Septic Tank Treatment System (SepTTS) Model for Cleaning Product Chemicals
User's Manual
Version 1.0

The Soap and Detergent Association
1997

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INSTALLATION

SepTTS requires a minimum of 500 Kbytes of free random access memory, a hardisk and Microsoft Windows 3.1+. Additional system requirements include a 386+ microprocessor and a color VGA monitor.

SepTTS is distributed in a compressed format, so you must use the INSTALL program before you can run the main program. To install SepTTS, type:

INSTALL

or from Windows, run **INSTALL** from the Program Manager.

Once installed, start the program by clicking the SepTTS icon from within the "Septic Tank Model" Group Window. If the program seems to perform sub-optimally, refer to your Microsoft Windows User's Guide for information about Windows resources and memory.

INTRODUCTION

The Septic Tank Treatment System (SepTTS) Model is a tool for predicting the concentration of cleaning product chemicals (i.e., non-volatile: carbon chain length > 12 or vapor pressure of 0.1 mm Hg or less) as they pass through a septic system and soil. The model consists of three compartments: (1) a septic tank, (2) an unsaturated soil zone, and (3) a saturated soil zone.

As with any model, this program should be used with caution. Since the calculations use simplifying assumptions, it could be misused and /or misinterpreted when assessing the fate of consumer product ingredients. Specifically, this model has only been assessed and calibrated for one geographic site on one class of compounds (i.e., detergent builders). While there is no reason to suggest that this model would not give good predictions for other classes of compounds (e.g., surfactants), they have not been tested to date. Based on the sensitivity analysis of the model, the biodegradation rate and the sorption coefficient did not effect the outcome of the model significantly. However, it is important that these parameters are known with some certainty if the model's results are to be used in a decision making process.

OVERVIEW OF MODEL THEORY

The hydraulic flow path in the model starts at the point where wastewater from the house enters the septic tank. Effluent from the tank (minus losses from biodegradation and adsorption) passes into the unsaturated zone via a tile field. The direction of flow in the unsaturated zone is downward. Decreases in chemical concentration can occur in the unsaturated zone depending on the depth of the zone and factors such as the rate of biodegradation or the partitioning of the chemical on to soil particles. The output from the unsaturated zone provides the input for the saturated zone. The direction of hydraulic flow is essentially horizontal for the saturated zone (Figure 1).

All of the equations used in the model are based on mass balance theory. The septic tank is assumed to be completely mixed. Vertical flow is assumed to dominate in the unsaturated zone and horizontal flow is assumed in the saturated zone. Steady-state solutions of the governing equations are used to describe the behavior in the septic tank and unsaturated zone since chemical concentrations in these compartments reach steady-state quickly. A time variable solution of the one-dimensional mass balance equation was used to predict chemical transport in the saturated zone because of the slow rate of transport for many substances within this compartment.
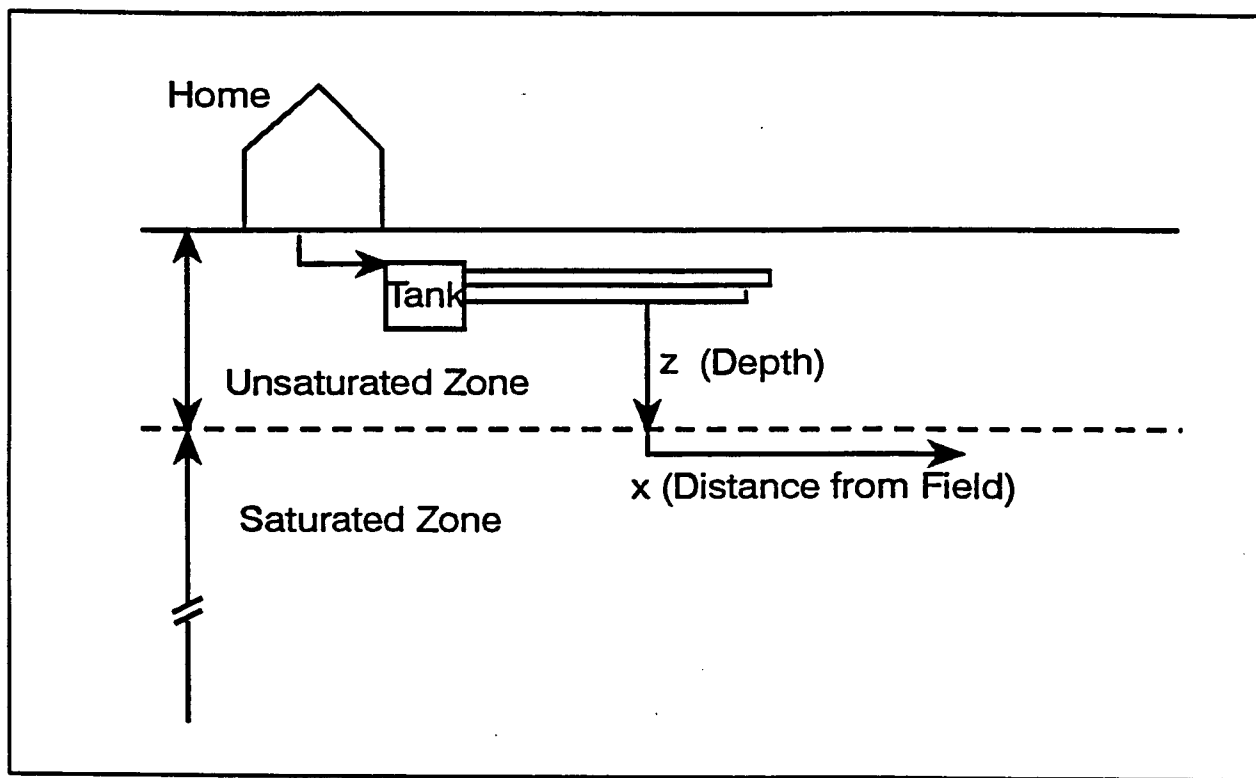
Figure 1

