Shaw Peat
Technical Manual

Approved Manual: April 3, 2003

Modular On-Site Wastewater Treatment Systems Using Natural Peat Moss

This technical manual provides information on the Shaw Peat Modular O-Site Wastewater Treatment Systems. This manual includes introductory information, an overview of the Shaw Peat Systems, design procedures and installation and maintenance information. This manual is periodically updated.

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1.0 A SHORT HISTORICAL OVERVIEW OF PEAT TREATMENT

1.1 EARLY HISTORY

The use of peat for wastewater treatment is not new. The absorption and odor control properties were well known in ancient times. In World War 1 when cotton became scarce, peat moss was used with much success as surgical dressings in field hospitals. In Finland, treatment of wastewater from a town was accomplished by pumping raw sewage to a large storage ditch in a nearby peatland. The wastewater then percolated through the peat to intercept ditches 20 meters away. The reported removal of phosphorus was 82%, nitrogen 90%, BOD 95%, and pathogenic bacteria 99%. This system has been in use since 1957 and is reported to be still functioning.

In 1972, Dr. Jim Brown and Dr. Rouse Farnham reported on the use of a peat filter to treat the effluent from an aerated activated sludge plant. Their findings indicated the peat provided tertiary treatment of the effluent.

1.2 THE MAINE EXPERIENCE

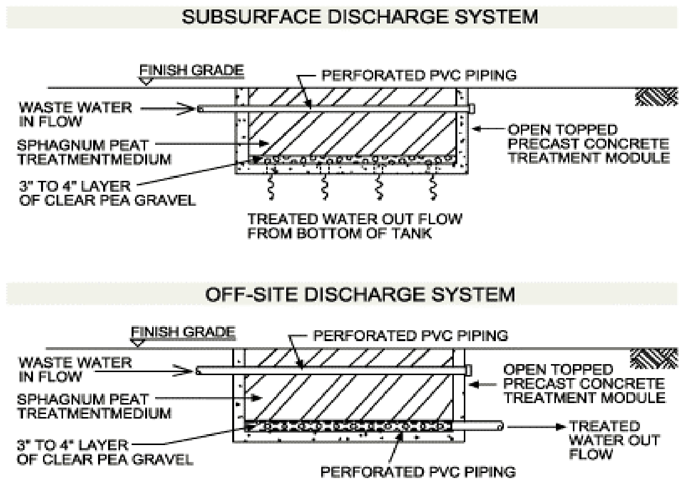
The first peat based on-site sewage treatment system in Maine was installed in 1978. Dr. Joan Brooks, as a part of her Masters Thesis, designed this system. The system is a peat bed for a single-family dwelling. For many years the system serviced a house occupied by 9 people (the Brooks family). The system was monitored (effluent in and effluent out) for 23 parameters for eight years. Test results showed the peat system treated septic tank effluent to drinking water standards. The system is still in service 25 years later. Random tests show this system is still providing a high quality effluent.

The Brooks Family Peat Treatment System

Over the next 10 years, 1978 to 1988, Dr. Brooks installed 7 more peat bed systems in Maine. During this time evaluations of the systems were carried out to refine system design. Parameters such as system construction, sewage dosage rate, peat compaction level and peat type were investigated and refined. All 7 systems are still functioning.

In 1988 the State of Maine recognized peat (beds) as an *"Approved System"*. Since the 1988 approval approximately 200 peat bed systems have been installed in Maine. Most systems are servicing single or multifamily homes. Two systems service schools: Haystack Mountain School of Crafts and Surry Elementary School. Both of these systems have piped surface discharges: one to a recreational stream and one to the Atlantic Ocean.

1.3 MODULAR PEAT SYSTEMS



During the early to mid 1990's Dr. Brooks developed the "Modular Peat System". With this system, trained work crews place the peat in tanks inside a fabrication plant. The crews are trained directly by Dr. Brooks. The peat is specified by Dr. Brooks and the peat suppliers are educated by Dr. Brooks on the peat specifications. The modular system is designed to ensure all peat treatment tanks or modules are properly fabricated. The prefabricated peat modules are sent to site where the contractor's job is largely placement of the peat modules and connection of the modules to the septic tank.

1.4 FROM THE 1990'S INTO THE NEW MILLENIUM

In the mid 1990's Dr. Brooks installed 5 peat beds on Cape Cod. All systems are still functioning.

Dr. Brooks has 3 peat bed systems in the province of New Brunswick. These systems were installed in the mid 1990's. All systems are still functioning.

In the Province of Ontario there are 13 functioning peat systems. These systems were installed between October 1990 and September 1995. These systems serve a variety of institutions and homes, Restaurants, Shopping Centers, Schools and Multi unit town houses.

In 2000 the State of Florida approved Modular Peat Systems. Over the past 2 years approximately 20 modular Peat systems have been installed in Florida and all are still functioning.

In addition to Florida and Maine, peat systems have been approved in Alabama, Ohio and a number of other states.

As of December 2002, there are approximately 40 modular Shaw Peat systems approved by the Nova Scotia Department of Environment and Labour (NSDEL), installed and functioning in Nova Scotia. A partial list of Nova Scotia peat systems is provided in Appendix E.

2.0 HOW PEAT TREATS WASTEWATER

Peat works to treat wastewater through three processes; physical filtration, absorption and microbial activity.

Physical filtration of the wastewater flow is facilitated by the structure of the peat moss. As the wastewater trickles through the peat moss, solids and organisms in the effluent are intercepted and retained by the peat moss.

Absorption is enhanced by the high ion exchange capacity of peat. Peat is quite acidic and is thus positively charged. Negatively charged particles in the wastewater effluent are highly attracted to the peat and will adhere to the peat. As the wastewater flows through the peat, particles are absorbed by the peat and removed from the flow.

For microbial activity the cool acidic environment and large surface area provided by the peat affords a very favourable environment for the growth of microscopic fungi. Many of these fungi have the ability to assimilate all forms of nitrogen present in septic tank effluent. These fungi produce bactericides that contribute to the die-off of fecal coliforms and other bacteria.

Cold temperatures (i.e. winter) do not adversely affect the performance of the Shaw Peat Treatment Systems. In fact, during colder times of the year an increase in performance is often observed. Bacteria, which feed on the microscopic fungi, are reduced in numbers due to colder temperatures resulting in larger microscopic fungi population and therefore higher treatment levels.

3.0 PEAT MOSS

There are three types of peat moss: sphagnum, reed-sedge and woody peats. The sphagnum peat is the peat of choice. Less treatment is obtained with reed-sedge or woody peat. Sphagnum peat is also more resistant to breakdown than reed-sedge and woody peat.

Important parameters for peat to be used in treatment systems include:

- Von Post Degree of decomposition: H-4
- pH: 3.5 to 4.5
- Organic Matter Composition: At least 95%
- Nitrogen Content: 0.5 to 1.0% of the dry organic material
- Moisture Content: 50 to 60%

Commercially available horticulture peat is not suitable for use in treatment systems.

4.0 WHY USE A PEAT SYSTEM

A few of the many applications for a peat system follow:

- **Undersized lots** – Numerous sites are too narrow or too small to allow for a conventional contour system. The compact nature of a modular peat system will allow placement of three peat modules, with sufficient treatment capacity for a three-bedroom house, on an approximate footprint of 4m x 7m. (Space will also be required for a septic tank, say 3m x 1.5m).

- **"Tight" Soils –** Sites with "tight" or less permeable soils present the problem of hydraulic acceptance of the untreated sewage into the soils. A peat system releases treated effluent. Peat systems can provide cost effective solutions for "tight" soils.

- **Lakeside Lots –** Many lakeside lots are small. This means that a conventional contour field may simply be too large for the lot or may represent a significant physical intrusion (i.e. the "mound"). A mound may have an unattractive and unwelcome impact on site aesthetics. Another option is a holding tank which requires regular clean out by a vacuum truck. A peat system provides a compact, unobtrusive treatment system. A peat system can easily be blended into the natural setting with plantings

- **Sites with Bedrock** – On such sites the conventional solutions are holding tanks or expensive and intrusive mounds. A peat system can provide an economic alternative.

- **High Treatment Levels –** A peat system provides high levels of treatment. Additional information on treatment efficiency is provided in Chapter 7.

One very large advantage of a peat-based treatment system over other packaged/pre-engineered systems is the fact that it is a 'passive' system. Systems that have mechanical aerators and pumps requiring regular monitoring and maintenance are considered 'non-passive' systems. The advantage of a 'passive' system is that it requires less maintenance from the owner. 'Passive" systems do not depend on motors and other mechanical components, which are subject to wear and breakdown. When the mechanics of a 'non-passive' system stop working the treatment and flow of the wastewater stops.

Economics should be a part of every home or business owner's decision in selecting an on-site sewage treatment system. Approximate pricing information for a modular peat system is provided in Appendix G. Firm quotations for supply of a modular peat system to a specific project site can be obtained from Shaw Pipe.

Holding aside the higher treatment levels afforded by peat there are applications where a peat system will not provide the most economic solution:

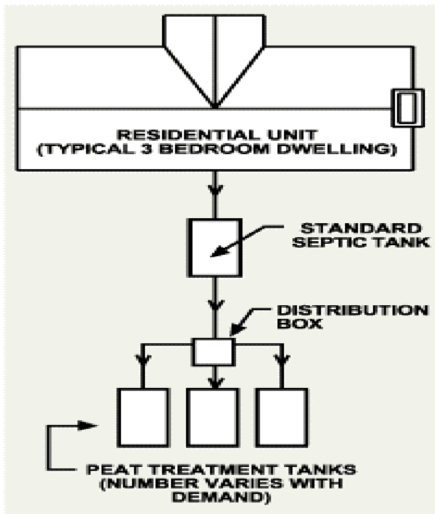
- **A Good Site -** If a site has permeable spoils, adequate size, water table separation and a good slope, a C1 contour system will be acceptable. A C1 system will be significantly less expensive than a peat system. A C2 contour system should also be less expensive than a peat system.

- **Low Flow Cottage –** If a seasonal cottage has low water usage the requirement to have a holding tank pumped may only be 2 or 3 times a summer. The relatively low installation cost and ongoing charges may be more economic than the capitol cost of a peat system.

5.0 SYSTEM OVERVIEW

The Shaw Peat Treatment System consists of several components that work together to efficiently treat wastewater effluent. A layout schematic of a typical system servicing a three-bedroom home follows. The Shaw Peat Treatment System is modular, making it adaptable to many applications. The capacity of a system can be easily increased by the addition of more treatment modules.

Typical System Layout for a Three-bedroom Home



The peat treatment system consists of the following components:

5.1 SEPTIC TANK

As with most conventional treatment systems the septic tank serves as a settling chamber, catches floatables and provides anaerobic treatment. For most residential applications, a 1000-gallon (4500L) tank is adequate. For larger applications a larger septic tank can be used or a multiple of tanks.

All septic tanks sold with the Shaw Peat Treatment System are CSA approved (CAN/CSA-B66-M90) precast concrete tanks. If an adequate septic tank already exists on site it may be reused provided that an effluent filter is installed in the septic tank.

5.2 EFFLUENT FILTER

Every Shaw Peat Treatment System is sold and shipped with a POLYLOK® effluent filter. This filter prevents solids and floatables from exiting the septic tank and entering the distribution lines and/or treatment modules.

5.3 PUMP CHAMBER

This component is not indicated on the schematic above, but can be incorporated into the Shaw Peat Treatment System. A pump chamber is only required when site grades will not allow a gravity system.

The size and configuration of pump chamber will depend on the size and configuration of each system. A typical pump chamber conforming to CAN/CSA-B66-M90 can be used in many instances. If system size or configuration should dictate, 1050mm (42") diameter or larger manhole sections can be utilized as the pump chamber. Engineers at SHAW PIPE are ready to assist you in determining the pump chamber that meets your needs.

5.4 DISTRIBUTION BOX

This component splits the wastewater flow from the septic tank into a series of parallel and equal flows, each of which is piped to a treatment module. Precast concrete distribution boxes are sold and shipped with every Shaw Peat Treatment System.

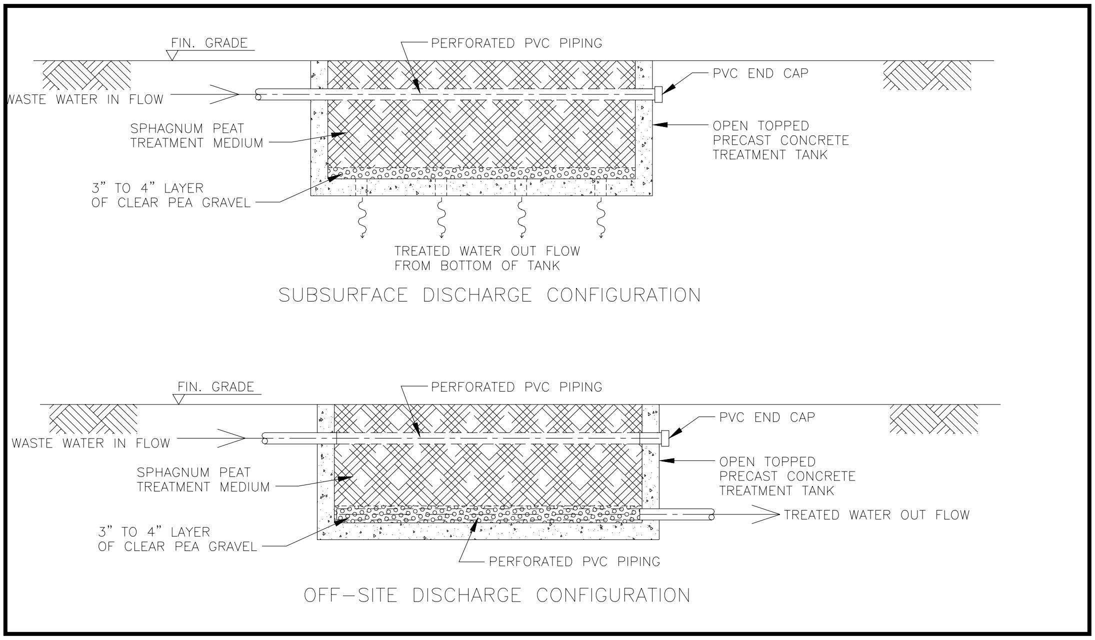
5.5 FLOW EQUALIZERS

These components are inserted into the ends of the 100mm (4") diameter discharge pipes in the distribution box to ensure equal flow to all treatment modules. Every Shaw Peat Treatment System is shipped with Equalizers by POLYLOK®. These flow equalizers are plastic adjustable weirs, which will maintain even flow to the treatment tanks if the distribution box should experience uneven settlement up to 10mm (3/8").

5.6 TREATMENT MODULES

These modules simply replace the distribution field in a conventional on-site system. The modules are fabricated from open top concrete tanks that are filled with compacted sphagnum peat. Each module is approximately 3.28m long by 2.06m wide with a 1.09m height (10'-9"L x 6'-9"W x 3'-7"H). A system of perforated PVC piping near the top of the module disperses the wastewater flow over the peat. The wastewater is treated (aerobic) as it percolates through the peat. Once the wastewater reaches the bottom of the module it is released directly into the soil through holes in the bottom and sides of the concrete tank. This is referred to as a Subsurface Discharge System. Alternately the wastewater flow may be collected at the bottom of the module and discharged through a single drainage pipe. This is referred to as an Off-Site Discharge System. The following schematics show the operation of each type of system.

Treatment Module Types:



Other components of the Shaw Peat Treatment System that are not supplied or produced by SHAW PIPE:

5.7 PIPING

100mm (4") diameter SDR 35 piping is recommended for all connection piping throughout the entire system. This material is much more durable than typical PVC and will result in less failure and damage due to backfilling procedures and settlement.

5.8 BASE MATERIAL/DISPERSION MANTLE

The imported material upon which a peat module is placed is known as the base material. In the case of an Off-Site Discharge System the base material simply supports the modules and prevents settlement. For these systems a level layer of granular material is placed and compacted.

For a Subsurface Discharge System the base material also serves as a dispersion mantle. The dispersion mantle provides an interface with the native subsoils through which the treated effluent is accepted into the subsoils. This dispersion mantle must be correctly sized based on the subsoil hydraulic acceptance rates. That is the dispersion mantle must provide enough interface area with the subsoil to allow acceptance of the full design flow by the subsoil.

Information on sizing of dispersion mantles is provided in chapter 6.

Dispersion mantles for Subsurface Discharge Systems are constructed with a sand which is either:

- A washed concrete sand that meets the current ASTM-33 or CSA A23.1 specifications, or

- A naturally occurring or washed sand having a permeability, as placed on site, between 0.0001 and 0.0008 m/second as determined by the falling head permeability test.

6.0 SYSTEM DESIGN

As with any on-site sewage disposal system, the design of a Shaw Peat Treatment System should be carried out by a competent professional experienced in the field of sewage treatment. The NSDEL requires that all onsite systems either be designed by a qualified Person Type 1 (QP1), usually an engineer, or be selected by a Qualified Person Type 2 (QP2) which is usually an installer. A peat system requires design by a QP1.

The design methodology provided below is simply a guide to the design of most Shaw Peat Treatment Systems. Designers must apply engineering judgment when designing each system.

The design methodology for the Shaw Peat Treatment System involves the following steps:

- Site Assessment
- Quantification of the Wastewater Design Flow Volume
- Sizing of the Treatment System – This involves sizing of the septic tank, determining the number of treatment modules required, etc.
- Layout of the system

6.1 SITE ASSESSMENT

Basic considerations in the assessment of a site, for the suitability to install a Shaw Peat Treatment System include:

- soil assessment
- bedrock elevation
- groundwater elevation
- slopes, surface drainage and changes in grade
- traffic areas
- well location
- type of facility to be serviced

As with all on-site systems, other considerations such as lot boundaries, wetlands, etc. must also be considered as per the NSDEL Guidelines for On-Site Sewage Disposal Systems.

Soil Assessment

The soil conditions are an important consideration for the selection of the type of Shaw Peat Treatment System (Subsurface Discharge versus Off-site Discharge). **For Subsurface Discharge Systems the design/size of the Dispersion Mantle under the peat treatment modules is affected by the soil conditions.**

All soil assessments must be carried out through test pit investigations. Factors to be determined during this investigation are:

Soil types and densities – The hydraulic loading rate or hydraulic acceptance rate of soil is a function of the soil type (e.g. clay, silt, sand, etc.) and the soil density. For the Subsurface Discharge System the size of the Dispersion Mantle is a function of the hydraulic loading rate(s) of the underlying soil(s). Thus determining the underlying soil types and densities is critical to the design of a Subsurface Discharge System. If impermeable soil is present an Off-Site Discharge System should be considered.

Soil profile – On many sites there may be more than one type of soil. The soil types are typically layered or stratified. In cases where the soil is stratified with carrying densities or soil types the lowest loading rate of the soil layers found should be used to design/size the Dispersion Mantle.

Depth to seasonal water table – A minimum vertical separation of 600mm (24”) must be provided between the underside of the base material under a subsurface discharge peat treatment module and the seasonal water table.

For subsurface discharge systems on sites with clayey silt or clay subsoils, as vertical separation of 150mm (6”) must also be maintained between the underside of the base material and the **mounded** water table. Refer to Section 6.10 of this manual.

Depth to bedrock or highly permeable soil – A minimum vertical separation of 600mm (24”) must be provided between the underside of the base material under a subsurface peat treatment module and bedrock or highly permeable soil.

Well Locations – Peat based treatment systems provide a high level of wastewater treatment making them an excellent choice for small confined lots with poor soils. However, maximum separation distances between the Peat Treatment System and the well should be maintained whenever possible.

Traffic Areas – Peat systems are susceptible to damage from vehicular and other heavy traffic that would compact the peat in the modules. This could even result in hydraulic failure if excessive compaction should occur. For this reason the Peat Treatment System should be located away from vehicular traffic areas and pedestrian traffic over the system should be kept to a minimum.

Slopes, surface drainage and changes in grade – Placing the peat treatment system on steep slopes or large changes in grade could require a costly cut and fill operation. Therefore, situations such as these should be avoided from a cost perspective. However, large slopes do not affect performance of the Peat Treatment System. Surface drainage from run-off and snowmelt entering the peat treatment tanks could hydraulically over load the system. The grades near the treatment modules should be sloped to direct surface run-off away from the modules. This may require the use of an interceptor trench in some situations.

Type of Facility – For applications other than residential (e.g. – restaurants, milk waste, etc.), consideration should be given to the nature and strength of the waste flow. For example, on commercial kitchens with deep fat fryers, a grease trap should be provided.

