the material proves to be unmarketable due to its characteristics).

Probably the fairest way of selecting a private sector operator would be to advertise publicly a request for proposals for the operation.

4.2.3 Selective Pumping

The *Fossetic* selective pumping process is judged to be a mature enough technology to merit its being implemented immediately. To this end a technology transfer program is recommended consisting of the following:

1) a one day seminar for licensed local haulers to introduce the technology

2) assistance in licensing and royalty arrangements; and

3) capital assistance in truck conversion.

The seminar might consist of the following agenda:

a) a review of the legal requirements for sewage haulage and disposal:

b) a description of the Fossetic process (possibly by Maurice Poulin of Fossetic Fossetic Inc.)

c) the benefits of the Fossetic process;

d) licensing and royalty arrangements;

e) a description of potential funding; and

f) anticipated disposal options.

Bibliography

1. United States Environmental Protection Agency, 1984, Handbook Septage Treatment and Disposal, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

2. Ontario Ministries of Agriculture and Food, Environment, and Health, 1978, revised 1986, Guidelines for Sewage Sludge Utilization on Agricultural Lands, Toronto, Ontario.

3. Stigebrandt, A., 1984, Treatment and disposal of sewage sludge, Mattsson produkter i Uddevalla AB, Sweden

4. Paulsrud, B. and Eikum, A.S., 1987, Septage Management Using Mobile Dewatering Trucks, Vatten 43, pgs 224-230, Norwegian Water Technology Centre A/S, Oslo, Norway.

5. Stigebrandt, A., Marstrands Vatten & Avloppstekniska AB, Personal Communications.

6. Brandes, M., 1976, Phosphorus Removal from Human Wastewater by Direct Dosing of Alum to a Septic Tank, Applied Sciences Section, Pollution Control Branch, Ontario Ministry of the Environment, Toronto, Ontario.

7. Poulin, M., 1988, Envirosol: Demonstration d'un systeme de Vidange et de Traitement des Boues de Fosses Septiques, Sciences et Techniques de L'Eau, Vol. 21, No 3, Aout 1988, pgs 277-284, Montreal, Quebec.

8. Poulin, M., 1986, Demonstration d'un Systeme de Vidange et de Traitement des Boues de Fosses Septiques, Fossetic Inc., prepared for the Environmental Protection Service of Environment Canada, Ste. Agathe-des-Montes, Quebec.

9. Poulin, M., Fossetic, Inc., Personal Communications.

10. Paulsrud, B. and Eikum, A.S., 1989, Mobile Septage Dewatering, Scandinavian Trends in Septage Management, Proceedings of International Onsite Symposium, April 1989, Annapolis, Maryland.

11. United States Environmental Protection Agency, 1980, Design Manual, Onsite Wastewater Treatment and Disposal Systems, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

12. Leffel *et. al*, 1977, United States Environmental Protection Agency, Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities, Office of Technology Transfer, Cincinnati, Ohio.

13. Ontario Ministry of the Environment, 1988 & 1989, Reports on the 1987 and 1988 Discharges from Sewage Treatment Plants in Ontario, MISA Municipal Section, Toronto, Ontario.

14. Nielsen, N., Simon Moos Maskinfabrik APS, Personal Communications.

15. Banach, R., Ontario Ministry of the Environment, North Bay District Office, Personal Communications.

16. Dawdy, B., 1990, Trout Lake Pollution Control Planning Study, Northland Engineering (1987) Ltd., North Bay, Ontario.

17. Ontario Ministry of the Environment, Manual of Policies, Procedures and Guidelines for Private Sewage Disposal Systems, May 1982, Toronto, Ontario.

Some Key Addresses

Fossetic System

Fossetic Inc.
C.P. 215,
Ste-Agathe-Des-Monts, P.Q.
J8C 3A3
1-819-326-3100
Attention: Mr. Maurice Poulin

Hamstern System

Marstrands Vatten & Avloppstekniska AB
P.O. Box 55
S-440 30 Marstrand
SWEDEN
Telephone: 011 46 303 61040 Facsimile: 011 46 303 60136
Attention: Mr. Ake Stigebrandt

MOOS KSA System

Simon Moos
Maskinfabrik ApS
Kallehave 33, Horup
DK 6400, Sonderborg
DENMARK
Telephone: 04 44 56 80 Facsimile: 04 44 52 08
Attention: Mr. A. Verner Nielsen

Norwegian Water Technolog Centre A/S

Norsk Institutt for Vannforskning (Viva)
P.O. Box 33 - Blindern N-0313
Oslo 3, Norway
Attention: Mr. Bjarne Paulsrud