MODEL EQUATIONS

1. Pre-Calculation

Certain calculations are performed prior to running the numerical formulations. These calculations are directed toward determining the chemical concentration and flow from the house to the septic tank. The concentration into the septic tank is calculated as:

$$C_{in} = \left(\frac{\frac{r}{100} U_c}{Q_c} \right) \cdot 10^3$$

where:

C_{in} = septic tank influent concentration (mg/l)
r = percent chemical ingredient in a product
U_c = product use per capita (gm/d/cap)
Q_c = water use per capita (l/d/cap)

The household flow is calculated as:

$$Q = \frac{Q_c F}{1000}$$

where:

Q = the daily total household wastewater flow (m³/d)
F = the family size (cap)

2. Septic Tank

For the septic tank, a mass balance equation assuming a 1st-order biological decay and particulate settling for chemical loss was developed (see Lee et al., 1996 for model development). It assumed that the flow rates into and out of the septic tank are equal. Assuming a constant input to the tank, the chemical concentration reaches steady-state in a relatively short period of time. The steady state solution is as follows:

$$C = \frac{C_{in}}{k_{b1} f_d \tau + k_s f_p \tau + 1}$$

where:

C = septic tank effluent concentration (mg/l)
k_{b1} = biodegradation rate constant (1/d)
f_d, f_p = fraction of dissolved and particulate adsorbed chemical
τ = hydraulic retention time (d)
k_s = settling rate (1/d)

$$k_s = V_s / H$$

where:

V_s = settling coefficient for tank solids (m/d)
H = depth of the tank (m)

$$\tau = V/Q$$

where:

V = volume of the tank (m^3)

$$f_d = 1/(K_{d1} {}^* M + 1)$$

$$f_p = 1 - f_d$$

where:

K_{d1} = distribution coefficient for suspended solids in the septic tank (l/kg)
M = suspended solids concentration in the septic tank (kg/l)

3. Unsaturated Zone

There are two chemical removal processes that are considered together in the unsaturated zone: (1) 1st-order biological decay and (2) sorption onto soil particles. Assuming that there is only vertical flow and that steady state is reached, the equation for the unsaturated zone (derived from Huyakorn et al., 1985; see Lee et al., 1996 for derivation) is as follows:

$$C(z) = C_e \exp(-\lambda z)$$

where:

$C(z)$ = concentration of chemical at depth z below the tile field (mg/l),
C_e = tank effluent concentration (mg/l)
z = depth of the unsaturated zone (m)
λ = loss or removal rate (1/m)

$$\lambda = \frac{Rk_{b2}}{u_z}$$

where:

u_z = water velocity in the downward direction (m/d)
k_{b2} = biodegradation rate (1/d)
R = retardation factor

$$u_z = \frac{Q}{A_e \phi S_w}$$

and

$$R = 1 + \frac{\rho_b K_{d2}}{\phi S_w}$$

where:

ρ_b = sediment bulk density (kg/l)
K_{d2} = distribution coefficient (l/kg)
ϕ = effective porosity
S_w = relative saturation of the water phase
A_t = effective area of the tile field (m^2)

4. Saturated Zone

Modeling the behavior of chemicals in the saturated zone is more complicated than in the unsaturated zone due to the fact that it is a far-field problem with large time constraints. Moreover, adsorption/retardation and the transport of chemicals in the saturated zone are, in theory, three-dimensional problems. In this model, however, the governing equation was simplified to a one dimensional form of the advection-dispersion equation:

$$\frac{\delta C}{\delta t} = -v\frac{\delta C}{\delta x} + D\frac{\delta^2 C}{\delta x^2} - \frac{\rho_b K_{d3}}{n}\frac{\delta C}{\delta t} - k_{b3}C$$

A one-dimensional contaminant transport model is a reasonable simplification, since the predominant movement of chemical is away from the tile field in the longitudinal direction.