6.2 QUANTIFICATION OF WASTEWATER DESIGN FLOW

Quantification of a design flow is usually a relatively straightforward exercise, which is independent of the treatment system to be employed. The design flow is a function of the facility being serviced (e.g. – number of occupants). Thus determining the daily design volume for a facility is a simple application of applicable (i.e. provincial) regulations.

The minimum flow for design of a residential on-site sewage disposal system is 1000 L/day. The recommended flows to be used for residential system design are taken from the NSDEL guidelines and are listed in the table below.

Dwelling Type	Average Daily Flow (L/day)
3 bedroom home	1000
3 bedroom home with high water use fixtures	1200
4 bedroom home	1350
4 bedroom home with high water use fixtures	1500

Shaw Peat Treatment Systems can also be used for commercial use applications such as stores, restaurants, garages, etc. To determine design flows for such buildings it is recommended that the suggested design flows listed in the NSDEL Guidelines for On-Site Sewage Disposal be followed. Design flow information from these Guidelines is provided in Appendix H of this manual.

6.3 SIZING THE SEPTIC TANK

NSDEL guidelines for on-site sewage disposal are to be followed when determining the minimum septic tank capacity or size.

Number of Bedrooms	Minimum Liquid Capacity (liters)*
3	2800
4	3300
5	4500

* As per N.S.D.E.L. Guidelines

It is recommended, but not required, that a 4500 liter (1000 gal) septic tank be provided for a single family, 3 bedroom home. For larger systems the capacity of the septic tank should be equal to two days design flow and can be calculated from the formula below.

$V_{tank} = 2Q_D$ V_{tank} = tank volume in liters
Q_D = average daily flow in liters

6.4 DISTRIBUTION BOX DESIGN

The purpose of the distribution box is to equally split the flow from the septic tank to each of the treatment modules. Distribution box size and configuration can vary depending on the capacity and layout of the system. The geometry of the system and the number of treatment modules largely govern the selection of a distribution box. Engineers at SHAW PIPE stand ready to assist you in determining the most efficient size and type of distribution box for your system.

Recommended Distribution Boxes

Number of Treatment Tanks	Type of Distribution Box
2 – 6	Small Box (typical)
7 – 9	Large Box
More than 9	1800 mm (72”) dia. Manhole

Shaw Peat Treatment Systems are normally sold and shipped with small distribution boxes for residential systems. These boxes are similar to those used with other on-site systems (i.e. area beds).

Inside a distribution box a Flow Equalizer is placed on the open end of each supply pipe for a treatment module. A Flow Equalizer is an adjustable weir. These adjustable weirs ensure the flow from the septic tank is spilt into equal flows for the treatment modules. The Flow Equalizers are designed to compensate for settlement of the distribution box. Over time organic material builds up on the weirs receiving excess flow, therefore raising the water level in the distribution box. Eventually equilibrium is reached between the weirs and flow is evenly split once again.

6.5 DETERMINATION OF REQUIRED NUMBER OF TREATMENT MODULES

The Shaw Peat Treatment System is adaptable to a range of system requirements and design flows. Sizing of the treatment system involves determining the number of treatment modules required based on the design flow. **A single treatment module has a treatment capacity of 340 liters per day (75 imperial gal/d).**

The number of modules required in a given application is determined by dividing the design flow volume by the established single module capacity. This for the three bedroom residence example, the number of treatment modules required would be calculated as follows:

$$\text{No. of Tanks} = \frac{\text{Design Flow Volume}}{\text{Single Module Capacity}}$$

$$= \frac{\text{1,000 liters per day}}{\text{340 liters per module per day}}$$

$$= \text{2.9 Treatment Modules}$$

Therefore 3 treatment modules are required.

6.6 SELECTION OF SYSTEM TYPE
(Subsurface Discharge vs. Off-site Discharge)

The selection of the type of Shaw peat Treatment System to be used for a particular application is an important decision. The parameters to be considered when selecting the system type include:

- potential discharge locations
- soil conditions
- depth to bedrock and water table
- implications of a discreet discharge
- slope of the site
- site conditions
- costs of installation

Where soil and site conditions will allow for a small dispersion mantle the Subsurface Discharge System is an economic solution which offers the advantage of complete subsurface disposal. On sites with impermeable soils, bedrock or other restrictive conditions, the Off-site Discharge System may be more economic. Existing Off-site Discharge Systems have treated effluent discharged to roadside ditches, streams and the ocean.

6.7 SIZING OF DISPERSON MANTLE
(Subsurface Discharge System Only)

Subsurface Discharge Systems are designed to release treated effluent directly into the existing subsoil. In order to facilitate acceptance of the treated effluent into the subsoil a dispersion mantle is constructed. The (dispersion mantle) base material shall have a minimum thickness of 150mm (6”) under the treatment modules. The base material shall be placed at least 100mm above the top of the openings in the sides of the treatment modules. The exposed top surface of this base material shall be covered with filter fabric to prevent fines from washing down into the dispersion mantle. (See details in Appendix A).

Determining the required size of the dispersion mantle is a straight forward hydraulic analysis. The purpose of this analysis is to ensure there is adequate subsoil interface available to allow acceptance of the treated effluent. For the purpose of discussion and design this manual uses the following notation:

A is the interface area with the subsoils at the underside of the dispersion mantle. ($meter^2$)

H is the depth of soil that will become saturated in order to move effluent in a lateral direction. (*meters)*

I is the hydraulic gradient (usually considered equal to the slope of the ground surface). *(meter/meter)*

K_H is the horizontal permeability of the soil through which flow moves. See Section 6.8. *(meters/sec)*

K_V is the *unit* vertical hydraulic acceptance capacity of the subsoil through which flow moves. See Section 6.9. *(liters/[meter^2 x day])*

L is the length over which any horizontal flow is occurring. This is the length of dispersion mantle measured perpendicular to the slope. *(meters)*

Q_D is the total daily flow which must be accommodated by the design. *(liters/day)*

Q_H is the horizontal hydraulic acceptance capacity. *(liters/day)*

Q_V is the vertical hydraulic acceptance capacity. *(liters/day)*

Q_T is the total hydraulic acceptance capacity of the subsoils. *(liters/day)*

Equation 1 (Eq. 1) states the purpose of the hydraulic analysis/design.

$$Q_T \geq Q_D \qquad \text{(Eq. 1)}$$

Once the treated effluent leaves the peat modules it may flow away into the insitnative subsoils both vertically or horizontally. The general equation for the total hydraulic acceptance capacity of the subsoils is:

$$Q_T = Q_H + Q_V \qquad \text{(Eq. 2)}$$

The horizontal hydraulic capacity (also known as Lateral Flow) may be calculated using D'arcy's Equation

$$Q_H = L \times H \times I \times K_H \qquad \text{(Eq. 3)}$$

The vertical hydraulic capacity may be calculated as follows:

$$Q_V = A \times K_V \qquad \text{(Eq. 4)}$$

Setting $Q_D = Q_T$ and substituting into Eq. 2 provides Eq. 5:

$$Q_D = L \times H \times I \times K_H + A \times K_V \qquad \text{(Eq. 5)}$$

Solving for the required area of the dispersion mantle (A) yields Eq. (6A):

$$A = (Q_D - L \times H \times I \times K_H) / K_V \qquad \text{(Eq. 6A)}$$

In many instances a peat system is being considered because site conditions (e.g. low slope, low permeability soils, etc.) limit the horizontal hydraulic acceptance capacity. Conservatively Q_H be set equal to zero producing Eq. 6B:

$$\boldsymbol{A = Q_D / K_V} \qquad \textbf{(Eq. 6B)}$$

Typically Eq. 6B is used for sizing of the dispersion mantle. A more detailed analysis may be performed using Eq. 6A.

When determining the layout and dimensions of the dispersion mantle it is advisable that an approximate 2:1 aspect ratio be used to maintain an even distribution of effluent.

6.8 HORIZANTAL PERMEABILITY OF SOIL

The horizontal permeability of a soil (K_H) is a measure of how quickly effluent moves laterally through the soil. The unit of measure for horizontal permeability is meters/sec. The horizontal permeability of a soil depends on soil texture, density and structure. Table 6.4 lists approximate ranges of horizontal permeabilities for various soil types.

TABLE 6.4 Guide to Approximate Horizontal Soil Permeabilities		
Soil Type	Permeability (meters/sec) x 10^{-6}	
	Approximate Range	Design Value
Medium to Coarse Sand	20 - 800	
Find Sandy Gravel	20 - 80	20
Silty Sand	8 - 20	15
Sandy Silt	3 - 8	5
Clayey Silt	0.8 - 3	1.5
Silty Clay	0.2 - 0.8	0.5
Clay	<0.8	-

Table 6.4 is in accordance with the November 15, 2000 NSDEL ON-SITE SEWAGE DISPOSAL SYSTEMS TECHNICAL GUIDELINES.

Identification of soil type should be performed by an experienced professional, through an on-site assessment carried out in accordance with the NSDEL guidelines.

6.9 UNIT VERTICAL ACCEPTANCE CAPACITY OF SOIL

The unit vertical acceptance capacity of soil (K_V) is a measure of a soils ability to accept a volume of vertical flow per horizontal unit area per day. The unit of measure for unit vertical acceptance capacity is liters per square meter of area per day. The unit vertical acceptance capacity is a function of the soil type. Table 6.5 lists approximate ranges of unit vertical acceptance capacities for various soil types.

A guide to Approximate Hydraulic Loading rates (Unit Vertical Acceptance Capacity) for Various Soils:

Table 6.5 Guide to Approximate Unit Vertical Acceptance Capacities	
SOIL TYPE	HYDRAULIC LOADING RATE* (L/day/m^2)
Rock, Clean Gravel	Unacceptably High
Medium to Coarse Sand	45
Fine Sandy Gravel	40
Silty Sand	32
Sandy Silt	27
Clayey Silt	22
Silty Clay	15
Clay	Unacceptably Low

The rationale for the values provided in Table 6.5 is provided in Appendix B. The values in table 6.5 assume no clogging mat in the subsoils as peat modules produce a treated effluent.

Identification of soil type should be performed by an experienced professional, through an on-site assessment carried out in accordance with the NSDEL guidelines.

6.10 MOUNDING AND WATER TABLE
(Subsurface Discharge System Only)

In conventional contour, mound and area bed systems the soil beneath the disposal field plays an important role in protection of groundwater quality. As effluent from a disposal field passes through a soil the particulate matter is physically filtered out in a short distance. Most bacteria, viruses or other pathogens are essentially eliminated within a short distance (say less than 600 mm) in an unsaturated soil due to the hostile environment. In saturated soils organisms may travel much greater distances.

Generally with conventional contour, mound and area bed systems protection of the groundwater is provided by either:

- Provision of a vertical separation distance of *unsaturated* soil from the bottom of the disposal field to the water table, highly permeable soil or bedrock.
- The presence of a layer of low permeable soil between the bottom of the disposal field and the water table, highly permeable soil or bedrock.

In Nova Scotia the intent of the Regulations and Guidelines for conventional systems appears to be that groundwater, highly permeable soil or bedrock should be protected by 1 meter of unsaturated soil and that where unsaturated soil will not occur protection can be provided by a layer of low permeable soil. Consider conventional systems in which the effluent moves primarily vertically down to the water table (e.g. area bed). Treatment of the effluent is achieved as the unsaturated flow moves through the vertical separation distance of say 1 meter to the groundwater table. Overtime the steady effluent flow will produce a local increase or mound in the water table. This produces a decrease in the distance from the bottom of the disposal system to the water table. This is in fact a reduction of the unsaturated soil vertical separation distance. Designers of conventional systems (with untreated effluent exiting the bottom of the disposal field) should consider in their designs that the depth of an unsaturated permeable soil under a disposal field will be reduced by mounding of a water table.

The effluent leaving a peat module is a highly treated effluent (see Chapter 7). Thus the soil beneath a peat system is no longer the critical effluent treatment medium. The primary function of the vertical separation specified for a Shaw Peat System is to conservatively provide a margin or safety against mounding of a water table up into the peat modules. The extra separation also provides for additional polishing of the effluent.

The vertical separation requirements for a Shaw Peat System are:

1. **A minimum of 600 mm from the underside of the base material to the seasonal water table.**
2. **A minimum of 600 mm from the underside of the base material to bedrock, highly impermeable soil or hard pan.**

An additional check on the mounded ground water table should be performed for:

1. **All systems discharging into subsoils with a Horizontal Soil Permeability (Hydraulic Conductivity) equal to or less than 3 x 10-6 m/sec (i.e. Clayey Silt or Clay). Refer to TABLE 6.4 in this Manual.**
2. **All systems with a continuous dispersion mantle larger than 150m^2.**

The vertical separation required on the mounded water table for these systems is 150mm from the underside of the base material.

The effects of groundwater mounding on a horizontal site may be estimated using a program available at the Center for Water Resources Studies (CWRS) web site (www.dal.ca/~cwrs/). This program is based on Finnemore's (1993) formula. The paper Estimation of Ground-Water Mounding Beneath Septic Drain Fields by E. John Finnemore is provided in Appendix I.

Worked example calculations, including mounding considerations using the program available at the CWRS website, are provided in Appendix C. In order to use the mounding program the Specified Yield of various soil types is required as an input. Specific Yield values from Crites and Tchobanoglous, 1998, Small and Decentralized Wastewater Management Systems are provided in TABLE 6.6.

Table 6.6 - Specific Yield Values for Various Soil Types	
Soil Type	Specific Yield
Gravel, coarse	0.23
Gravel, medium	0.24
Gravel, fine	0.25
Sand, coarse	0.27
Sand, medium	0.28
Sand, fine	0.23
Silt	0.08
Clay	0.03
Till, predominantly silt	0.06
Till, predominantly sand	0.16

6.11 OFF-SITE DISCHARGE DISPOSAL

The high treatment levels of a Shaw Peat System means the effluent from an Off-site Discharge Unit will meet recreational water quality standards. For the discharge of even a treated flow, *wherever possible*, preference should be given to larger water bodies with strong flushing actions. Thus the ocean would be preferred over a river, a river over a small stream and a small stream over a roadside ditch.

The end treatment for the piped effluent from an off-site discharge unit shall be a French Drain. A detail for a typical French Drain end treatment is provided on drawings 2003PE0205, 2003PE0206 and 2003PE0207 in APPENDIX A. The French Drain treatment disperses the flow over a wider/protected area. The cover provided by the large uniform granular material placed over the discharge pipe not only protects the pipe but also restricts contact with the treated effluent. In many cases the treated effluent never becomes visible as a surface flow.

For water bodies with limited flushing action (e.g. pond with no outlet stream) consideration should be given to additional Ultra-Violet (UV) disinfection. UV disinfection or other approved disinfection shall be provided for all piped discharges to a roadside ditch. UV disinfection units are relatively inexpensive and provide an added measure of safety for projects that involve potential stagnant waters or standing water in ditches. The Trojan UVMax models are examples of economic disinfection units, which can be applied to home and cottage projects. Additional information on model capacities is available at the

Trojan web site: www.trojanuvmax.com. There are numerous other companies offering reliable and economic UV disinfection technology. A disinfection unit can easily be mounted in a concrete manhole which can be shipped to the site with the peat system.

Special care should also be taken to ensure treated effluent or water does not back up into the peat modules even during wet times of the year. If water should back up into the peat modules for an extended period the breakdown of the effluent will become anaerobic and poor treatment will result. Important considerations to prevent "back –up" and anaerobic conditions are:

- Grades of discharge pipes – the grades on the discharge pipes should be 2% or greater.
- Seasonal high water levels of receiving waters - the peat modules should be set at a high enough elevation to prevent "back-up" from high tides or flooding brooks/river/ditches in the wet spring season.

6.12 PUMPING EFFLUENT

In some instances it will be necessary to pump to or from a Shaw Peat Treatment System. This could be due to a number of reasons such as: site layout, poor grades, plumbing in basement, etc. A pumping chamber can easily be added to the Shaw Peat Treatment System before or after the peat treatment modules.

When pumping the treated effluent from the treatment modules to a ditch, disposal field, etc., it is recommended that the effluent be collected together into one pipe which would enter a pumping chamber typically constructed from a small diameter manhole. Floats and a pump would be installed inside this chamber.

When pumping to the peat treatment modules, **steps must be taken to prevent direct application of pressurized effluent to the peat inside the treatment modules.** One approach is to pump to a distribution box that in turn gravity feeds to the treatment modules. This will prevent direct application of pressurized flow to the peat, which could cause erosion and the development of pathways for the effluent to quickly pass through the peat without receiving adequate treatment.

6.13 MAXIMUM PUMP RATE

The governing consideration for determining an acceptable "direct" pump rate is that the *volume of effluent pumped in a single pump cycle must not apply pressurized flow to the peat*. How this parameter is considered in a design may be illustrated by an example. Consider a system where there is gravity flow through the septic tank to a pump chamber. The effluent is then pumped to a distribution box. *(The pressurized inlet pipe should have a vertical elbow turned down in the distribution box).* The effluent then flows by gravity through three parallel 4-inch diameter pipelines to three peat modules. In a Shaw peat module the supply pipe then splits into three pipes to disperse the effluent over the peat.

The volume of effluent pumped to the distribution box in a single pump cycle should not exceed 75% of the total volume of the distribution box and gravity flow pipes supplying the peat (in this case the pipes downstream of the distribution box). The volume of the dispersion pipes in the peat modules may be included in the total volume of the gravity pipes. If the pump cycle delivers less volume than the volume available in the distribution box and gravity pipes the effluent in these pipes will not be pressurized. The 75% limit is a safety factor.

Assume in the example above there is 10 ft. of 4-inch diameter gravity flow pipe from the distribution box to each peat module. For small distribution boxes, the volume of the distribution box is conservatively ignored. In a Shaw peat module there is approximately 25 ft. of 4-inch diameter pipe. A 4-inch diameter pipe has a unit volume of 0.55 imperial gallons per linear foot.

PVmax =Maximum Pump Volume (1cycle)
=(75%) x (Gravity Pipe Total Volume)
=(75%) x (Length of Gravity Pipe) x (Pipe Unit Volume)
=(75%) x (3 x 10’ + 3 x 25’) x (0.55 gallons per ft.)
=43 gallons

6.14 GRAVITY DISTRIBUTION PIPES

A minimum slope of 2% shall be maintained to the septic tank. On all other system piping a minimum grade of 1.5% is to be maintained.

7.0 EFFICIENCIES

A monitoring program for the Shaw Peat Treatment System has been carried out by the Center for Water Resource Studies (CWRS) at Dalhousie University. Under this program the effluent treatment levels on three pilot systems located in Pomquet, Belle Cote and Boylston in Nova Scotia were monitored for periods ranging from 173 to 660 days.

The CWRN report (International Report No. 02-10) was finalized in May 2002.

Performance highlights for the study include:

- The three Shaw Peat pilot systems produced effluents with mean BOD_5 levels of 3, 8 and 14 mg/L.
- The three Shaw Peat pilot systems produced effluents with mean TSS levels of 6, 9 and 12 mg/L.
- The levels of BOD_5 and TSS treatment were consistent through the monitoring period and appeared to be unaffected by winter conditions.
- The Pomquet pilot system had a geometric mean E. coli for the treated effluent of 9/100ml with a maximum single sample count of 120/100ml.
- Initially the Belle Cote pilot system had a treated effluent geometric mean E. coli of 1,240/100ml. This treatment level improved within a few months to produce treated effluent with a geometric mean E.coli of 43/100ml with a maximum single sample count of 170/100ml.
- The E. coli reduction rate for the Boylston pilot system (95.47% - geometric mean effluent concentration of 3.5×10^3 CFU/100ml) was not as high as the media was the reason for the reduced level of treatment.
- To further investigate the consistency of E. coli treatment between peat systems, as single set of 5 samples was collected and tested at a fourth site in Hubbards, Nova Scotia. The treated effluent geometric mean E. coli for this series was 34/100ml (sample counts ranged from 0-340 CFU/100ml).
- Although the tops of the peat tanks are exposed to the atmosphere, no offensive odors were detected during the study period.

A complete copy of the report is available from Shaw Pipe upon request.

8.0 INSTALLATION

Installation of a Shaw Peat Treatment System is a quick and simple operation.

8.1 INSTALLATION OF THE SEPTIC TANK

The procedures for installation of a septic tank for a Shaw Peat Treatment System are the same as those for installation of a septic tank for a conventional on-site system. Some important items to note are:

- Provide a minimum slope of 2% on the drainage pipe from the building to the septic tank.
- Compaction of the soil under the septic tank will reduce the chance of settlement and possible damage to piping.
- Provide a compacted level bed under the septic tank.