Upon rearrangement, the above equation can be rewritten as follows:

$$R\frac{\delta C}{\delta t} = D\frac{\delta^2 C}{\delta x^2} - v\frac{\delta C}{\delta x} - k_{b3}C$$

where:

$\delta C/\delta x$, $\delta^2 C/\delta x^2$ = first and second partial derivatives with respect to distance
$\delta C/\delta t$ = the partial derivative with respect to time
C = chemical concentration in the saturated zone (mg/l)
D = hydrodynamic dispersion coefficient (m^2/d)
v = water velocity (m/d)
x = longitudinal coordinate (m)
t = time (d)
R = retardation coefficient
k_{b3} = biodegradation rate constant (1/d)

$$v = \frac{V_H G_H}{n}$$

and

$$R = 1 + \frac{\rho_b K_{d3}}{n}$$

where:

n = effective porosity in the saturated zone
K_{d3} = distribution coefficient in the saturated zone (1/kg)
ρ_b = sediment bulk density in the saturated zone (kg/l)
V_H = hydraulic conductivity (m/d)
G_H = hydraulic gradient (m/m)

Chemical concentrations in the saturated zone may take years or decades to reach steady-state depending upon the chemical characteristics. The time-variable solution (see van Genuchten, 1981, for derivation) to the above equation is used to predict the chemical behavior in the saturated zone:

$$C = \frac{C_o}{2}\left[\exp\left(\frac{(v-u)x}{2D}\right)erfc\left(\frac{Rx-ut}{2\sqrt{RDt}}\right) + \exp\left(\frac{(v+u)x}{2D}\right)erfc\left(\frac{Rx + ut}{2\sqrt{RDt}}\right)\right]$$

where:

C_o = chemical concentration at interface between the unsaturated zone and the water table (mg/l)
$erfc$ = complementary error function
u = effective velocity of compound (m/d)

$$u = v\sqrt{\left(1 + \frac{4k_{b3}D}{v^2}\right)}$$

For this model, the following boundary conditions were assumed:

$$C(x,0) = 0 \qquad\qquad x \geq 0$$
$$C(0,t) = C_0 \qquad\qquad t \geq 0$$
$$\delta C/\delta t(\infty,t) = 0 \qquad\qquad t \geq 0$$

The complementary error function (erfc) is defined as:

$$erfc(x) = \frac{2}{\sqrt{\pi}} \int_{x}^{\infty} e^{-t^2} dt$$

5. Temperature Corrections

All biodegradation rate constants (k_{b1}, k_{b2}, k_{b3}) are assumed to be appropriate for 20 °C.

OVERVIEW OF MODEL OPERATION

1. *Main Menu*

The main menu consists of the **File**, **Data**, **About**, and **Help** options (Figure 2).
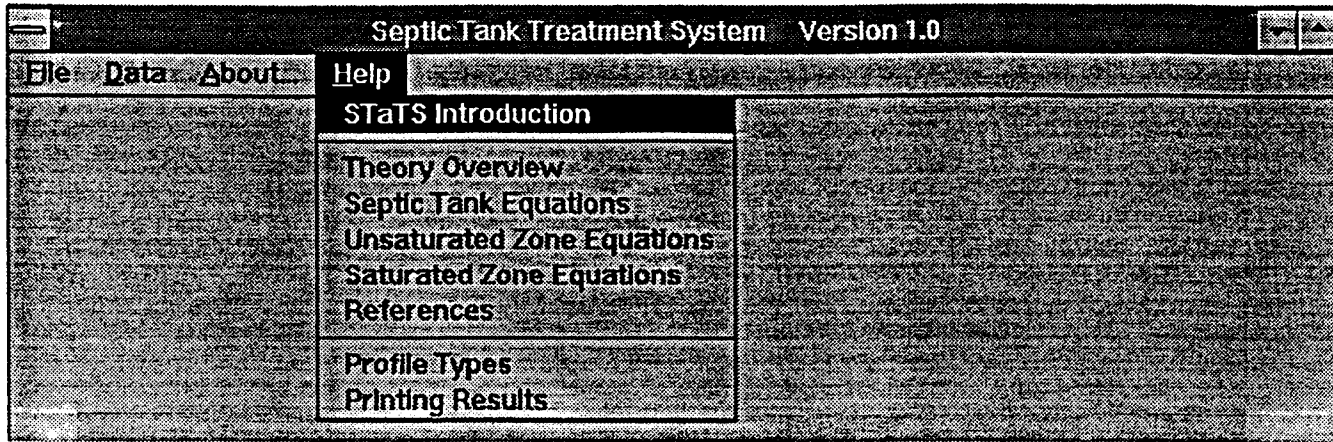

Figure 2

Each option is described below:

FILE:

Save Input : allows you to save all the input parameters to a file for future use.