If the invert of the tank or chamber will be installed below groundwater level, it shall be secured to prevent floatation.

8.2 INSTALLATION OF THE DISTRIBUTION BOX

Care must be taken when installing the distribution box to ensure that even flow is provided to all peat treatment modules. The installation of the distribution box is a simple operation. Some important items to note are:

- The elevation the distribution box/treatment module should be set to provide a minimum slope of 1.5% on the drainage pipe from the septic tank to the distribution box.
- Provide a 150mm (6”) thick layer of free draining granular base under the distribution box to help prevent frost heave and settlement.
- When installing piping into the distribution box pull the POLYLOK® gaskets out by the provided tabs. Do not try to cut the gaskets.

8.3 PREPARATION OF THE SUBGRADE FOR PEAT MODULES

Preparation of the subgrade differs for the two types of treatment systems.

Items to consider when preparing the subgrade for installation of Subsurface Discharge System:

- Ensure location and size of the dispersion mantle is within the limits on the approved contract drawings and all applicable provincial guidelines are met.
- During excavation for the peat modules, great care shall be taken to ensure that the bottom of the excavation does not become compacted. This means

reducing foot traffic on the excavation and at not times shall equipment be allowed to drive over the infiltration surface.
- A level base material of 150m (6”) minimum thickness shall be placed prior to installation of treatment modules. The base material shall be a sand in compliance with Section 5.8.
- Once the treatment modules have been placed and leveled, a layer of base material shall be placed to a height at least 100mm (4”) above the top of the drainage holes in the sides of the treatment modules.
- A layer of filter fabric shall be placed over the top of the base material prior to final backfilling.

Items to consider when preparing the subgrade for installation of Off-Site Discharge System:

- Ensure location and size of the base material is within limits on the approved contract drawings and all provincial guidelines are met.
- The subgrade below the treatment modules should be compacted to reduce settlement.
- A level base material of imported granular material or on-site material as approved by the engineer shall be placed and compacted prior to installation of peat tanks. The base material id to have a minimum thickness of 150mm (6”).

8.4 INSTALLATION OF TREATMENT MODULES

A single Shaw Peat Treatment Module weighs 7484kg (16,500 lbs.). Usually a crane is required for the installation of the peat treatment modules. It may be feasible to use a large excavator to place peat modules where there is good site access. Even larger excavators have limited lift capacities for longer reaches. Id an excavator is to be used the lift capacity and reach of the excavator should be carefully reviewed.

The Shaw Peat Treatment System will arrive at site in a flat bed trailer. The contractor will be responsible for providing site access for the tri-axle trailers and off-loading of all components. SHAW PIPE does not provide a lifting device for the treatment modules. The lifting device consists of a spreader beam, steel cables and four (4) connection devices, which screw into inserts located at the top of the walls in each module. The lifting device must be returned with the truck after installation has been completed.

Installation of the treatment modules is a quick and easy procedure. Some important items to note are:

- Ensure the treatment modules are level prior to final backfilling.
- Ensure the treatment modules have complete bearing on the prepared subgrade.
- The treatment modules should be installed at an elevation to allow a minimum slope of 1.5% on inlet and outlet piping.
- All piping connected to the treatment modules is to be secured with proper adhesive and be free of leaks.

When installing any Shaw Peat Treatment System care is to be taken to ensure that the underside of the treatment modules is well above the water table, the bottom of any receiving ditch or French Drain and the high water mark of any adjacent watercourses. At no times shall water be allowed to back up into the treatment modules.

8.5 INSTALLATION OF PIPING

The procedures for installation of piping for a Shaw Peat Treatment system are the same as those for installation of piping for a conventional on-site system.

Some important items to note are:

- 100mm ∅ (4”) SDR 35 is recommended for all piping.
- A minimum slope of 2% is to be maintained on all gravity piping up-slope of the septic tank.
- A minimum slope of 1.5% is to be maintained on all gravity piping down-slope of the septic tank.
- Subgrade below system piping should be compacted to prevent excessive settlement.
- Imported, free draining, granular material installed below and around all system piping is recommended. This will help prevent settlement, frost heave and damage during backfilling.

8.6 INSTALLATION OF EFFLUENT FILTER

The effluent filter provided with the Shaw Peat Treatment System is installed inside the septic tank on the open end of the exit or outlet pipe. The filter has three components; filter housing, a filter cartridge and pipe adapter. The installation procedure follows:

- The pipe adapter is simply snapped onto the filter housing and both are inserted onto the end of the outlet pipe with the use of adhesive.
- There is a small hole in the top of the pipe adapter where a stainless steel

screw is to be installed to prevent rotation of the filter.
- The filter cartridge is then inserted into the housing.
- In some cases where a baffle exists in the septic tank, modification of the baffle may be required to aloe for installation of the filter.

8.7 SETTING THE FLOW EQUALIZERS

To evenly split the effluent flow into a distribution box ‘flow equalizers’ are used. Typically ‘flow equalizers’ are devices which are attached to the outlet pipes and allow the adjustment of the flow level into each outlet pipe. Once conventional ‘flow equalizers’ are adjusted subsequent differential settlement of the distribution box can result in unevenly split flows. The Polylok Equalizer provided with the Shaw Peat Treatment System automatically compensates to maintain equal flow from the distribution box to all treatment modules.

If a distribution box shifts over time and directs more water to a low outlet pipe, organic slime builds up on the weir of the Polylok Equalizer. The buildup acts like a self-leveling organic dam, raising the level on the low outlet to equalize flow to all pipes.

Installation Instructions:

- Insert one Equalizer onto the open end of each outlet pipe in the distribution box with the adjustment knob positioned at the top.
- Rotate all adjustment knobs counter-clockwise to the full down position.
- Add water to the distribution box until it reaches the weir openings of the Equalizers. Using the water as a level, observe which outlet sits highest in the box and do not adjust the Equalizers fitted to this outlet. Rotate all remaining Equalizer knobs clockwise, moving the weirs up to match the level of the highest Equalizer. Fine tune by adding water to make sure all weir openings are at the same level.

8.8 FINAL BACKFILLING

The backfill placed over the base material and the filter fabric shall be approved on-site material or clean loamy sand. This material shall be graded to provide a 4:1 positive drainage slope away from the treatment modules in accordance with the drainage plan. The graded surface of the final backfill shall be covered with topsoil and seeded to prevent erosion. The surface of the peat material should be seeded with lawn grass or shallow rooted vegetation. However, no fill, topsoil or any type of ground cover shall be placed on the peat surface.

9.0 MAINTENANCE

The operation of a Shaw Peat Treatment System is the same as for any on-site wastewater treatment system. There are three areas where actions of the homeowner can have an effect on the system. They are (1) what is flushed down the drain; (2) the septic tank; and (3) the Shaw Peat Treatment Modules.

(1) MATERIALS DISPOSED OF THROUGH THE HOUSEHOLD PLUMBING FIXTURES – The use of garbage disposal units is not recommended because their use increases the amount of suspended particulate matter in the septic tank effluent. The suspended particles can be carried over into the peat modules where they can cause premature failure. Where a garbage disposal is installed additional septic tank retention is required such as a two-compartment septic tank or two tanks in series. Filters should be used on the effluent line from the septic tank to prevent carry over of excessive solids. Filters require regular maintenance and cleaning by the owner (generally once a year for residential and every 6 months for commercial uses).

The use of normal house hold cleaning chemicals such as bleach, detergents and cleaning agents will not cause problems in the system if they are used according to directions and not in excessive amounts. Other chemicals used around the house such as paint, paint thinner, glue, furniture strippers, oils, greases and darkroom chemicals must not be disposed of via household plumbing. Large quantities of grease and oil from frying must be disposed of with the solid waste and not down the drain.

Only readily biodegradable material may be disposed of in the system. Disposable diapers, condoms, sanitary napkins and tampons, kitty litter, facial tissues, paper towels, coffee grounds, coffee filters and similar products must be disposed of with the solid waste. Introducing them into a septic system may cause relatively rapid failure of the system.

(2) THE SEPTIC TANK – The purpose of a septic tank is to remove solids, greases and oils from the wastewater. Materials are partially decomposed in the septic tank with a more rapid rate of accumulation than that of decomposition.

The use of septic tank starters or additives is not recommended or necessary. Septic tanks must be pumped out on a periodic basis to prevent carry-over of solids to the peat tanks or clogging of the system.

(3) THE SHAW PEAT TREATMENT MODULES – As the septic tank effluent passes through the peat in the treatment modules, the pollutant concentrations are greatly reduced.

As with any on-site wastewater disposal system no vehicular traffic should be allowed on the surface of the system. As well, pedestrian traffic should be kept to a minimum. The back-flush from a water treatment system should not be disposed of in any on-site wastewater treatment system.

If the surface of the peat in the Shaw Peat Treatment System is planted to grasses it may be mowed during the growing season with a power mower, but not with a ride-on mower. If the surface is planted to shallow rooted vegetation and not mowed, it should be weeded at least every two (2) years to remove deep-rooted vegetation that may begin growing.

Providing vegetative cover over the peat ensures that erosion of the peat does not take place and the peat remains at its optimum moisture content, which is critical to its performance.

Some readily available plants that grow well in our peat treatment tanks are:

- Heathers
- Heaths
- Goose Neck
- Bee Balm
- Mint
- Herbs
- Grass
- Jacobs Ladder
- Johnny Jump Ups

If any of the above plants are not available or other plant types are desired, a local nursery should be consulted to confirm acceptable alternatives. When planting any vegetation in your peat treatment modules be sure that it is shallow rooted and capable of living in a moist and acidic environment.

To function properly the peat treatment modules require oxygen and therefore must open to the air. For this reason it is very important to note that the modules can only be covered with vegetation as noted above. Under no circumstances shall the modules be covered with soil, sod, wood chips, hay, plastic, etc. It is recommended that vegetation be planted in the modules soon after installation has been completed.

The FLOW WEIRS in the distribution box should be checked regularly (minimum once per year) to ensure the flow is equally split among all the treatment modules.

10.0 ADDITIONAL INFORMATION

For additional information on the application of a Shaw Peat Treatment System for your home, cottage or business, Shaw Pipe may be contacted at the following numbers:

Office (Lantz): Phone: (902) 883-2201
Fax: (902) 883-1273
E-mail: sales@shawpipe.com

Office (Moncton): Phone: (506) 388-8887
Fax: (902) 859-7390
E-mail: shawpipemoncton@nb.aibn.com

APPENDIX A – TYPICAL DRAWINGS, DETAILS AND NOTES

Explanatory Comments on Typical Details

Overview

Shaw Pipe provides two types of peat treatment systems:

- Subsurface Discharge Systems – The Shaw Pipe typical details for this system are 2003PE0101 to 2003PE0104.
- Piped Discharge System – The Shaw Pipe typical details for this system are 2003PE0201 to 2003PE0207.

In the Piped Discharge System the treated effluent is collected at the bottom of the peat treatment modules through a system of perforated pipes. The collected effluent is then carried away from the peat treatment modules via a four-inch pipe to an approved discharge location.

In the Subsurface Discharge System the treated effluent is released from the peat treatment modules into a layer of Base Material and then directly into the subgrade. The function of the Base Material is to disperse the effluent over a sufficient subgrade area to allow for acceptance of the effluent flow volume by the subgrade.

The Shaw Pipe typical details for both systems are a series of standard details which define the major components and layout for a peat treatment system. With minor modifications these typical details can be converted to a set of project specific drawings. These project drawings can be used for permit applications and will prove a valuable tool for the on-site installer.

The following comments provide information on the various details.

System Schematic (2003PE0101 and 2003PE0201)

The schematic provides a plan layout of the major components of the peat system. The System Schematic is not intended to serve as a "to scale" plan layout. The major components of the peat system are listed below:

- Septic Tank – The septic tank should be fitted with an effluent filter which is provided by Shaw Pipe.
- Distribution Box – The purpose of the distribution box is to split the flow from the septic tank so it may be distributed to the peat modules.
- Peat Modules – In the typical detail three peat modules are drawn as would be required for a standard three-bedroom home. For systems which require more (or fewer) modules the schematic should be modified.

There are two pieces of project specific information which should be added to the schematic:

- System Design Flow
- Septic Tank Capacity

<u>Section A</u> (2003PE0102 and 2003PE0202)

This is a longitudinal section through the system. This section is intended as a schematic.

<u>Section B</u> (2003PE0103 and 2003PE0203)

This is a cross section through the system which shows three peat treatment modules. For systems which require more (or fewer) modules the section should be modified. This section is intended as a schematic.

In the case of the Subsurface Discharge system it is important to note there are some restrictions which apply to the elevation at which the peat modules are located. These restrictions are defined in the following note which is provided in Section B:

The elevation of the underside of the Base Material shall be established to meet all of the following criteria:

- *A minimum of 600mm above the seasonal water table.*
- *A minimum of 600mm above a restrictive layer (e.g. – hardpan).*
- *A minimum of 600mm above bedrock.*

<u>Tank Opening Locations</u> (2003PE0104 and 2003PE0204)

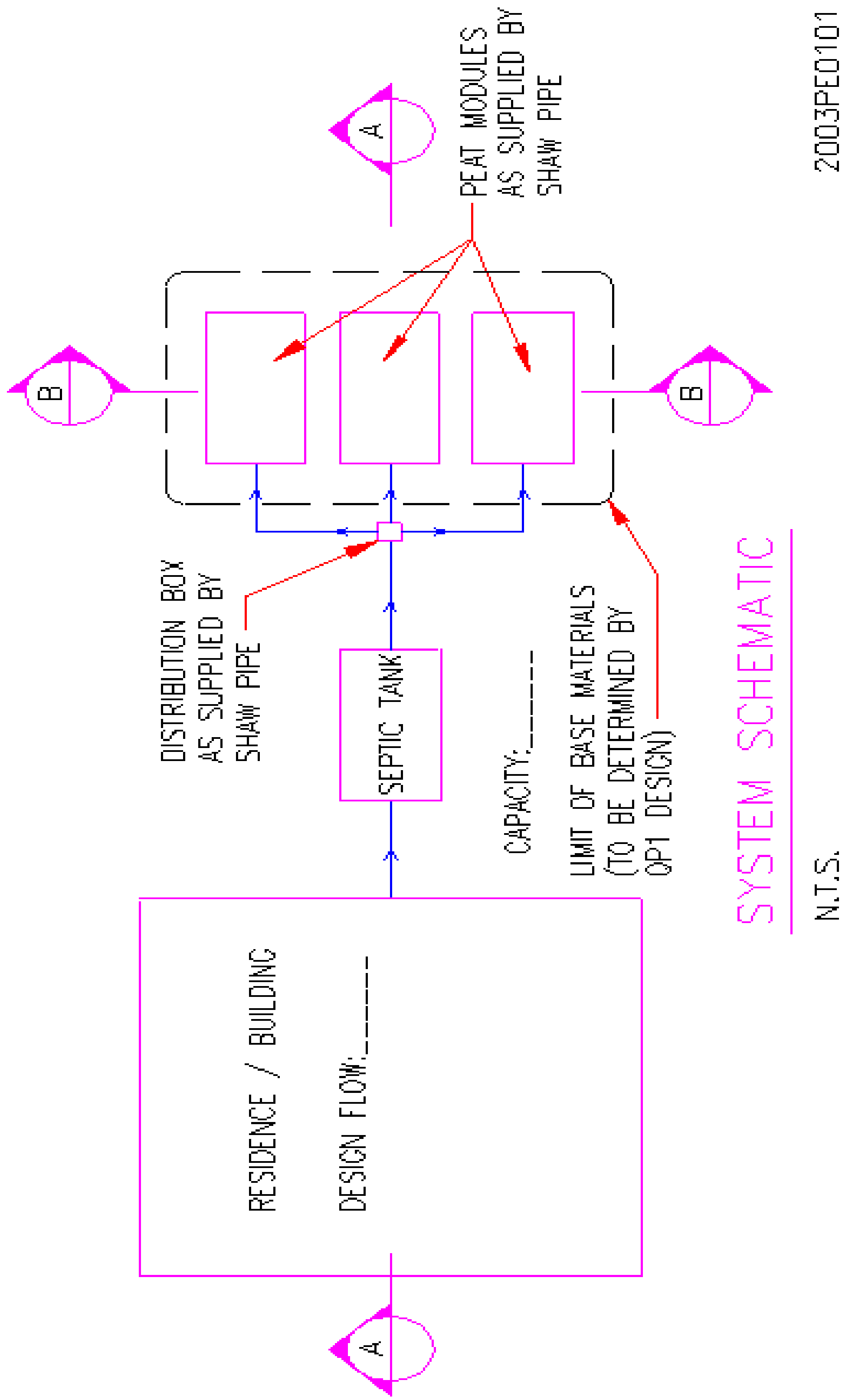
This tank end elevation provides the locations of the inlet and outlet holes on the peat treatment modules.

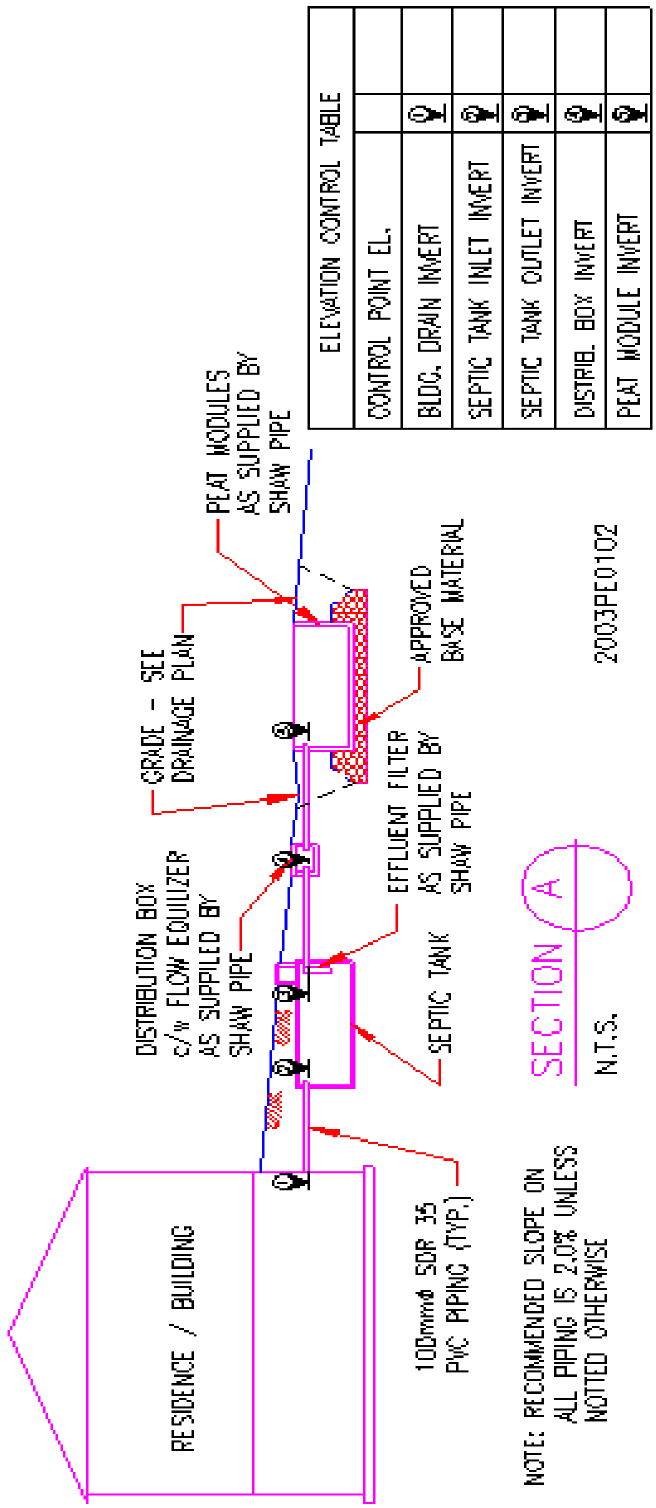
<u>The Drainage Plan</u> (not included)

There is no drainage plan provided as a typical detail as all drainage plans are site specific. **All project drawings should have a drainage plan.** The drainage plan should be to a "to scale" plan layout which defines the locations of the various system components and the finished site contours. It is essential that the site drainage plan be developed such that the peat treatment modules are not installed in a local "low spot".

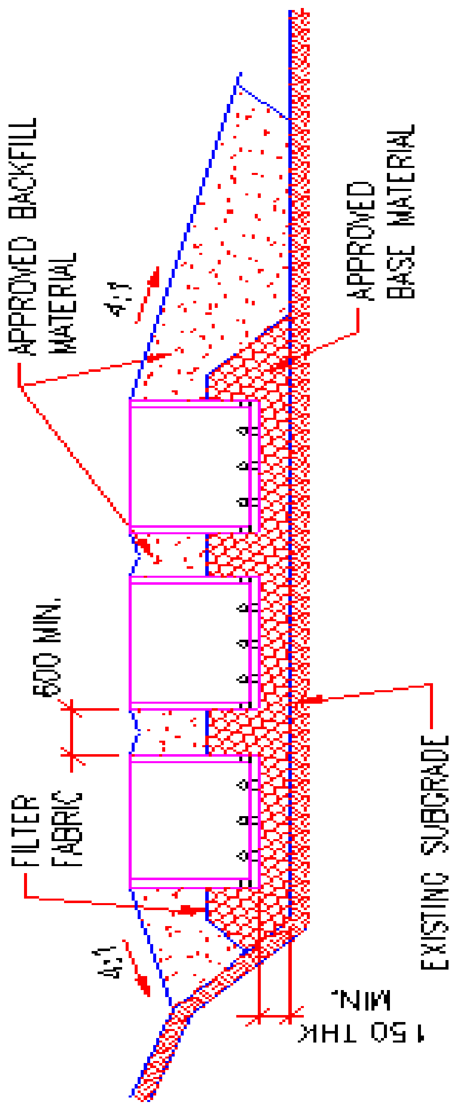
Notes

These notes provide installation instructions and requirements which are standard for peat systems. For the Subsurface Discharge System the required plan area of the Base Material under the peat tanks should be defined in Note 4. The required plan area of the dispersion mantle is a function of the design flow and the subgrade soil type (e.g. – permeability of the subgrade). The sizing of the dispersion mantle should be carried out by a Qualified Professional (e.g. – QP1).


PEAT MODULES
AS SUPPLIED BY
SHAW PIPE
2003PE0101
A
B
B
DISTRIBUTION BOX
AS SUPPLIED BY
SHAW PIPE
SEPTIC TANK
CAPACITY:______
LIMIT OF BASE MATERIALS
(TO BE DETERMINED BY
QP1 DESIGN)
SYSTEM SCHEMATIC
N.T.S.
RESIDENCE / BUILDING
DESIGN FLOW:______
A



ELEVATION CONTROL TABLE		
CONTROL POINT		EL.
BLDG. DRAIN INVERT	1	
SEPTIC TANK INLET INVERT	2	
SEPTIC TANK OUTLET INVERT	3	
DISTRIB. BOX INVERT	4	
PEAT MODULE INVERT	5	



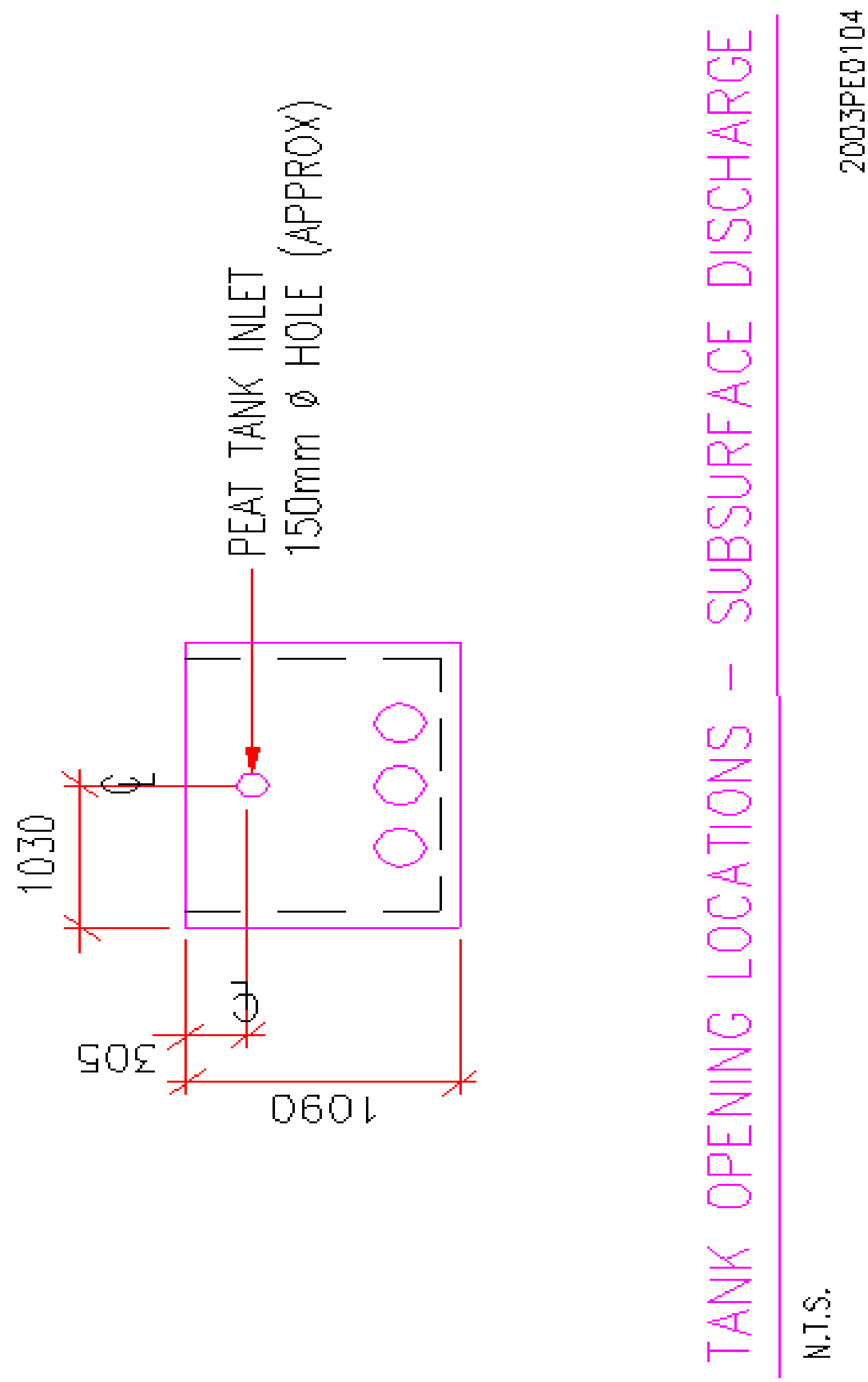
The elevation of the underside of the base material shall be established to meet all of the following criteria:

1. A minimum of 600mm above the seasonal water table

2. A minimum of 600mm above a restrictive layer (e.g hardpan)

3. A minimum of 600mm above bedrock

SECTION B
N.T.S.


PEAT TANK INLET
150mm Ø HOLE (APPROX)
1030
305
1090
TANK OPENING LOCATIONS - SUBSURFACE DISCHARGE
N.T.S.
2003PE0104

SUBGRAGE DISCHARGE SYSTEM

Notes

1. On-site excavation/filling shall be carried out as required to place base material and set the peat modules in accordance with the minimum required base material plan area and the elevation control table.

2. The base material shall be:
   - A washed concrete sand that meets the current ASTM-33 or CSA A23.1 specifications OR
   - A naturally occurring or washer sand having a permeability, as placed on site, between 0.0001 and 0.0008 m/second as determined by the falling head permeability test.

3. The minimum thickness of the base material shall be 150mm.

4. The minimum required base material plan area shall be Xm x Ym. The surface of the base material shall be leveled prior to placement of the peat modules.

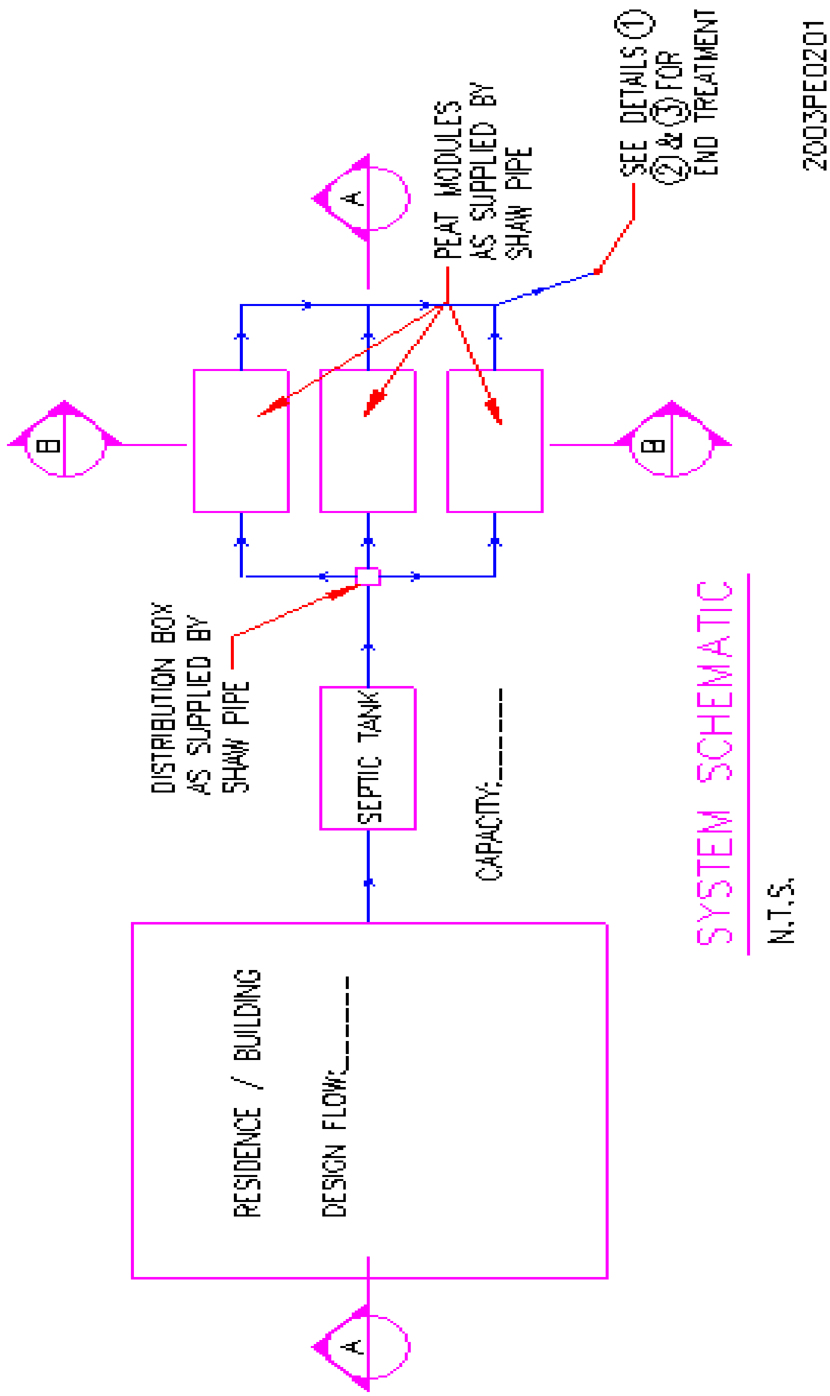
5. Once the peat modules have been placed and leveled, a 300mm wide x 300mm high layer of base material shall be placed around the perimeter of each module. (see Sections A & B).

6. A layer of filter fabric shall be placed over the top of the base material prior to final backfilling.

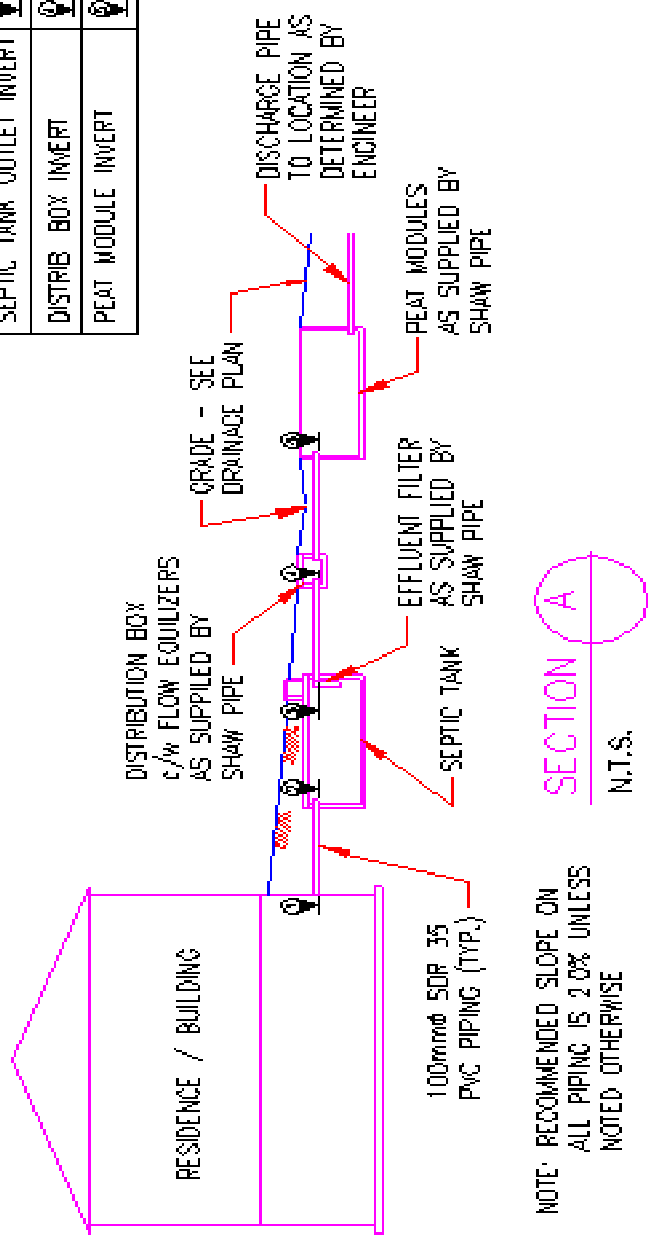
7. The backfill placed over the base material and filter fabric shall be clean loamy sand or approved on-site material. This material shall be graded to provide a 4:1 positive drainage slope away from the peat modules in accordance with the drainage plan.

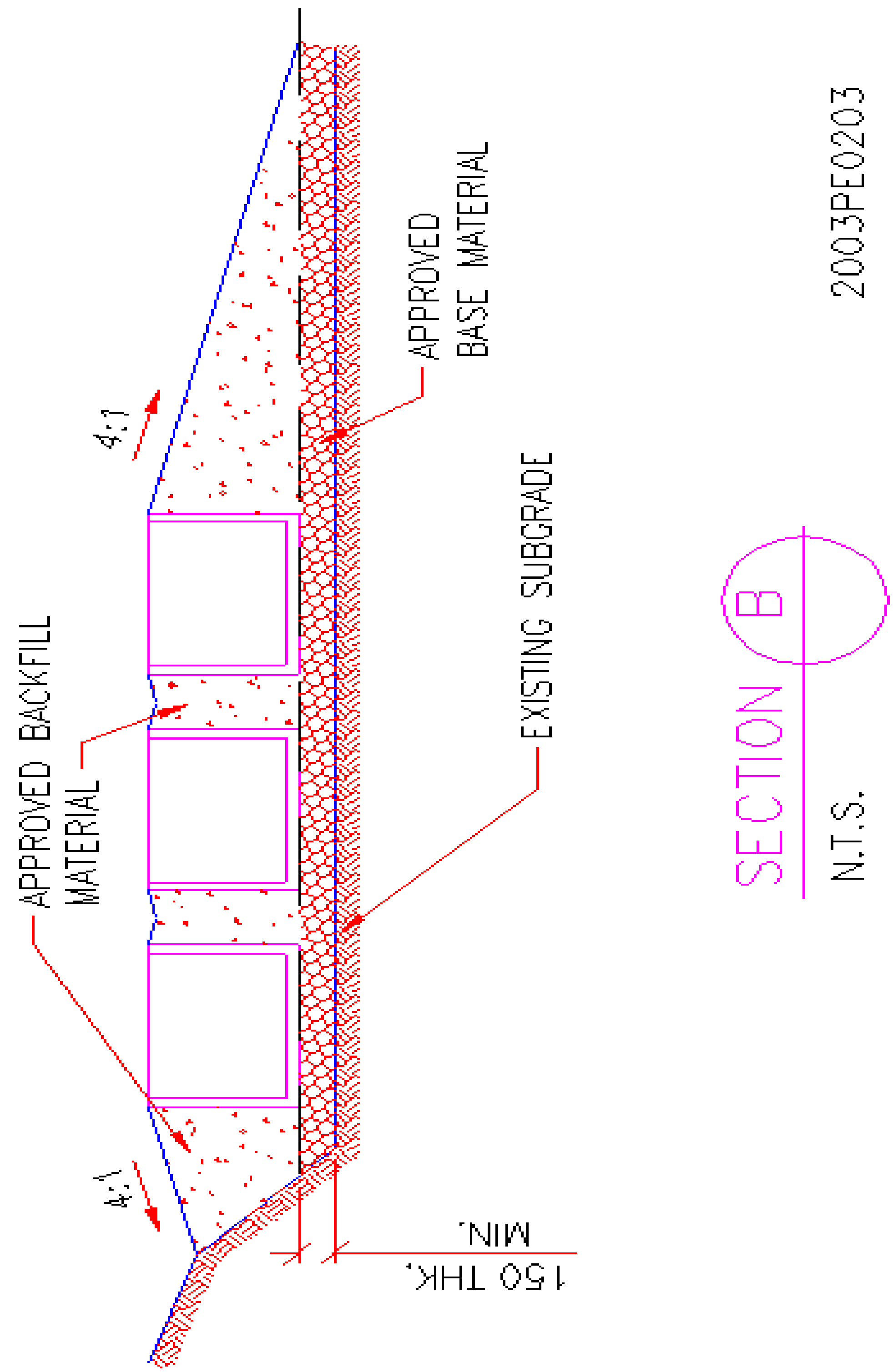
8. The graded surface of the final backfill shall be loamed and seeded to prevent erosion.

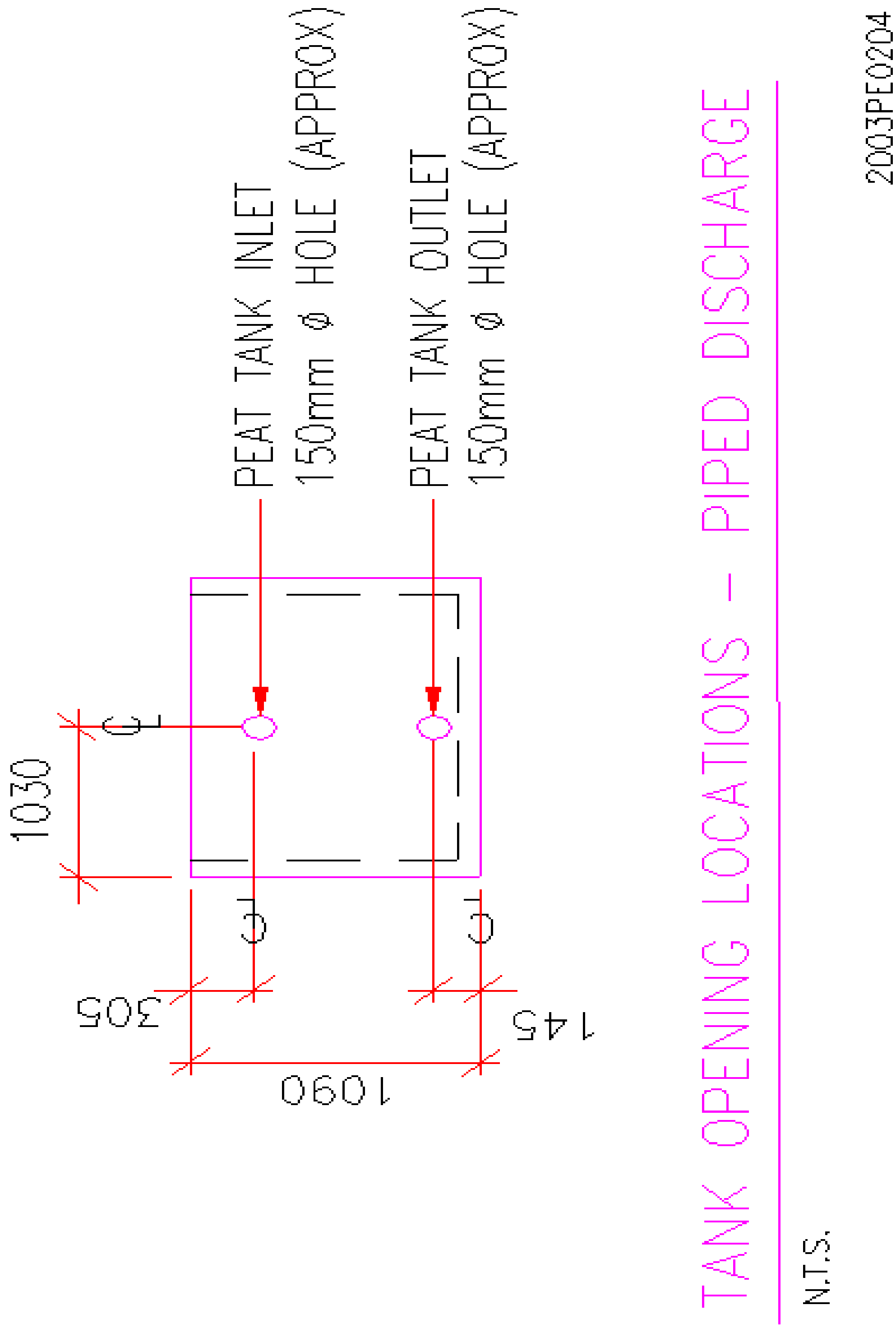
9. The surface of the peat material may be seeded with lawn grasses or shallow rooted vegetation.