Load Input : enables you to select an input file, which was saved previously, and use it within a calculation.

Print Results : prints a summary of all input parameters, a profile for the unsaturated and saturated zones and a tabular list of the profiles.

Save Results : saves all profile data for the unsaturated and saturated zones to an ASCII, comma-delimited file.

Exit leaves the program.

DATA:

Hydraulic Parameters : displays a tool for altering all hydraulic parameters. Parameters are grouped by their associated compartment (tank, unsaturated, saturated).

Chemical Compound Parameters : displays a tool for altering all chemical and physical parameters. Parameters are grouped by their associated compartment (tank, unsaturated, saturated).

Plotting Constraints : allows the user to alter the time interval and distance to be displayed for the saturated zone profile.

ABOUT:

Disclaimer : displays legal notice.

Copyright : displays copyright and credits.

HELP:

This option displays various help screens.

2. Worksheet

2.01 Organization

The SepTTS Worksheet (Figure 3) is the main tool for managing model calculations. There are four general categories for interacting with the Worksheet: (1) altering of model parameters (editing), (2) storing, loading or printing of input and output data (data management), (3) displaying of tabular and graphical output data (data visualization) and (4) coordinating the appearance of all input and output screens (synchronization; Figure 4).
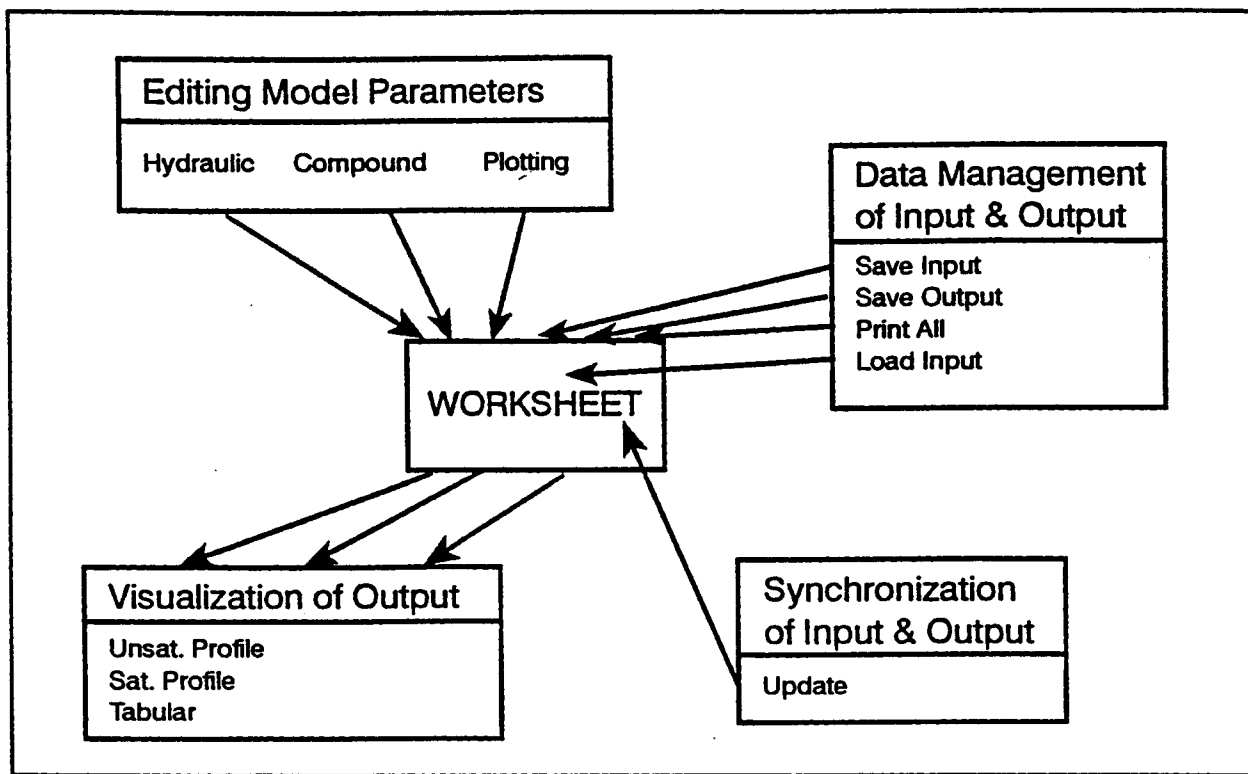

Figure 3

Figure 4

The Worksheet options for each category are as follows:

Editing:

> **Hydraulic:** displays a tool for altering all hydraulic parameters. Parameters are grouped by their associated compartment (septic tank, unsaturated zone, saturated zone).

> **Compound:** displays a tool for altering all chemical and physical parameters. Parameters are grouped by their associated compartment (septic tank, unsaturated zone, saturated zone).

> **Plotting:** allows the user to alter the time interval and distance to be displayed for the saturated zone profile.

Data Management:

> **Save Input:** allows you to save all the input parameters to a file for future use.

> **Save Output:** saves all profile data for the unsaturated and saturated zones to an ASCII, comma-delimited file.

Print All: prints a summary of all input parameters, a profile for the unsaturated and saturated zones and a tabular list of the profiles.

Load Input : enables you to select an input file, which was saved previously, and use it within a worksheet. This option is activated by selecting the **User Define** option from the combo box directly to the left of the **Load Input** button.

Data Visualization:

Unsat. Profile: displays an X-Y plot of soil depth (cm) versus chemical concentration (mg/l) for the unsaturated zone.

Sat. Profile: displays and X-Y plot of chemical concentration (ug/l) versus distance (m) from the tile field. Five curves are presented on the plot at different time intervals.

Tabular: displays entire model output in a text format. Although there are options available for saving model output (see **Save Output**), it is also possible to use the Windows Clip Board to copy data from the **Tabular** output and paste it into another Windows application (e.g., a wordprocessor or spreadsheet).

Synchronization:

Update: coordinates all input and output to ensure that all calculations are up-to-date. Generally, this option is inactive and requires no user response. If the **Update** button becomes activated, it is a signal that the current input values are not reflected in the current output windows.

2.02 Pre-Calculation Parameters

The model parameters that relate to (1) the calculation of wastewater flow and (2) the chemical input concentration to the septic tank are addressed directly from the Worksheet. Note that the corresponding model parameters have been added to Figure 3. See Section on Model Equations for a description of each parameter.

2.03 Hydraulic Parameters

By selecting the **Hydraulic** button from the Worksheet, a tool appears that allows a user to edit model parameters related to the movement of water within the septic tank, unsaturated zone and saturated zone (Figure 5). Note that the symbols used for the model parameters in this manual have been overlaid on to Figure 5 to aid in understanding how the software uses each input field.

Figure 5

To accept the model parameters, press the **OK** button. To return without accepting any alterations of model parameters, press the **Cancel** button. Use the **Help** button for context-sensitive help.

By selecting the **Compound** button from the Worksheet, a tool appears that allows a user to edit model parameters related to the characteristics of the chemical compound being modeled (Figure 6). Note that the symbols used for the model parameters in this manual have been overlaid on to Figure 6 to aid in understanding how the software uses each input field.

Figure 6

To accept the model parameters, press the **OK** button. To return without accepting any alterations of model parameters, press the **Cancel** button. Use the **Help** button for context-sensitive help.

2.05 *Plotting Parameters*

By selecting the **Plotting** button from the Worksheet, a tool appears that allows a user to edit model parameters related to the appearance of saturated zone profile (Figure 7). Note that the symbols used for the model parameters in this manual have been overlaid on to Figure 7 to aid in understanding how the software uses each input field.
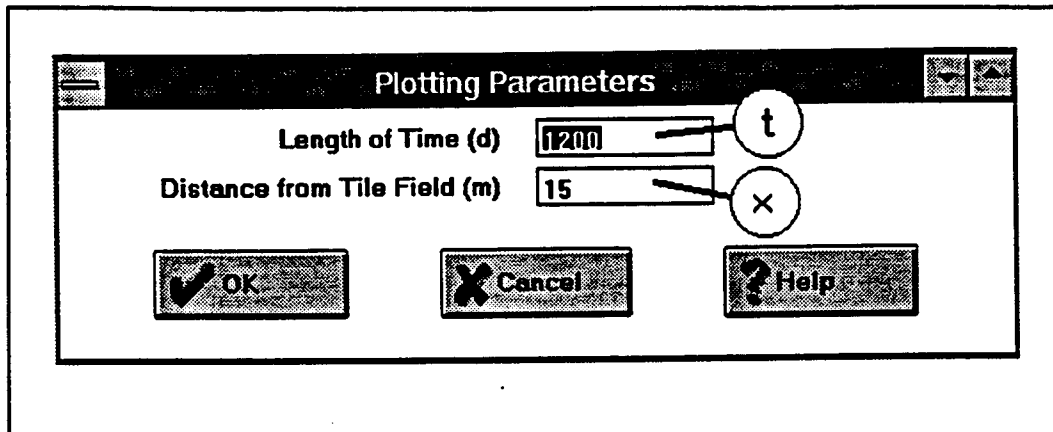
Figure 7

To accept the model parameters, press the **OK** button. To return without accepting any alterations of model parameters, press the **Cancel** button. Use the **Help** button for context-sensitive help.