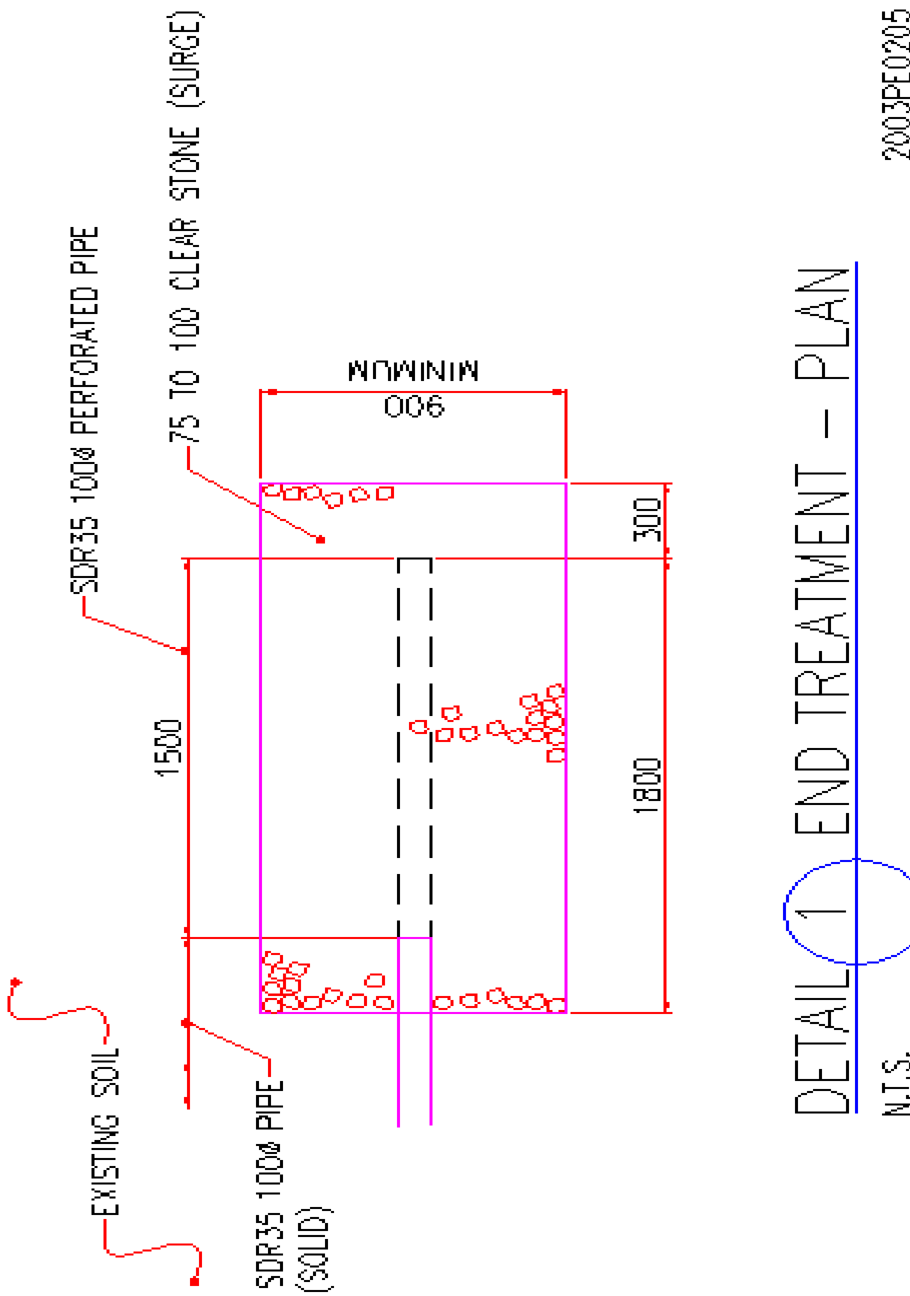

A
B
B
PEAT MODULES
AS SUPPLIED BY
SHAW PIPE
SEE DETAILS 1
2 & 3 FOR
END TREATMENT
2003PE0201
DISTRIBUTION BOX
AS SUPPLIED BY
SHAW PIPE
SEPTIC TANK
CAPACITY:______
SYSTEM SCHEMATIC
N.T.S.
RESIDENCE / BUILDING
DESIGN FLOW:______
A

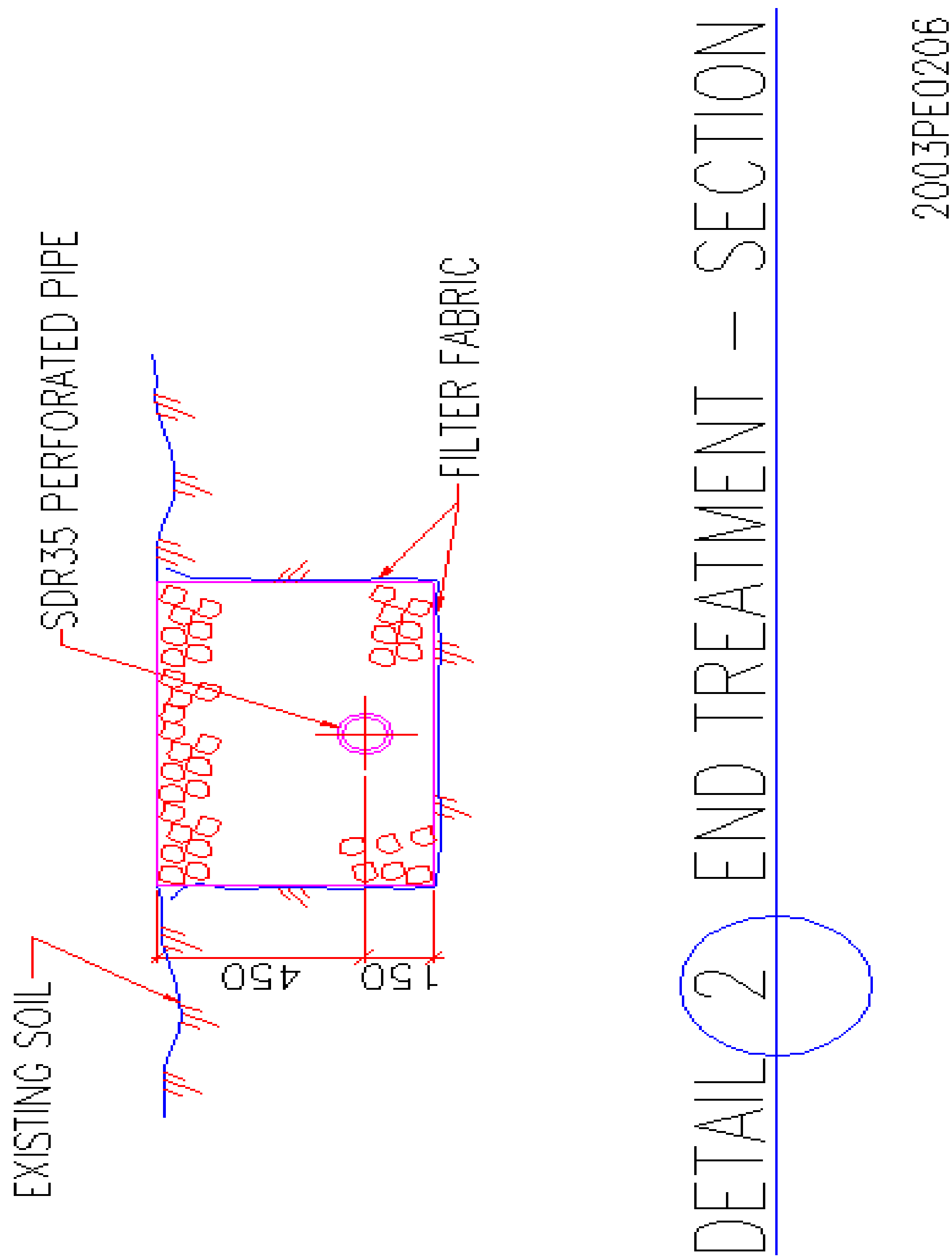
ELEVATION CONTROL TABLE		
CONTROL POINT EL.		
BLDG. DRAIN EXIT INVERT		
SEPTIC TANK INLET INVERT		
SEPTIC TANK OUTLET INVERT		
DISTRIB BOX INVERT		
PEAT MODULE INVERT		

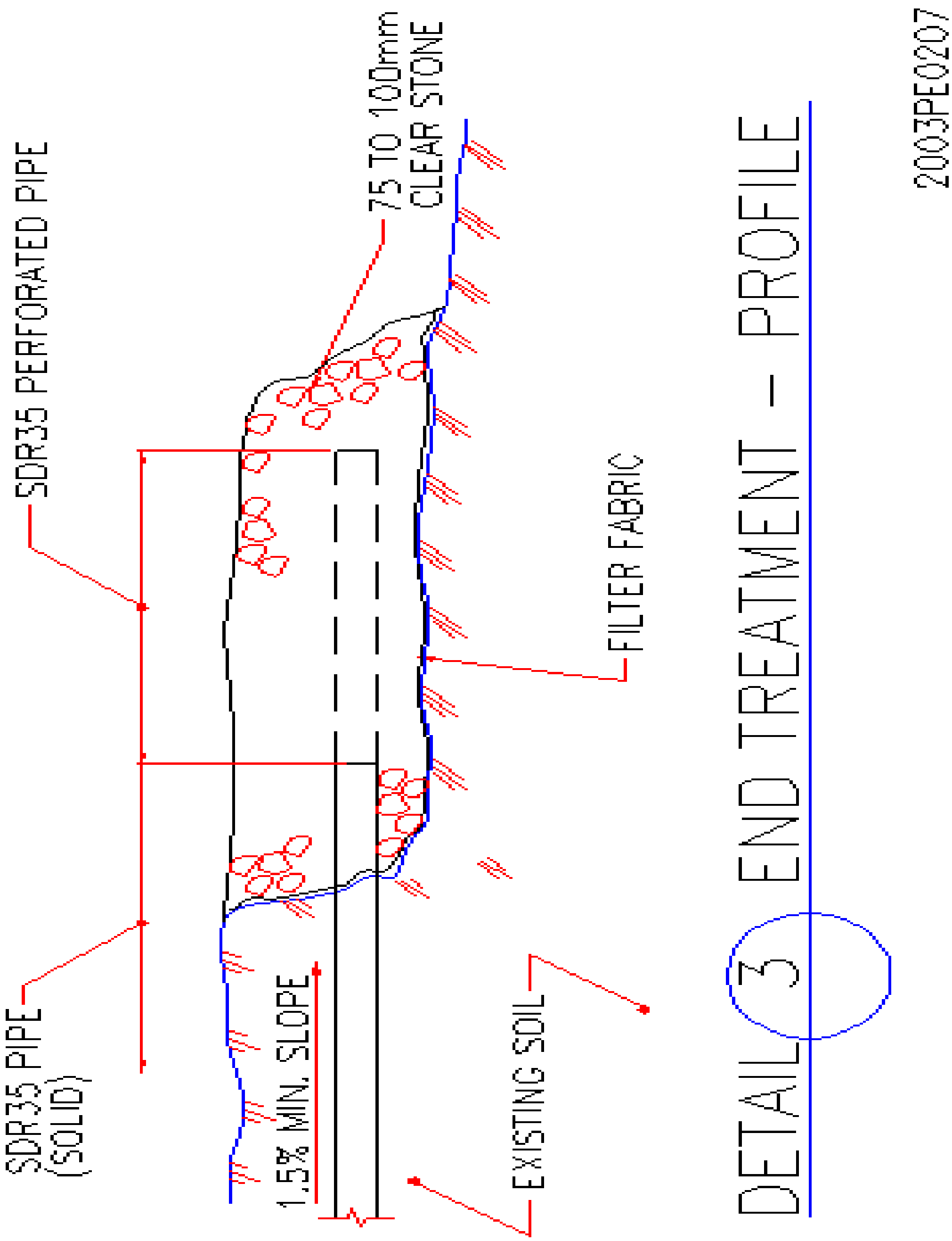



APPROVED BACKFILL
MATERIAL
4:1
4:1
APPROVED
BASE MATERIAL
EXISTING SUBGRADE
150 THK.
MIN.
SECTION B
N.T.S.
2003PE0203


PEAT TANK INLET
150mm Ø HOLE (APPROX)
PEAT TANK OUTLET
150mm Ø HOLE (APPROX)
1030
305
145
1090
TANK OPENING LOCATIONS – PIPED DISCHARGE
N.T.S.
2003PE0204


SDR35 100Ø PERFORATED PIPE
75 TO 100 CLEAR STONE (SURGE)
900
MINIMUM
300
1500
1800
EXISTING SOIL
SDR35 100Ø PIPE
(SOLID)
DETAIL 1 END TREATMENT – PLAN
N.T.S.
2003PE0205


SDR35 PERFORATED PIPE
FILTER FABRIC
EXISTING SOIL
450
150
DETAIL 2 END TREATMENT — SECTION
2003PE0206


SDR35 PERFORATED PIPE
75 TO 100mm
CLEAR STONE
FILTER FABRIC
SDR35 PIPE
(SOLID)
1.5% MIN. SLOPE
EXISTING SOIL
DETAIL 3 END TREATMENT - PROFILE
2003PE0207

PIPE DISCHARGE SYSTEM

Notes

1. On-site excavation/filling shall be carried out as required to place the base material and set the peat modules in accordance with the elevation control table.

2. The base material shall be imported granular material or onsite material as approved by the engineer.

3. The minimum thickness of the base material shall be 150mm. The surface of the base material shall be leveled prior to placement of the peat modules.

4. The backfill placed over the base material shall be clean loamy sand or approved on-site material. This material shall be graded to provide a 4:1 positive drainage slope away from the peat modules in accordance with the drainage plan.

5. The graded surface of the final backfill shall be loamed and seeded to prevent erosion.

6. The surface of the peat material may be seeded with lawn grass or shallow rooted vegetation.

APPENDIX B – UNIT VERTICAL ACCEPTANCE CAPACITIES

OVERVIEW

The unit vertical acceptance capacity of soil (K_V) is a measure of a soils ability to accept a volume of vertical flow through a (horizontal) planar area per day. The unit vertical acceptance capacity of a soil is a function of a number of parameters.

- Soil type – A fine-grained soil is less permeable and this has a lower unit vertical acceptance capacity.

- Clogging mat – After several months of operation a disposal field which deposits an *untreated effluent* into a subsoil (or filter sand) will develop a clogging mat in the subsoil (or filter sand). The clogging mat consists mainly of organic debris and microorganisms that feed on and digest the organic material in the untreated effluent. The clogging mat reduces the permeability of the medium (subsoil or filter sand) in which it is established. *Clogging mats do not develop where the effluent is treated (e.g. effluent from a peat system).*

The unit vertical acceptance capacities for various soils, *based on treated effluent from a peat system*, are provided in TABLE 6.5 of this manual (see chapter 6).

TABLE 6.5 Unit Vertical Acceptance Capacities (K_V) for Peat Treated Effluent

SOIL TYPE	**UNIT VERTICAL ACCEPTANCE CAPACITY (L/day/m^2)**
Rock, Clean Gravel	Unacceptably High
Medium to Coarse Sand	45
Fine Sandy Gravel	40
Silty Sand	32
Sandy Silt	27
Clayey Silt	22
Silty Clay	15
Clay	Unacceptably Low

The rationale for establishment of the unit vertical acceptance capacities in Table 6.5 is based on:

- The effluent exiting a peat system is treated (therefore no clogging mat)

- Consideration of the following technical references:
  - MAINE SUBSURFACE WASTE DISPOSAL RULES
  - U.S. Environment Protection Agency Design Manual (1980)
  - Tyler, E.J. and Converse, J.C., 1994, “Soil Morphology and Wastewater Quality” proc. 7th A.S.A.E. International Symposium on Individual and Small Community Sewage Systems, Atlantic, GA, pp 185-194.

MAINE SUBSURFACE WASTE DISPOSAL RULES (MSSWD Rules)

The MSSWD Rules provide unit vertical acceptance rates for various soils in Table 600.1 of the Rules. Further, the Rules allow for two adjustments on these acceptance rates.

- **Clause 1304.4 – Sizing of the disposal field:** The disposal field used for final disposal is sized at… 90% of the minimum hydraulic rate required in Table 600.1.
- **TABLE 603.1 -** Allows for an Adjustment factor of 0.5 on the minimum hydraulic rate for a treated effluent with a combined BOD plus TSS concentration of less than 30 (milligrams/liter). This Adjustment factor recognizes the lack of a clogging mat for a treated effluent.

Table B1 summarizes, converts units (imperial to metric) and applies Adjustment factors for table 600.1 of the MSSWD Rules.

TABLE B1: Conversion of Table 600.1 of the MSSWD Rules (For Treated Effluent)

Soil Type	(Vertical) Hydraulic Loading Rate (Ft^2/US gallon/day)	**Converted Unit Vertical Acceptance Capacity (Liters/m^2/day)**	***Adjusted Unit Vertical Acceptance Capacity (Liters/m^2/day)*****
6	2.0	20.5	***45.6***
4, 5	2.6	15.6	***34.7***
2, 3, 7	3.3	12.3	***27.3***
1, 8	4.1	9.9	***22.0***
9	5	8.1	***18.0***

** Combined Adjustment factor = 1/(0.9 x 0.5) = 2.22 allows for *treated effluent* dispersed over a bed area.

The soil types from the MSSWD Rules are described as follows:

Soil Type 6 – *“Loamy sand… to coarse sands… tends to be loose.”*

Soil Types 4 and 5 – *“Sandy loam”* to *“Loam to loamy sand textured upper horizon overlying fine and medium sand particles”.*

Soil Types 2, 3 and 7 – *“Sandy loam”* to *“15 inches of sand loam to loamy sand glacial till… overlying marine or lacustrine deposited silt to silty clay”.*

Soil Types 1 and 8 – *“Silt loam” to “Loam to fine sand loam upper horizon overlying firm silt loam.”*

Soil Type 9 – *“Silt loam upper horizon overlying firm silt loam to silty clay textured lower horizons”.*

U.S. ENVIRONMENTAL PROTECTION AGENCY (USEPA) DESIGN MANUAL
ONSITE WASTEWATER TREATMENT AND DISPOSAL SYSTEMS

The USEPA Design manual provides unit vertical acceptance rates for various natural soils in table 7-10 of the manual. Table B2 summarizes the USEPA table 7-10 with an additional column for converted (metric) units.

These unit vertical acceptance rates "assume that a clogging mat forms at the fill/natural soil interface".

TABLE B2: Conversion of Table 7-10 of the MSSWD Rules (For Untreated Effluent; a clogging mat is assumed)		
Soil Type	**(Vertical) Hydraulic Loading Rate (US gallon/Ft^2/day)**	**Converted Unit Vertical Acceptance Capacity (Liters/m^2/day)**
Sand, Sandy Loam	1.2	***48.9***
Loams, Silt Loams	0.75	***30.8***
Silt Loams, Silty Clay loams	0.5	***24.5***
Clay Loams, Clay	0.25	***10.3***

"SOIL MORPHOLOGY AND WASTE WATER QULAITY" TYLER & CONVERSE

Table B3 provides hydraulic loading rates provided by Tyler and Converse for various soil types receiving Septic tank Effluent and Sand Filter Effluent. The septic tank effluent is untreated and thus the hydraulic loading rates allow for establishment of a clogging mat in the soils. For the effluent from the Sand Filter the clogging mat (and some treatment) occurs in the Sand Filter. Thus these rates would be applicable for the treated effluent from a peat system.

TABLE B3: Hydraulic Acceptance Rates from Tyler & Converse		
Soil Type	**Septic Tank Effluent (Liters/m^2/day)**	**Sand Filter Effluent (Liters/m^2/day)**
Silty Sand	33	***245 - 530***
Sandy Silt	25	***190 - 200***
Clayey Silt	17	***60 - 130***
Silty Clay	8	***20 - 60***

APPENDIX C – EXAMPLE CALCULATIONS

Example problems 2003 – 1

GIVEN

Design Flow:	1000 l/day (3 bedroom home)
Soil Type:	Silty Sand
Site Slope:	Less than 1% (Assume flat)
Depth to Seasonal Water Table:	3 ft
Total Depth of Test Pit:	9 ft
Available Water Course:	None available for piped discharge
Comments:	Subsurface discharge is preferred

SOLUTION

The number of treatment modules required is 3.

$$\text{No. of Modules} = \frac{\text{Design Flow Volume}}{\text{Single Module Capacity}} = \frac{1{,}000\ \text{l/day}}{340\ \text{l/module/day}} = 2.9\ \text{modules} \quad \text{Use 3}$$

The system shall be designed as a Subsurface discharge system.

Given that the site is essentially flat assume no lateral flow through subsoil.
$Q_H = 0$
Set $Q_V = Q_D = 1000$ l/day
That is assume entire Design Flow is to flow vertically through the subsoil directly to the water table.

The elevation of the Peat modules must be set to ensure a minimum 2 ft clearance between the underside of the base material and the seasonal water table. Assume the modules are set so this clearance is 2.5 ft.

The size of the dispersion mantle may be determined from Equation 6B.
$A = Q_D/K_V$

From table 6.5 the unit vertical hydraulic acceptance capacity (K_V) for Silty Sand is 32 l/day/m^2.
$A = (1000\ \text{l/day})/(32\ \text{l/day/m}^2) = 31.25\ \text{m}^2 = 336$ sq. ft.
Provide a drainage mantle of 24 ft x 15 ft. (Area provided is 360 sq. ft. > 336 sq. ft.)

Given that the horizontal soil permeability of the subsoils is greater than 3 x 10-6m/sec, a mounding check is not required.

For educational purposed a mounding check using the program available at the CWRS web site follows.

MOUNDING 2003-1

The dispersion mantle dimensions of 16 ft by 24 ft are entered into the appropriate fields of the spreadsheet.

The Design Flow of 1000 l/day is equivalent to 220 imperial gallons per day. Using the spreadsheet this may be converted into Recharge rate of 0.0919 feet/day for the given dispersion mantle dimensions. Please note that conversion of the Design Flow units from a Volume per day to ft/day means the converted value is a function of the dispersion mantle area. Remember to rerun this conversion every time the mantle size is changed.
The Recharge Rate of 0.0919 feet/day is entered into the spreadsheet.

The (horizontal) Hydraulic Conductivity of the subsoil may be obtained from TABLE 6.4 of this Design annual. For Silty Sand the Conductivity or (horizontal) Permeability is 15 x 10-6 m/sec. This is entered as 1.5 x 10-5 m/sec in the conversion section of the spreadsheet to obtain a Conductivity of 4.2519 ft/day in imperial units.
The Hydraulic Conductivity of 4.2519 ft/day is entered into the spreadsheet.

The Specific Yield for various subsoils may be obtained from TABLE 6.6 in this manual. For Silty Sand use a Specific Yield of 0.16 (Till, predominantly sand).
The Specific Yield of 0.16 is entered into the spreadsheet.

The original depth of the borehole was 9 ft with the seasonal water table at a depth of 3 ft. Thus the initial depth of the saturated zone is **at least** 6 ft.
Initial depth of saturated zone if entered as 6 ft (conservative).

A return period of 20 years is entered into the spreadsheet.

The Calculate Mound Height button is “pressed” to provide the following:

Disposal Field Width	16 ft
Disposal Field Length	24 ft
Average recharge Rate of wastewater	0.0919 ft/day
Hydraulic Conductivity of Host Soil	4.2519 ft/day
Specific Yield	0.16
Initial Depth of Saturated Zone	6 ft
Time	20 years
Mound Height	**1.11 ft**

The clearance between the underside of the dispersion mantle and the initial water table is 2.5 ft. A 1.11 ft mounding of the water table will not result in mounding of the water table into the peat modules. DESIGN OK.

EXAMPLE PROBLEM 2003 – 2

GIVEN

Design Flow:	1000 l/day (3 bedroom home)
Soil Type:	Sandy Silt
Site Slope:	Less than 1% (Assume flat)
Depth to Seasonal Water Table:	2.5 ft
Total Depth of Test Pit:	12 ft
Available Water Course:	None available for piped discharge
Comments	Subsurface discharge is preferred

SOLUTION

The number of treatment modules required is 3.

$$\text{No. of Modules} = \frac{\text{Design Flow Volume}}{\text{Single Module Capacity}} = \frac{1{,}000 \text{ l/day}}{340 \text{ l/module/day}} = 2.9 \text{ modules} \quad \text{Use 3}$$

The system shall be designed as a Subsurface discharge system.

Given that the site is essentially flat assume no lateral flow through subsoil.
$Q_H = 0$
Set $Q_V = Q_D = 1000$ l/day
That is assume entire Design Flow is to flow vertically through the subsoil directly to the water table.

The elevation of the Peat modules must be set to ensure a minimum 2 ft clearance between the underside of the base material and the seasonal water table. Assume the modules are set so this clearance is 2.5 ft.

This size of the dispersion mantle may be determined from Equation 6B.
$A = Q_D/K_V$

From Table 6.5 the unit vertical hydraulic acceptance capacity (K_V) for Sandy Silt is 27 l/day/m^2.
$A = (1000 \text{ l/day})/(27 \text{ l/day/m}^2) = 37 \text{ m}^2 = 400$ sq. ft.
Provide a drainage mantle of 24 ft x 18 ft. (Area provided is 432 sq. ft. > 400 sq. ft.)

Given that the horizontal soil permeability of the subsoils is greater than 3 x 10-6m/sec a mounding check is not required.

For education purposes a mounding check using the program available to the CWRS web site follows.

MOUNDING 2003-2

The dispersion mantle dimensions of 18 ft by 24 ft are entered into the appropriate fields of the spreadsheet.

The Design Flow of 1000 l/day is equivalent to 220 imperial gallons per day. Using the spreadsheet this may be converted into Recharge Rate of 0.0817 feet/day for the given dispersion mantle dimensions. Please note that conversion of the Design Flow units from a Volume per day to ft/day means the converted value is a function of the dispersion mantle area. Remember to rerun this conversion every time the mantle size is changed.
The Recharge Rate of 0.0817 ft/day is entered into the spreadsheet.

The (horizontal) Hydraulic Conductivity of the subsoil may be obtained from TABLE 6.4 of this Design Manual. For Sandy Silt the Conductivity or (horizontal) Permeability is 5 x 10-6 m/sec. This is entered as 0.5 x 10-5 m/sec in the conversion section of the spreadsheet to obtain a Conductivity of 1.4173 ft/day in imperial units.
The Hydraulic conductivity of 1.4173 ft/day is entered into the spreadsheet.

The Specific Yield for various subsoils may be obtained from TABLE 6.6 in this manual. For Sandy Silt use a Specific Yield of 0.08.
The Specific Yield of 0.08 is entered into the spreadsheet.

The original depth of the borehole was 12 ft with the seasonal water table at a depth of 2.5 ft. Thus the initial depth of the saturated zone is **at least** 9.5 ft.
Initial depth of saturated zone is entered as 9.5 ft (conservative).

A return period of 20 years is entered into the spreadsheet.

The Calculate Mount height button is “pressed” to provide the following:

Disposal Field Width	18 ft
Disposal Field Length	24 ft
Average Recharge Rate of wastewater	0.0817 ft/day
Hydraulic Conductivity of Host Soil	1.4173 ft/day
Specific Yield	0.08
Initial Depth of Saturated Zone	9.5 ft
Time	20 years
Mound Height	**2.06 ft**

The clearance between the underside of the dispersion mantle and the initial water table is 2.5 ft. The clearance from the underside of the peat module to the initial water table is 3 ft allowing for the 6-inch thick dispersion mantle. A 2.06 ft mounding of the water table results in a clearance of 0.94 ft from the underside of the peat module to the water table. DESIGN OK.

EXAMPLE PROBLEM 2003 – 3

GIVEN

Design Flow:	1000 l/day (3 bedroom home)
Soil Type:	Clayey Silt
Site Slope:	Less than 1% (Assume flat)
Depth to Seasonal Water Table:	2.5 ft
Total Depth of Test Pit:	15 ft
Available Water Course:	None available for piped discharge
Comments:	Subsurface discharge is preferred

SOLUTION

The number of treatment modules required is 3.

$$\text{No. of Modules} = \frac{\text{Design Flow Volume}}{\text{Single Module Capacity}} = \frac{1{,}000\text{ l/day}}{340\text{ l/module/day}} = 2.9\text{ modules} \quad \text{Use 3}$$

The system shall be designed as a Subsurface discharge system.

Given that the site is essentially flat assume no lateral flow through subsoil.
$Q_H = 0$
Set $Q_V = Q_D = 1000$ l/day
That is assume entire Design Flow is to flow vertically through the subsoil directly to the water table.

The elevation of the Peat modules must be set to ensure a minimum 2 ft clearance between the underside of the base material and the seasonal water table. Assume the modules are set so this clearance is 2.5 ft.

The size of the dispersion mantle may be determined from Equation 6B.
$A = Q_D/K_V$

From Table 6.5 the unit vertical hydraulic acceptance capacity (K_V) for Clayey Silt is 22 l/day/m^2.
$A = (1000\text{ l/day})/(22\text{ l/day/m}^2) = 45.5\text{ m}^2 = 489$ sq. ft.
Provide a drainage mantle of 13 ft x 39 ft. (Area provided is 507 sq. ft. > 489 sq. ft.)

Given that the subsoils have a horizontal soil permeability less than 3 x 10-6m/sec, as mounding check is required.

MOUNDING 2003-3

The dispersion mantle dimensions of 13 ft by 39 ft are entered into the appropriate fields of the spreadsheet.

The Design Flow of 1000 l/day is equivalent to 220 imperial gallons per day. Using the spreadsheet this may be converted into Recharge Rate of 0.0696 feet/day for the given dispersion mantle dimensions. Please note that conversion of the Design Flow units from a Volume per day to ft/day mans the converted value is a function of the dispersion mantle area. Remember to rerun this conversion every time the mantle size is changed.
The Recharge Rate of 0.0696 ft/day is entered into the spreadsheet.

The (horizontal) Hydraulic Conductivity of the subsoil may be obtained from TABLE 6.4 of this Design Manual. For Clayey Silt the Conductivity or (horizontal) Permeability is 1.5 x 10-6 m/sec. This is entered as 0.15 x 10-5 m/sec in the conversion section of the spreadsheet to obtain a Conductivity of 0.4252 ft/day in imperial units.
The Hydraulic conductivity of 0.4252 ft/day is entered into the spreadsheet.

The Specific Yield for various subsoils may be obtained from TABLE 6.6 in this manual. For Clayey Silt use a Specific Yield of 0.06.
The Specific Yield of 0.06 is entered into the spreadsheet.

The original depth of the borehole was 15 ft with the seasonal water table at a depth of 2.5 ft. Thus the initial depth of the saturated zone is **at least** 12.5 ft.
Initial depth of saturated zone is entered at 12.5 ft (conservative).

A return period of 20 years is entered into the spreadsheet.

The Calculate Mound Height button is “pressed” to provide the following:

Disposal Field Width	13 ft
Disposal Field Length	39 ft
Average Recharge Rate of wastewater	0.0696 ft/day
Hydraulic Conductivity of Host Soil	0.4525 ft/day
Specific Yield	0.06
Initial Depth of Saturated Zone	12.5 ft
Time	20 years
Mound Height	**4.45 ft**

The clearance between the underside of the dispersion mantle and the initial water table is 2.5 ft. The clearance from the underside of the peat module to the initial water table is 3 ft allowing for the 6-inch thick dispersion mantle. A 4.45 ft mounding of the water table results in mounding of the water table into the peat module. THE DESIGN IS NOT ACCEPTABLE.

Separating the peat modules and placing each module on a separate dispersion bed improves the design. The design flow to each peat module would be 333 l/day = 74 imperial gallons/day. Placing each module on a separate dispersion mantle 12 ft x 15 ft results in a Recharge Rate of 0.0651 ft/day at each mantle.

The CWRS mounding spreadsheet provides the following for separated dispersion mantles:

Disposal Field Width	12 ft
Disposal Field Length	15 ft
Average Recharge Rate of wastewater	0.0651 ft/day
Hydraulic Conductivity of Host Soil	0.4525 ft/day
Specific Yield	0.06
Initial depth of Saturated Zone	12.5 ft
Time	20 years
Mound Height	**1.83 ft**

This design is acceptable:

Please note the following:

1. An acceptable design could have been produced if the 2 ft clearance had been accepted and mounding was not checked for this soil with a clay component.
2. Mounding concerns can be addressed by varying dispersion mantle dimensions and by separating the treatment modules.

APPENDIX D – INSTALLATION PHOTOGRAPHS

SITE PREPARATION – Prepare site as per approved plan layout drawing (prepared by qualified engineer). Scarify soil under the entire area of the base material. Place base material level and to a minimum thickness of 150mm.

OFF-LOADING – Off-load Peat System with a crane or large excavator. (Peat Module weight = 16,500lbs). Lifting device is supplied by Shaw Pipe. Ensure the crane and truck may be parked close to the system location and have adequate access to the site, prior to delivery.

PLACEMENT – Place peat module on prepared base material as per approved layout drawing. It is recommended that the location of the modules be marked out prior to placement to ensure precise placement.

LEVELING – During placement ensure that each peat module is level and adequate grade is provided to each module to maintain proper effluent flow through the system.

BACKFILL – Place a 12” deep by 12” wide layer of base material around all sides of the modules. Then place a layer of filter fabric on top of all the base material. Backfill with loamy sand fill or approved on-site material to the underside of the pipe inlets. Compact soil under piping to prevent settlement.

CONNECTING PIPING – When connecting pipes to peat modules ensure that a minimum grade of 2% is provided at all times and all joints are properly glued. Provide imported granular material under and around all pipes.

DISTRIBUTION BOX – Install the distribution box on level, compacted, free draining granular stone. Install outlet pipes and flow equalizers. Adjust flow equalizers as per instructions provided with each adjustable weir.

BACKFILLING COMPLETE – Complete backfilling to within 3” of the top of the peat modules and remove shipping plastic. Peat modules shall be planted with grass or shallow rooted plants to prevent erosion.

No fill material or on-site material shall be placed on the surface of the Peat Modules.

APPENDIX E – PARTIAL LIST OF SHAW PEAT SYSTEMS IN NOVA SCOTIA

SYSTEM NO.	LOCATION	DESIGN FLOW	NO. & TYPE OF MODULES	SHIPPING DATE	SYSTEM DESIGNER
Pilot 1	Pomquet	1000 L / Day	3 Piped Drainage Modules	June 1999	-
Pilot 2	Belle Cote	3000 L / Day	9 Piped Drainage Modules	October 1999	Joe Janega
Pilot 3	Boylston	1000 L / Day	3 Piped Drainage Modules	December 1999	-
2002-01	Hubbards	1000 L / Day	3 Piped Drainage Modules	June 2002	-
2002-02	Lake Echo	1000 L / Day	3 Piped Drainage Modules	July 2002	-
2002-03	Green Bay, Bridgewater	1000 L / Day	3 Piped Drainage Modules	July 2002	Phil Collins
2002-04	Waverly	1000 L / Day	3 Piped Drainage Modules	July 2002	-
2002-05	Eskasoni	1000 L / Day	3 Piped Drainage Modules	July 23, 2002	Paragon Engineering
2002-06	Chester Basin	1000 L / Day	3 Piped Drainage Modules	August 2002	Dan Moscovitch
2002-07	Chester Basin	1000 L / Day	3 Piped Drainage Modules	August 2002	Phil Collins
2002-08	Lunenburg	1000 L / Day	3 Piped Drainage Modules	August 2002	Jeff Phiney
2002-09	Hubbards	1000 L / Day	3 Piped Drainage Modules	June 2002	-
2002-11	East Preston	1000 L / Day	3 Piped Drainage Modules	August 28, 2002	Paul Kundzins
2002-12	Chester	1000 L / Day	3 Piped Drainage Modules	October 10, 2002	Tim Veniot
2002-13	Hubbards	1000 L / Day	3 Piped Drainage Modules	October 2002	Frank Lockver
2002-14	Port Hood	1000 L / Day	3 Piped Drainage Modules	December 2002	Joe Jaqnega
A	Herring Cove	1000 L / Day	3 Piped Drainage Modules	April 11, 2002	-
B	Herring Cove	Approx. 600 L / Day	2 Piped Drainage Modules	May 29, 2002	-
2003-01	Albert Ridge	1000 L / Day	3 Piped Drainage Modules	January 13, 2003	Grant McCharles

APPENDIX F – INFORMATION ON LIFTING & HANDLING A PEAT MODULE

OFF-LOADING AND PLACING A SHAW PEAT MODULE

Telephone: (902) 883-2201
Fax: (902) 883-1273

SHAW PEAT MODULE INFORMATION

- Plan dimensions: Approximately 7 ft wide X 11 ft long
- Height: Approximately 3.5 ft
- Weight: Approximately 16,500 LB (8.25 ton)

REQUIRED LIFT CAPACITY

The size of the crane or boom-truck required to off-load and place a peat module is a function of both the module weight and the ***"Required Reach".*** *Reach is the distance measured from the centerline of the crane to the center of the load* (i.e. center of the peat module). The Required Reach is *not* the distance from the edge of the crane or boom-truck to the edge of the excavation or module. The following crane capacities are based on lifting a 16,500 LB peat module.

- For a *Required Reach* of **25 ft** a **22 ton crane** is required
- For a *Required Reach* of **30 ft** a **30 ton crane** is required
- For a *Required Reach* of **35 ft** a **35 ton crane** is required
- For a *Required Reach* of **40 ft** a **50 ton crane** is required

One of the most common mistakes made by installation contractors is undersizing of the boom-truck or crane. If an excavator is to be used to handle the treatment modules the lift capacity should be carefully reviewed.

Typically boom-trucks have lift capacities of less than 10,000 LB. A boom-truck which can handle 16,500 LB at a 25 ft reach is a very special and rare boom-truck. It is expected that a boom-truck will be used in off-loading and handling then extra care should be taken to confirm the boom-trucks lift and reach capacities.

For placement of a peat module a Required Reach of 25 ft is only possible if the crane can be set up immediately adjacent to the final placement location for the peat module. When undersized cranes or boom-trucks are on-site it may not be possible to off-load the peat modules and this will result in additional transportation charges (e.g. wait time, requirement for second delivery, etc.)