2.06 *Identification of Model Runs*

The fields at the top of the Worksheet are identification fields (Title, User Name, and Chemical Name; Figure 8) and are not required to perform a calculation. However, it is recommended that if you are going to perform several runs that need to remain distinct and well identified that you fill in these fields. The identification data is stored with all other input data (see **Save Input**) so it is possible to identify model input as well as output.

Figure 8

2.07 *Graphical Profiles*

To display a profile for either the unsaturated or saturated zones, click on one of the "Profile" buttons at the bottom side of the screen (Figure 9).
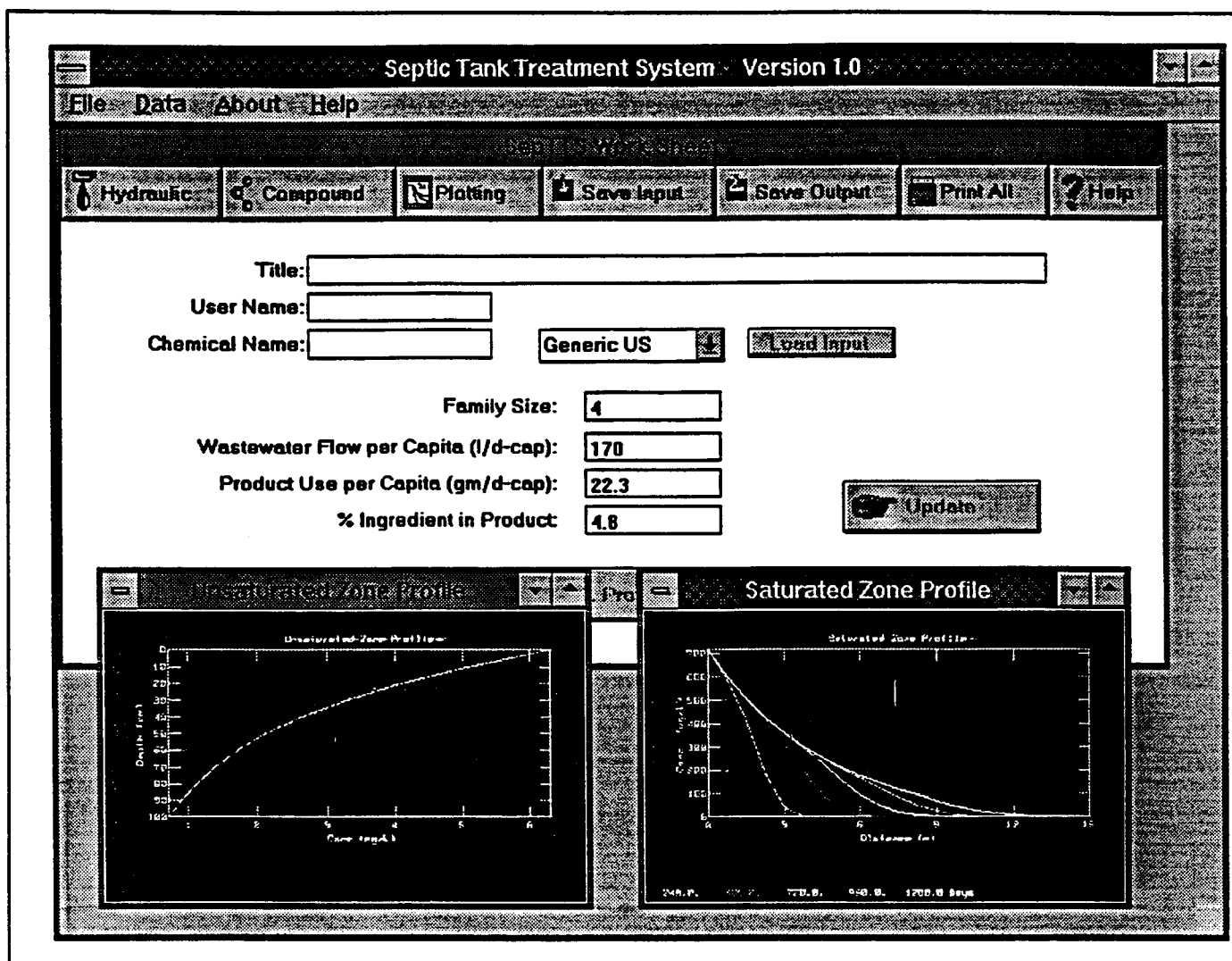
Figure 9

Two types of graphs are produced under SepTTS: unsaturated and saturated zone profiles. The unsaturated zone profile has the depth (cm) on the Y axis with zero at the top and increasing depth displayed downward. Chemical concentration (mg/l) is displayed on the X axis (Figure 10-A). The resolution of the chemical profile is set by default to 10 cm (0.1m).