SOME BOOM TRUCK AND CRANE COMPANIES IN YOUR AREA

Halifax

• Sagadore	Karl Shay	Ph: 902-468-6620
• Ace	Junior Lohnes	Ph: 902-455-1566 (24 hour service)

Truro

• Sagadore	Robert Fraser	Ph: 902-922-2300
• Hubtown Crane Service		Ph: 902-893-7715

New Glasgow

• Sagadore	Robert Fraser	Ph: 902-922-2300

Antigonish

• Alva Construction	Reg Tramble	Ph: 902-863-6445

Port Hawkesbury

• Sagadore	Jack MacLean	Ph: 902-625-1400

Sydney

• Sagadore	Kim McIntyre	Ph: 902-562-6300
• Miller Rentals	Danny Walsh	Ph: 902-562-0631

Liverpool

• Lawrence Veinotte Enterprises		Ph: 902-624-8872

Shelburne

• Sagadore		Ph: 902-468-6620

Yarmouth

• Yarmouth Crane	Terry Gibbons & Warren Gibbons	Ph: 902-749-1065 (24 hour service)

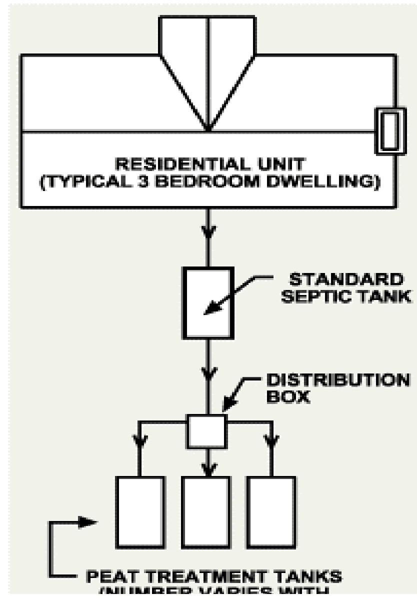
Windsor

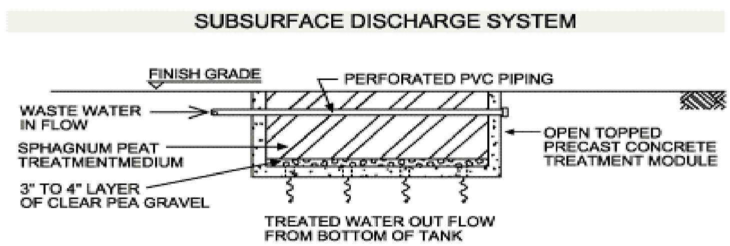
• Ace	Junior Lohnes	Ph: 902-455-1566 (24 hour service)
• Sagadore	Karl Shay	Ph: 902-468-6620

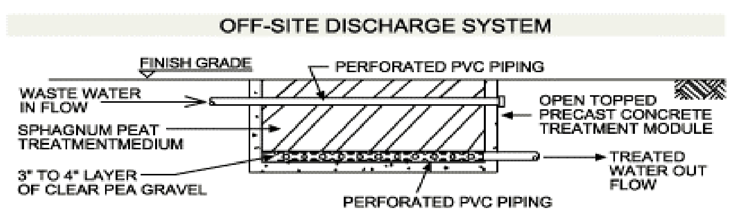
The above listing of crane companies is not intended as a complete list of companies in Nova Scotia. For additional boom-truck and crane companies please consult your yellow pages.

APPENDIX G – APPROXIMATE PRICING INFORMATION

- For a typical 3 bedroom house a peat treatment system includes a 1000-gallon septic tank (c/w effluent filter), a 5-hole distribution box (which splits the flow) and 3 peat treatment modules. A single peat module is 7 ft wide by 11 ft long. This 3 peat modules can be placed in a footprint approximately 12 ft x 22 ft. A peat tank is 3 ft 7 inches deep.
- The price for this system is $9,550 plus freight.
- A system of 3 peat treatment modules, a 1000-gallon septic tank (c/w effluent filter) and a distribution box can be delivered to site on a single truck.
- The price for each additional peat module is $2,850 plus freight.
- All site preparation/excavation, off-loading, placement and hook-up (including supply of connection piping) would be by an on-site contractor. The peat modules weigh approximately 8 tons each and a crane or large excavator will be required for off-loading and placement. Installation costs can run in the order of $2,000 to $3,000 depending on the site.
- If pumping is required a pump chamber and pump must be supplied at additional cost.
- A QP1 (i.e. Qualified Person) is required to design a peat system. Information and methodology for the design of a Shaw Peat System are provided in the **Shaw Peat Technical Manual.**
- Peat Systems are ideal for cottage lots as an alternative to a holding tank.
- For additional information and pictures you can visit the Shaw Pipe web site at www.shawpipe.com







Some individual prices for components of a peat system follow:

- The price for a single 1000-gallon septic tank is $725 pus freight. (*Sold only as part of Peat System)*
- The price for a 5-Hole Distribution Box is $120 plus freight. *(Sold only as part of Peat System)*
- The price for a septic tank effluent filter is $125 plus postage.
- The price for an adjustable weir is $10 each plus postage

PRICES SUBJECT TO CHANGE

APPENDIX H – DESIGN WASTEWATER FLOWS

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Institutional			
Assembly Halls No kitchen or meals	person	8	
Assembly Halls With varying facilities	person	9	
Churches With kitchen	seat	26	
Churches No kitchen	seat	9	
Churches Kitchen & paper service	meal	4.5	
Churches Kitchen & normal service	meal	13.5	
Churches Suppers	person	45	
Fire Station Without full time employee, floor drains or food	person	19	
Town Hall	seat	19	
Medical/Personal Care			
Hospital	bed	409	
Hospital Including laundry	bed	750	
Hospital Excluding laundry	bed	550	
Hospital mental	bed	340	
Hospital mental Add per employee	employee	23	
Special Care Home	resident	136	
Special Care Home Add per employee	employee	45	
Medical Office Doctors, nurses, medical staff	person	273	
Medical Office Office staff Add	person	73	
Medical Office Patient Add	person	23	
Dental Office	chair	757	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Dental Office Staff Add	person	132	
Schools			
School Cafeteria & gym & shower	student	68	
School Cafeteria only	student	45	
School Gym Only	student	68	
School Washrooms only	student	13.5	
School Elementary	student	26	
School High	student	45	
School Junior High	student	34	
School Boarding Resident student	student	136	
School Boarding Non-resident staff	person	50	
Prison			
Prison	inmate	136	
Prison Add for personnel	employee	23	
Food service			
Bakery	employee	68	
Bar/Lounge	customer	8	
Bar/Lounge	seat	125	
Restaurant Not 24 hr	meal	9	
Restaurant Not 24 hr	seat	31	
Restaurant Auto dishwasher - Add	seat	12	
Restaurant 24 hr	seat	189	
Restaurant 24 hrs highway	seat	265	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Restaurant 24 hrs highway & shower	seat	400	
Restaurant Kitchen & toilet waste only	seat	113	
Restaurant Kitchen & toilet waste only	patron	30	
Restaurant Kitchen waste only	meal	11	
Restaurant Banquet rooms-each banquet	seat	30	
Restaurant Drive in	seat	125	
Restaurant Drive in - all paper	car space	57	
Restaurant Drive in all paper inside seat	seat	57	
Taverns/Bars/Lounges with Minimal food service	seat	76	
Night Club/Restaurant	seat	113	
Restaurant/Dining Rooms/ Dining Lounges	square footage of dining area	9	
Take out	square footage	2	
Banquet & Dining Room	square foot	1.5	
Caterers	patron	45	
Cafeteria	customer	4.5	
Coffee Shop	customer	19	
Coffee Shop Add per employee	employee	36	
Dining Halls	meal	18	
Commercial			
Airport	passenger	9	
Airport Add for each employee	employee	41	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Beauty Salon	station	400	
Beauty Salon Add for personnel	person	38	
Veterinary Clinic (3 doctors or less) No Boarding	total	2900	
Veterinary Clinic (3 doctors or less) Boarding	total	5700	
Dog Kennel	enclosure	73	
Laundromat Self serve	machine	1514	
Laundromat Per wash	wash	168	
Laundromat In apartment building	machine	1135	
Commercial/Shopping			
Department Store	toilet room	1513	
Department Store	employee	36	
Shopping Center No food, laundry	parking space	4	
Shopping Center	employee	40	
Shopping Center Washrooms only	square meter of store space	5	
Shopping Center Toilet rooms	each	1665	
Shopping Center Excluding caf., and laundry	1/square meter	7	
Shopping Center Large dry goods	1/square meter	2	
Shopping Center Large supermarket & meat department, no garbage	1/square meter	3	
Shopping Center Large supermarket & meat dept., no garbage grinder	1/square meter	5	
Shopping Center Small dry goods store	each	379	
Commercial/Automobile			
Automobile gas station Vehicle served	vehicle	22	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Automobile gas station Add for catch basin in floor		372	
Automobile gas station Single house pump	unit	568	
Automobile gas station Double house pump	unit	1136	
Automobile gas station Island	island	1893	
Automobile gas station Vehicle served	vehicle	38	
Car Wash	car	189	
Car Wash	truck	378	
Commercial/Hospitality			
Motel Bath & toilet only	person	118	
Motel Full housekeeping	person	180	
Motel Central bath	person	150	
Motel	unit	318	
Motel	housekeeping unit	454	
Motel Dining room add	seat	122	
Motel Bar & Lounge add	seat	68	
Motel Non-residential staff add	employee	40	
Motel Bed & Breakfast	person	27	
Hotel	guest	136	
Hotel Add for employees	employee	36	
Boarding House	resident	150	
Dormitory Bunkhouse	person	91	
Senior Citizen Home	resident	227	
Day Care Centers Staff & children	employee	73	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Industrial/Office			
Industrial buildings Excluding industrial waste, cafeteria & showers	employee	45	
Industrial buildings Excluding industrial waste, including showers	employee	75	
Heavy industry Excluding industrial waste, incl. Cafeteria & shower	employee	132	
Warehouse	employee	132	
Industrial Park	acre	63,644	
Industrial Park	employee	68	
Office No cafeteria	employee	50	
Office Including cafeteria	employee	76	
Town Offices Office employees	employee	57	
Town Offices Transients	person	19	
Unspecified office space	square meter	7613	
Recreation/camping			
Campgrounds Tents only	site	181	
Campgrounds Trailers, water & electrical	site	227	
Campgrounds Trailers, water, sewer & electrical	site	284	
Campgrounds with central comfort stations	add for dump station per space	19	
Cabin Resort	person	159	
Day Camps No meal	person	38	
Day Camps Meals	person	68	
Day Camps Primitive camps	person	40	
Construction Camps Flush toilets	person	189	
Construction Camps No flush toilets	person	123	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Industrial/Office			
Construction Camps Migrant workers - central bathroom	person	123	
Youth Camps	person	189	
Luxury Camps	person	378	
Work Camps	bed	227	
Cottages & Small Seasonal Dwellings	unit	189	
Parks, Beach and Picnic Grounds			
Picnic & fairgrounds with bath houses, showers, toilets	person	89	
Picnic & fairgrounds with toilets only	person	18	
Beaches with showers & toilets	person	40	
Visitor Center	person	23	
Country Clubs			
Country Club Resident present	person	372	
Country Club Non resident	person	95	
Country Club Showers in use	fixture	1800	
Country Club Water closet	fixture	550	
Country Club Lavatory	fixture	350	
Country Clubs Urinals - hand flush	fixture	350	
Country Clubs Showers	person	40	
Country Clubs Day staff - Add	employee	50	
Recreation - General			
Dance Halls Washrooms only per day in use	square meter	11	
Dance Halls Restaurants	seat	15	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Dance Halls Bar	seat	10	
Dance Halls Including bar & restaurant	patron	76	
Theatre	seat	14	
Theatre Drive-in - no food	space	11	
Theatre Drive-in - food	space	23	
Theatre Fixed seat	seat	9	
Recreation/Sport			
Bowling Alleys Without bar & restaurant	alley	105	
Bowling Alleys With bar or restaurant	alley	800	
Ice Rink	seat	11	
Ice Rink Participant Add	person	38	
Stadium	seat	14	
Swimming Pool	customer	14	
Swimming Pool Area	square meter	50	
Water Slide Park	visitor	5	
Gym Participant	person	38	
Gym Spectator	person	11	
Tennis/Racquetball Excluding food	court	946	
Ski Areas Without cafeteria	person	38	
Ski Areas With cafeteria	person	57	
Outdoor Sport Facilities Toilet waste only	person	19	
Recreation/Sport			
Floor Drains	unit	189	

DESIGN WASTEWATER FLOWS			
Facility	**Unit of Measure**	**Minimum Design Flow Liters/Day**	**Comment**
Catch basins Garages, service stations, etc.	unit	375	

Approximate flushing frequencies		
Residential	5 flushes per resident per day	
Schools	2 flushes per student per day	
Hotel/Motel Room	4-6 flushes per guest per night	
Restaurant	0.5 flushes per meal per day	
General Commercial	2-4 flushes per employee per 8 hr	
Industrial	3 flushes per employee per 8 hr	
Ski Areas	1 flush per skier per day	
Campgrounds with facilities	3 flushes per person per night	
Public Restrooms Stay under 0.5 hr	0.4 flushes per visitor per hr	
Public Restrooms Stay from 0.5 hr to 1 hr	0.6 flushes per visitor per hr	
Public Restrooms Stay from 1 to 2 hrs	0.8 flushes per visitor per hr	
Public Restrooms Stay over 2 hr	1.0 flushes per visitor per hr	

APPENDIX I – MOUNDING BY FINNEMORE

Estimation of Ground-Water Mounding Beneath Septic Drain Fields

by E. John Finnemore[a]

Abstract

Localized ground-water mounding beneath larger on-site sewage disposal fields (septic drain fields) can reduce and even eliminate the waste-water treatment that occurs in the unsaturated soil zone. Such mounding was previously predicted for longer times by a procedure of uncertain accuracy and having a number of limitations. In this paper, a new procedure is developed on a stronger theoretical basis. The governing equation may be solved by four different methods. The new procedure considerably extends the time range of applicability, and no longer restricts the proportions of the rectangular disposal field. Errors in the previous methods approached 20% in some cases. Comparisons of different methods to reduce mound heights where they are critical indicate that the most effective method is to subdivide the disposal field into separated subareas.

Introduction

About one-third of U.S. homes are served by septic drain fields, also known as filter fields, leach fields, soil absorption systems, and on-site sewage disposal systems. They largely occur in urban fringe and rural residential areas, and also commonly serve rural institutional buildings and recreational developments. Dependence on such systems has grown as a result of their being increasingly viewed as permanent rather than interim facilities. Both this increasing dependence and the general growth of environmental awareness have resulted in greater concern that such disposal systems may be contributing to long-term ground-water pollution.

Authorities responsible for environmental health strive to protect ground-water quality by specifying a minimum setback, or vertical distance, between the bottom of the disposal trenches or beds and the water table; this is typically from 2-5 ft deep. In this unsaturated soil zone occur relatively high levels of physical, biological, and chemical treatment.

Depending on the type of soil, and on the design and use of the disposal system, the water table beneath the discharge area could rise enough to reduce the unsaturated zone depth and the treatment it provides, or even short-circuit it entirely. Therefore, it is vitally important that designers and regulators of such disposal systems should have reliable methods to estimate the water-table rise or mounding that might occur over the life of the facility, and that they should be able to use these methods to identify designs which reduce mounding where necessary.

The purposes of this paper are to provide an improved procedure for the prediction of long-term ground-water mounding beneath septic drain fields, and to suggest further design strategies to reduce mounding.

Ground-Water Mounding

Here we shall consider the common situation where a disposal field drains down into, and forms a ground-water mound on, an extensive and initially near-horizontal saturated zone (Figure 1). Various methods for analyzing this situation have been reviewed and/or summarized in a number of publications (Finnemore and Hantzsche, 1983; Hensel et al., 1984; Urish, 1991). The majority of these procedures either follow or are based on the method of Hantush (1967), mainly because it is more generalized and more accurate than the other methods.

The analysis is greatly simplified by limiting it to the highest, and therefore most critical, point on the ground-water mound.

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Previous Simplified Long-Term Mounding Prediction

From the Hantush (1967) procedure for predicting ground-water mound heights, the rise of the highest point at the center of the mound can be expressed as

$$z_m = \frac{ItS^*}{S_y} \qquad (1)$$

in which I = average volume recharge rate of waste-water entry into unit area (e.g., 1 ft^2 or 1 m^2) of soil; t = time since the beginning of waste-water application; S_y = specific yield of aquifer, which is the volume fraction of the total aquifer which will drain freely; and S^* is a tabulated function of α and β. Here

$$\alpha = \frac{L}{4}\sqrt{S_y/(K\bar{h}t)} \qquad (2a)$$

$$\beta = \frac{W}{L}\alpha \qquad (2b)$$

in which L and W = respectively, the length and width of the disposal field (waste-water application area; L ≥ W); K = horizontal hydraulic conductivity of the aquifer; and

$$\bar{h} = h_0 + \tfrac{1}{2} z_m \qquad (3)$$

Besides the inconvenience of the need to look up tabulated values, usually requiring interpolation, the tabulated values limit applications to maximum rise times of about 2-8 years, depending on parameter values.

For longer times, t, on the order of 10-40 years, which are of particular concern with disposal fields, the magnitudes of α and β become very small. In order to approach the origin more closely where tabulated values of α and β are unavailable, Finnemore and Hantzsche (1983) fitted the tabular function for S^* by expressions of the form $S^* = C\alpha^n$ in the region where α and β are ≤ 0.04. They presented values of the constants C and n for length-to-width ratios (L/W) of 1, 2, 4, and 8. This form of expression for S^* enabled equations (1) and (2a) to be combined, leading to their equation for longtime mound height

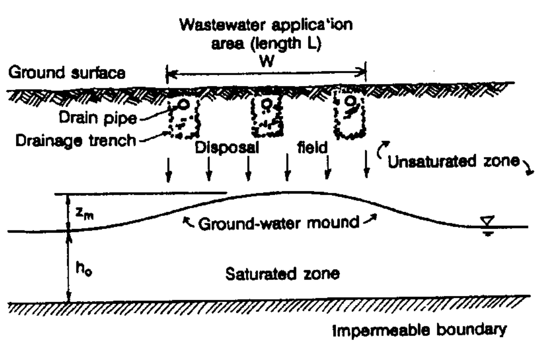

Fig. 1. Ground-water mound beneath rectangular disposal field (modified from Finnemore and Hantzsche, 1983).

$$z_m = IC\left(\frac{L}{4}\right)^n \left(\frac{1}{K\bar{h}}\right)^{0.5n} \left(\frac{t}{S_y}\right)^{1-0.5n} \qquad (4)$$

The fact that these fits were made for $\alpha \le 0.04$ led to the requirement that $t > t_{min} = 40L^2 S_y/(Kh_0)$ for results to be accurate.

Equation (4) provided for the first time an ability to predict maximum mound heights at long times. As a result, equation (4) has been used by state regulatory agencies concerned with septic drain field design (Hensel et al., 1984; Urish, 1991). It is not straightforward to solve (4) for z_m given t, however, because z_m is included in $\bar{h}$. Various solution methods have subsequently been suggested by Finnemore (1992).

New Simplified Long-Term Mounding Prediction

Although the smallest tabulated values of S^* given by Hantush (1967) were for α and β equal to 0.02, he stated in his equation (25) that

$$S^* \approx \frac{4}{\pi}\alpha\beta\left\{3 - \left[\frac{\alpha}{\beta}\tan^{-1}\frac{\beta}{\alpha} + \frac{\beta}{\alpha}\tan^{-1}\frac{\alpha}{\beta}\right] + E(u)\right\} \qquad (5)$$

provided $u = (\alpha^2 + \beta^2) \le 0.10$; this approximation becomes more accurate as $u \to 0$. Here E(u) is the exponential integral of u; for specific values of u it is known to hydrologists as the well function of u, W(u).

From (2b) we note that $\alpha/\beta = L/W$; letting the length-to-width ratio $L/W = r$, we can write

$$\frac{\alpha}{\beta}\tan^{-1}\frac{\beta}{\alpha} + \frac{\beta}{\alpha}\tan^{-1}\frac{\alpha}{\beta} = r\tan^{-1}\frac{1}{r} + \frac{1}{r}\tan^{-1} r = J(r) \qquad (6)$$

so that (5) becomes

$$S^* \approx \frac{4}{\pi}\alpha\beta\{3 - J(r) + E(u)\} \qquad (7)$$

where we find that $(\pi/2) \ge J(r) > 1$ because $1 \le r < \infty$.

Substituting for S^* from (7) into (1), while also substituting for α and β from (2), we obtain

$$z_m \approx \frac{L^2 I}{4\pi r K\bar{h}}\{3 - J(r) + E(u)\} \qquad (8)$$

If we let Q be the average volume recharge rate of waste-water entry into the entire disposal field, then $Q = LWI = L^2 I/r$ and (8) can be written

$$z_m \approx \frac{Q}{4\pi K\bar{h}}\{3 - J(r) + E(u)\} \qquad (9)$$

E(u) may be written as the series expansion

$$E(u) = -\gamma - \ln u + u - \frac{u^2}{4} + \ldots + \frac{(-1)^n u^n}{n.n!} \qquad (10)$$

Here γ is Euler's constant = 0.5772156649. We notice in (10) that as $u \to 0$, the polynomial terms $\to 0$ rapidly, and so

$E(u) \rightarrow -\gamma - \ln u$. Earlier we noted that this equation requires $u \leq 0.10$. So writing the sum of the small polynomial terms after $\ln u$ in (10) as $\epsilon(u)$, substituting for $E(u)$ from (10) into (9), and rearranging a little yields

$$\frac{4\pi K}{Q} z_m \bar{h} \approx 3 - \gamma - J(r) - \ln u + \epsilon(u) \qquad (11)$$

Evaluation of the right side of equation (11) for various values of u reveals that $\epsilon(u)/(\text{right side})$ is less than 3.1% for $u \leq 0.10$, and less than 0.7% for $u \leq 0.03$. Therefore, for the application considered here, the terms represented by $\epsilon(u)$ may be neglected when $u \leq 0.03$, when the approximation involved is also more accurate, so that a new governing equation may be written as

$$z_m = \frac{Q}{4\pi K\bar{h}} \{3 - \gamma - J(r) - \ln u\} \qquad (12)$$

Making use of equations (2) and our definition of r, (12) is valid provided

$$u = (\alpha^2 + \beta^2) = \alpha^2 \left(1 + \frac{1}{r^2}\right) = \frac{L^2 S_y}{16K\bar{h}t} \left(1 + \frac{1}{r^2}\right) \leq 0.03$$

which, by noting that $[1 + (1/r^2)] \leq 2$ and $h_0 \leq \bar{h}$, leads to the requirement that $t > t_{min} = 4.17 L^2 S_y/(K h_0)$ for results from equation (12) to be accurate.

If z_m is given, and one wishes to solve for t, which is included in u, equation (12) can be rearranged into

$$t = \frac{L^2 S_y}{16K\bar{h}} \left(1 + \frac{1}{r^2}\right) \exp\left[\frac{4\pi K}{Q} z_m \bar{h} - 3 + \gamma + J(r)\right] \qquad \ldots (13)$$

However, we usually wish to solve for z_m at prescribed times. In this case, solving for z_m is not straightforward because it is included in both $\bar{h}$ and u in such a way that it cannot be separated out. Four different methods of solving equation (12) for z_m given t are now suggested.

Method 1. An iterative procedure may be used, starting with a value of z_m estimated from experience or from an approximate application of method 3 below; better first estimates of z_m will reduce the number of iterations needed. The estimated value of z_m is used to calculate $\bar{h}$ and u, and the right side of equation (12) then yields an improved estimate of z_m. If this is not the same as the assumed value, the process must be repeated.

Method 2. Iterations can be greatly reduced by the use of Newton's method. With this applied to equation (12), a better estimate of z_m is

$$z_{m1} = z_m - \frac{z_m (h_0 + \frac{1}{2} z_m) - 2B[3 - \gamma - J(r) - \ln u]}{(h_0 + z_m) - B/(h_0 + \frac{1}{2} z_m)} \qquad \ldots (14)$$

where $B = Q/(8\pi K)$. This converges far more rapidly.

Method 3. Iteration can be avoided all together as follows. Setting $z_m/h_0 = \xi$, equation (12) can be rearranged into the form

$$\frac{\xi(1 + \frac{1}{2}\xi)}{3 - \gamma - J(r) - \ln[N[1 + (1/r^2)]/(1 + \frac{1}{2}\xi)]} = \frac{Q}{4\pi K h_0^2} \qquad (15)$$

where $N = L^2 S_y/(16 K h_0 t)$ which is dimensionless; for t to be greater that t_{min}, N must be $< 1.498 \times 10^{-2}$. If we call the right side of (15) R, which is also dimensionless, then both N and R contain all known quantities. So a graph of ξ vs R, plotted for various values of r and N, as in Figur . 2, enables ξ (and so z_m) to be found directly when R, r, and N are known. The accuracy of this method is limited by the accuracy of reading and interpolating from the graph, but it is fast. It also provides a good initial estimate to speed up methods 1 and 2.

Method 4. Equation (12) can be solved accurately and without manual iteration by use of a programmable scientific calculator which has an equation (root) solving capability, as on the Hewlett-Packard 42S and 48S calculators. With such calculators the equation must first be entered and stored permanently; if necessary it can be corrected by editing. Values of each of the known variables in the equation are then stored in memory locations. Then the root solving capability is activated to solve for the unknown variable; internal programs cause the calculator to perform the iterations needed to find the value of the unknown variable, in our case z_m, which satisfies the equation. Once installed and verified, this is the most convenient and accurate method.

Values of z_m obtained by methods 2-4 can always be checked by using them to evaluate the right side of equation (12), which should of course equal the left side.

Examples of the growth of mound height with time are presented as solid curves in Figures 3-4 for various soil horizontal conductivities. Below the limit for accuracy, i.e.

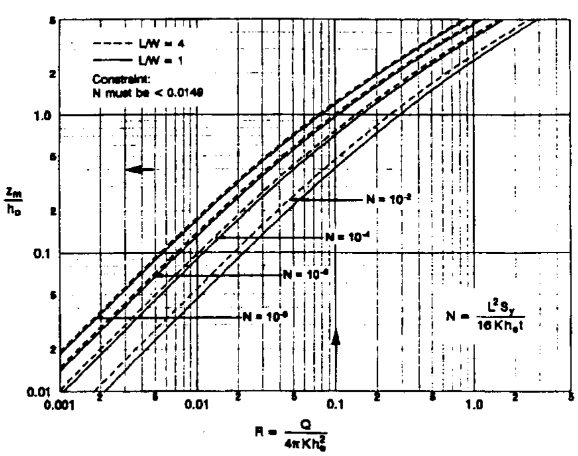

Fig. 2. Graphical solution of equation (12).

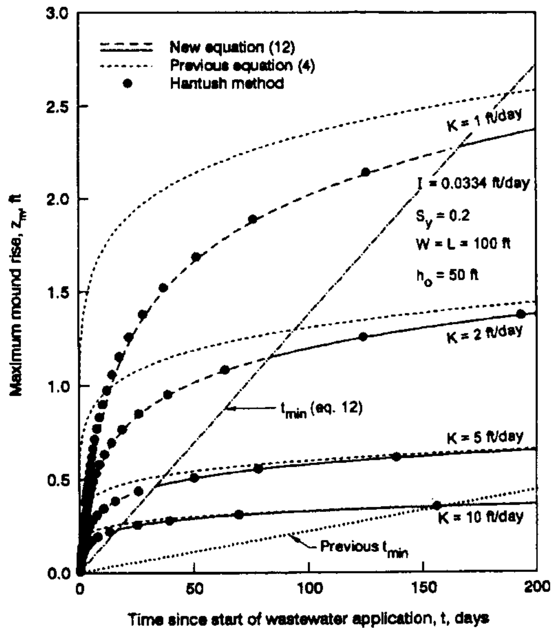

Fig. 3. Example mound growths at short waste-water application times (adapted from Finnemore and Hantsche, 1983).

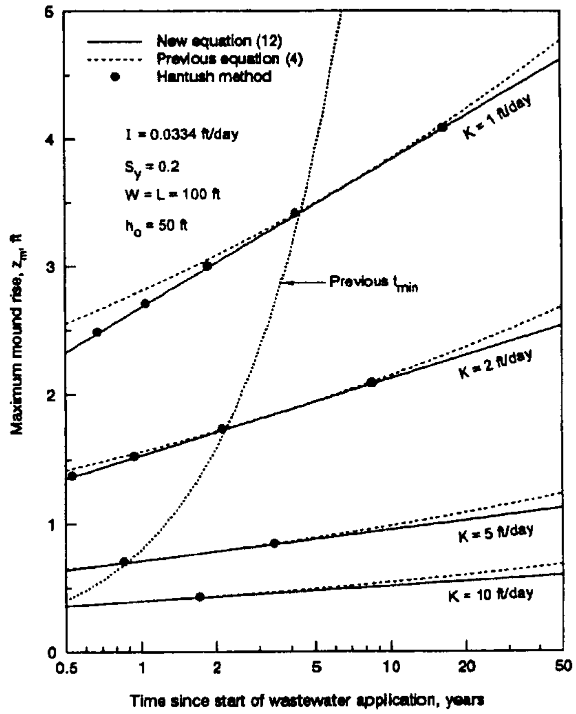

Fig. 4. Example mound growths at long waste-water application times (adapted from Finnemore and Hantzsche, 1983).

for $t < t_{min}$, the curves are shown dashed. They are compared with accurate results computed from Hantush's tabulations presented as solid circles, and with previous equation (4) shown as dotted curves.

We observe in Figures 3-4 that a mound continues to grow without limit, though at ever reducing rates. The curves of Figure 4 may be misleading in this regard, as they are distorted by the logarithmic time scale used; and although they may appear to be straight, they are slightly curved downwards. The unending mound growth follows from the Hantush equations and tabulations, and results from his assumption of an infinite aquifer. Because actual aquifers have outlets at finite distances, the mound growth will be limited and estimates given by the Hantush procedure and the above equations will be safe estimates on the high side.

It is important to remember that the mound height calculation method described here, and the Hantush equation upon which it is based, calculates the effect of only a single septic drain field, and so does not consider the cumulative effects of multiple, interfering drain fields. At higher development densities these cumulative effects will certainly increase mound heights.

Comparisons of Predictions and Methods

Before the above new simplified method was developed, the accuracy achieved by using the fitted equation $S^* = C\alpha^n$ was not known for longer times. Some differences can be seen on Figures 3 and 4. Considering new equation (12) to be correct for $t > t_{min}$, more examples of differences predicted by previous equation (4) are presented in Figure 5. Percentage errors are seen to vary with time, and to approach 20% in some instances. In most cases the errors were on the high side, overpredicting mound heights. Although such high predictions by equation (4) may be viewed as being on the safe side, in certain tight design situations they might unnecessarily disqualify a valid solution. Fortunately, most of the larger percentage errors were found to occur when mound heights are smaller.

There are four notable advantages of the new prediction method described here, in comparison to previous

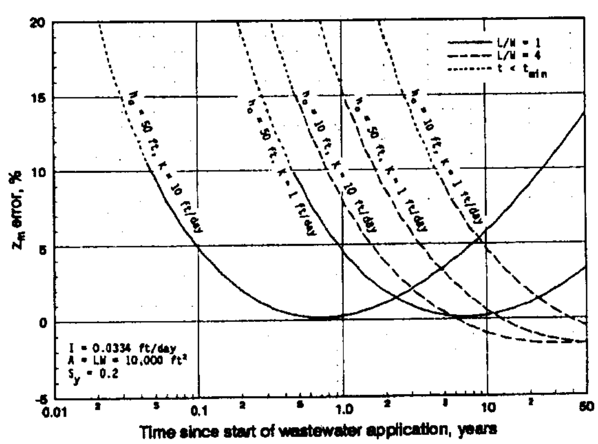

Fig. 5. Example differences between equations (4) and (12).

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equation (4). These advantages are as follows. First, the new method does not use any fitted functions, and so avoids any fitting errors such as those just described. Second, the nature of all its approximations to the Hantush procedure are quite apparent, so that their magnitudes can be readily estimated. Third, the new method can use any L/W ratio; the previous method was limited to ratios of 1, 2, 4, and 8. Fourth, the minimum time limit for reliability with the new method is about one-tenth of that for the previous method (comparing coefficients of 4.17 and 40). This greatly extends the range of accuracy to shorter times. This is particularly helpful for drain fields with larger L/W ratios since they have large accuracy limits, t_{min}, because these are proportional to L^2. For larger drain fields with larger L/W ratios, low soil hydraulic conductivities, and shallow saturated zones, t_{min} for the previous method could easily exceed 50-100 years, which made it of little practical utility in such cases. With the new method, these time limits become 5-10 years, making it very usable.

In addition to these advantages, equation (12) is usually more convenient to use than (4). Instead of evaluating three quantities raised to different exponents, there are two arctangents and one logarithm to evaluate; the two arctangents (in J) change only with changing L/W ratio.

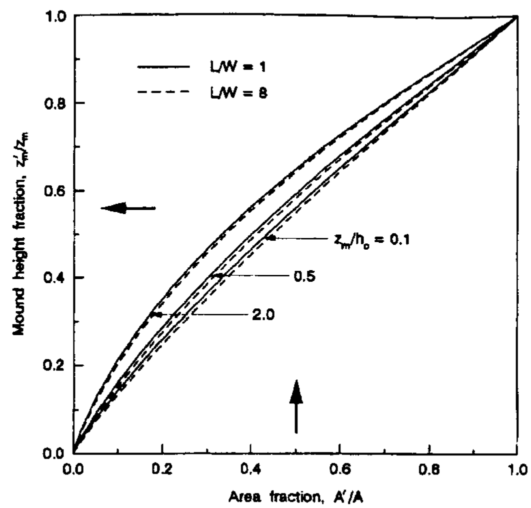

Fig. 6. Influence on mound growth of dividing up and widely separating disposal fields.

Design Considerations

When undertaking disposal field design, a good appreciation of the respective impacts of the various parameters involved is required.

Examples of the effects of hydraulic conductivity K and time t on mound height z_m are shown in Figures 3 and 4. There we may see that mounds grow much larger for smaller K values, which impede the spreading of the extra water. It is important to remember that the K values cited are in the horizontal direction, which for many soils may be significantly larger than the vertical conductivities. The strong influence of the saturated zone depth h_o, particularly when shallow, and the relatively minor effect of specific yield S_y, have been described by Finnemore and Hantzsche (1983).

Methods of determining the aquifer properties (h_o, K, S_y) required for prediction and design are discussed by Finnemore and Hantzsche (1983). They noted that the accuracy of the prediction methods depends in particular on the accuracy of the determination of K and h_o.

When mound heights are critical, four different design options for reducing them are: drain field elongation (of a given area); drain field enlargement, which reduces I; intermittent drain field operation; and drain field subdivision. The effects of the first three of these options are discussed more fully by Finnemore and Hantzsche (1983); in summary, mound height reductions obtained by the first two are minor, and by the third are negative. The effect of subdividing a single disposal field into a number of widely separated smaller fields, each with the same I and L/W proportions as the original, may be found more conveniently from equation (4) than from (12). Using a prime to indicate parameters for one of the smaller fields, we may write (4) twice, for the original field and for the smaller field with primes, and take the ratio of the two equations to obtain the ratio of the two mound heights. Many quantities cancel because they are the same in both equations. After some rearrangement, and noting that field area A is proportioned to L^2, we obtain

$$\frac{A'}{A} = \left(\frac{z_m'}{z_m}\right)^{2/n} \left(\frac{h_o}{z_m} + \frac{1}{2}\frac{z_m'}{z_m}\right) \Big/ \left(\frac{h_o}{z_m} + \frac{1}{2}\right) \quad (16)$$

From this, the mound height fraction, z_m'/z_m, may be plotted against the area fraction, A'/A, for various z_m/h_o and L/W ratios. These plots are presented in Figure 6, which reveals that the z_m/h_o ratio has a minor effect on results, and that the L/W ratio has a very slight effect. More importantly, it demonstrates that subdividing a single disposal field into widely separated, smaller fields reduces mound heights far more effectively than the other three options. For example, Figure 6 indicates that replacing a single field by two widely separated fields each with half the area reduces the mound height to 55-65%.

As noted earlier, the amount of mound height reduction achieved by disposal field subdivision depends upon the amount of separation; the amounts indicated by Figure 6 are the greatest reductions obtainable, when the mounds are sufficiently widely spaced to have negligible effects upon one another. The interactive effects of less widely spaced mounds are not presently known. However, as two widely spaced mounds are brought closer together, and the interaction effects become stronger and lessen the height reduction due to subdivision, the limiting case will be when they make contact and become a single, elongated mound. The height reduction for this limiting case can be calculated from equation (12), and it is known to be minor (Finnemore and Hantzsche, 1983). In this way mound height reductions for intermediate spacings may be bracketed, and it is clear that they must be greater than the minor reductions obtainable by drain field elongation or enlargement.

Practical applications to design are discussed at some length by Finnemore and Hantzsche (1983), and so need little repetition here. Notably, 20-year mound heights for individual homes are unlikely to exceed one foot except where aquifers are very shallow ($h_0 < 10$ ft) and soil conductivities are very low (i.e., $K \approx 1$ ft/day, which is marginally acceptable). Larger mounds of concern are more likely to occur beneath disposal fields serving clusters of homes, institutional buildings, or recreational developments. Flow rates Q and I used in calculations should be average values because mounding is a long-time cumulative effect. A 20-year life is recommended for design, as suggested by Urish (1991), because it is representative of the life of the facility; if it should serve for 40 years, the mound could grow by only another 7-8%.

Summary and Conclusions

Ground-water mounding beneath on-site sewage disposal fields, particularly larger ones, can threaten the wastewater treatment that occurs in the unsaturated soil zone. This paper presents an improved procedure for predicting longer-time mound heights, having a stronger theoretical basis.

The new procedure considerably extends the range of applicability to shorter times. In some cases the time limit of applicability of the only available former method was so large as to invalidate it for the normal service lifetimes of such facilities. Also, the new procedure no longer restricts the rectangular disposal field to a few specified proportions; any length-to-width ratio may now be used. The accuracy of the former prediction method was previously unknown. Comparisons with the new procedure indicate that the former method usually overpredicts mound heights, by amounts that may approach 20% in some instances.

Mound heights will be greatest in shallow aquifers of low permeability. The most effective method to reduce mound heights is to divide the disposal field into subareas, the more widely separated the better. Field enlargement or elongation achieves relatively slight reductions, and intermittent field operation increases maximum mound heights.

As noted by Finnemore and Hantzsche in 1983, such prediction methods need to be used with judgment by experienced engineers who are aware of the limitations, and there continues to be a need for field verification.

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APPENDIX J – NSDEL APPROVAL LETTER

NOVA SCOTIA
Department of Environment and Labour

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Our File Number:

Gerard MacLellan,
Executive Director,
Environmental Monitoring and
Compliance Division

April 10, 2003

Mr. J. Bradey Hawley, P.Eng.
Division Engineer
Shaw Pipe
P.O. Box 2130
Lantz NS B0N 1R0

Dear Mr. Hawley:

Re: Shaw Peat Treatment Systems

Departmental staff have completed their review of the revised Shaw Peat Technical Manual and met with you on April 3, 2003 to discuss the latest revisions. Staff have also initiated correspondence with the Department of Transportation and Public Works (NSDOT&PW) in respect to off-site (surface) discharges of treated effluent to roadside ditches. The response received from the NSDOT&PW specifies they are not prepared to allow a newly constructed on-site sewage disposal system to discharge treated effluent into their ditches. Furthermore, NSDOT&PW never intended to accept treated effluent discharge on their property unless it was a last resort situation to fix an existing malfunction (or total lack of system) on an existing lot supporting a home or business.

Based upon the response form NSDOT&PW, the technical review by staff and the subsequent revisions to the Manual, the Shaw Peat System is approved by the department for use in Nova Scotia as an on-site sewage disposal system for new installations, with the exception of off-site discharge to roadside ditches, subject to the following conditions:

1. Any application submitted to the department for approval for the installation of a Shaw Peat System shall be designed by a Level 1 Qualified person (QPI). The system drawings shall be provided with the application and shall include the design flow, system components and system layout.

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Mr. J. Bradey Hawley, P.Eng.
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2. The system design shall reference the April 3, 2003 version or latest revised version of the Shaw Peat Technical Manual. The Technical Manual shall be revised periodically as deemed necessary by Shaw Pipe or if required by the department.

3. The Shaw Peat System shall be designed, installed and maintained in accordance with the specific On-Site Sewage Disposal System Approval, the Shaw Peat Technical Manual and manufacturer's recommendations.

4. Shaw Pipe shall notify the department of any manufacturer's modifications to the Shaw Peat System that may effect its treatment efficiency and shall submit these modifications to the department for approval before any modified systems can be installed in Nova Scotia.

5. Pursuant to Section 60 of the Environment Act, Shaw Pipe shall submit to the department any new and relevant information respecting any adverse effect that actually results, or may potentially result, from the use of the Shaw Peat System and that comes to the attention of Shaw Pipe after the issuance of this Approval.

6. The department may modify, amend or add conditions to this approval pursuant to Section 58 of the Environment Act.

In addition to these conditions, a Variation is hereby granted pursuant to Subsection 29(3) of the On-Site Sewage Disposal System Regulations to permit the vertical separation distance of 600mm between the bottom of the dispersion mantle and either bedrock, maximum groundwater table or other limiting conditions such as impermeable soil.

I trust this explains the department's position regarding the use of the Shaw Peat System as a conventional on-site sewage disposal system in Nova Scotia. Should you wish to pursue the issue of off-site discharge to roadside ditches, I recommend that you contact the Department of Transportation and Public Works on this matter. If you have any questions, please contact either Brent Baxter at (902) 424-5300 or Jay Brenton at (902) 893-5880.

Sincerely,

Gerard MacLellan
Executive Director
Environmental Monitoring &
Compliance Division

cc: B. Langdon
B. Baxter
J. Brenton
R. Anderson