The saturated zone profile has concentration (ug/L) displayed on the Y-axis and the distance (m) away from the tile field shown on the X-axis. Five profile lines are displayed, one for each time period leading up to the total duration of the simulated run (Figure 10-B). All chemical concentrations less than 0.001 ug/l are interpreted as equal to zero. Generally, this presents little concern. However it should be noted that at extremely low concentrations it is possible to generate discontinuities in the profile plots.
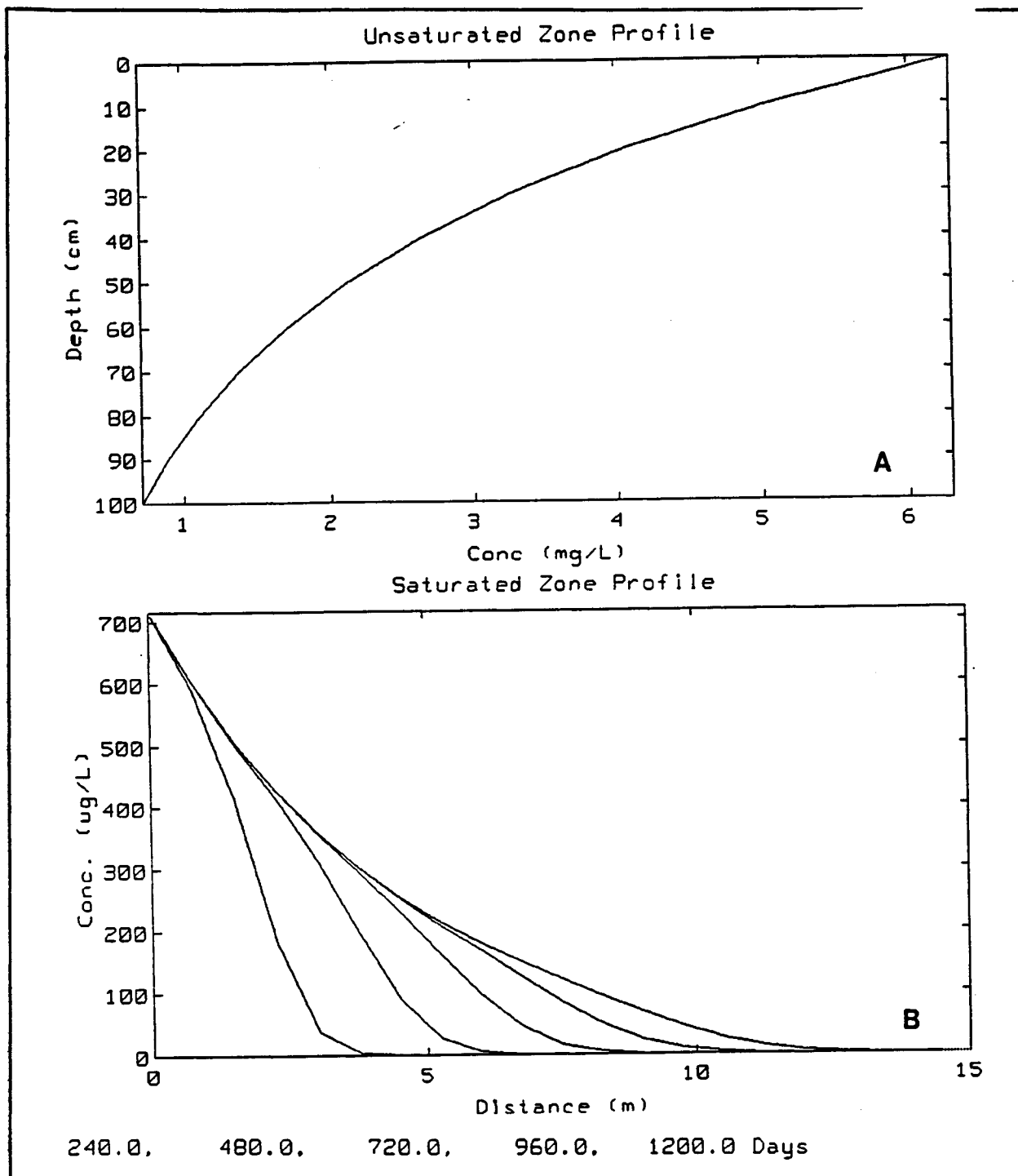
Figure 10

Tabular output includes the same output data used to produce the graphical profiles of the saturated and unsaturated zones. In addition, the following model values are included:

- A summary of all input data

- The influent and effluent concentration in the septic tank

- The water velocity within the unsaturated zone

- The water velocity and corrected velocity within the saturated zone

- The retardation factor for the unsaturated and saturated zone

- The hydraulic retention time in the septic tank

- The travel time in the unsaturated zone

Example Tabular Output:

```
SepTTS  Version   1.0                                      Page  1
Septic  Tank  Treatment   System  Model                   Jul-11-1996

Title:
                          User  :
                      Chemical  :
                                 Family   Size  :        4.00
        Wastewater  Flow Per Capita  (l/d-cap)  :      170.00
           Product  Use Per Capita  (gm/d-cap)  :       22.30
            Percent   Ingredient  in  Product   :        4.80
```

~~~~   SEPTIC SYSTEM MODELINGFOR ~~~~

GENERALDESCRIPTION OF THE SYSTEM

SEPTIC TANK

Volume of Septic Tank(m3):	3.78
Flow rate (m3/day):	.68
Biodegradation rate (1/day):	.0000
Partition Coef. (l/kg):	15.0000
Fract. of Dissolved:	1.00
Fract. of Particulate:	.00
Total Suspended Solids (mg/l):	200.00
Area of tile Field (m2):	10.00

UNSATURATEDZONE DESCRIPTION

Effective Porosity:	.4000
Relative Saturation:	.3750
Sediment Bulk Density (kg/l):	1.2000
Partitioning Coeff. (l/kg):	1.4000
Biodegradation Rate (1/day):	.0900
Depth of Unsat. Zone (m):	1.0000

SATURATED ZONE DESCRIPTION

Effective Porosity:	.4000
Sediment Bulk Density (kg/l):	1.2000
Partitioning Coeff. (l/kg):	1.8000
Biodegradation Rate (1/day):	.0140
Lat. Dispersion Coef. (m2/day):	.0070
Hydraulic Conductivity (m/day):	20.0000
Hydraulic Gradient (m/m):	.0010

```
        Septic   Tank   Inf.   Chemical   Conc.   (mg/l)          6.3000
        Septic   Tank   Eff.   Chemical   Conc.   (mg/l)          6.2960
Hydraulic   Retention   Time   In   Septic   Tank   (d)           5.5588
        WATER VELOCITY   IN   UNSAT.   ZONE (m/d)         .4533
             TRAVEL TIME  IN   UNSAT.   ZONE (d)         2.2059
        RETARDATION FACTOR IN  UNSAT.   ZONE           12.2000

UNSATURATED ZONE CHEMICAL CONC. WITH DEPTH
     DEPTH(cm)    CHEMICAL CONC.(mg/l)

           .0        .6296E+01
         10.0        .5067E+01
         20.0        .4078E+01
         30.0        .3282E+01
         40.0        .2641E+01
         50.0        .2125E+01
         60.0        .1710E+01
         70.0        .1376E+01
         80.0        .1108E+01
         90.0        .8915E+00
        100.0        .7174E+00

     WATER VELOCITY  IN   SAT.   ZONE (m/d)          .0500
ADJUSTED VELOCITY  IN   SAT.   ZONE (m/d)           .0532
     RETARDATION FACTOR IN   SAT.   ZONE            6.4000

SATURATED ZONE OUTPUT -- CONCENTRATIONS IN  ug/l
AS A FUNCTION OF DISTANCE FROM TILE FIELD
FOR VARIOUS TIME INTERVALS (d)
(ZEROS ARE PRINTED FOR CONC. VALUES < 0.001  ug/l)

DIST.        240.00      480.00      720.00      960.00     1200.00
    0.000    .717E+03    .717E+03    .717E+03    .717E+03    .717E+03
     .750    .591E+03    .603E+03    .604E+03    .604E+03    .604E+03
    1.500    .414E+03    .506E+03    .508E+03    .508E+03    .508E+03
    2.250    .182E+03    .415E+03    .427E+03    .427E+03    .427E+03
    3.000    .376E+02    .313E+03    .358E+03    .359E+03    .359E+03
    3.750    .314E+01    .195E+03    .294E+03    .302E+03    .302E+03
    4.500    .983E-01    .896E+02    .230E+03    .253E+03    .254E+03
    5.250    .111E-02    .279E+02    .162E+03    .209E+03    .214E+03
    6.000    .446E-05    .557E+01    .968E+02    .168E+03    .179E+03
    6.750    .000E+00    .691E+00    .461E+02    .126E+03    .149E+03
    7.500    .000E+00    .522E-01    .168E+02    .849E+02    .121E+03
    8.250    .000E+00    .237E-02    .457E+01    .495E+02    .941E+02
    9.000    .000E+00    .644E-04    .907E+00    .242E+02    .682E+02
    9.750    .000E+00    .000E+00    .130E+00    .963E+01    .447E+02
   10.500    .000E+00    .000E+00    .134E-01    .307E+01    .258E+02
   11.250    .000E+00    .000E+00    .976E-03    .777E+00    .128E+02
   12.000    .000E+00    .000E+00    .000E+00    .154E+00    .541E+01
   12.750    .000E+00    .000E+00    .000E+00    .238E-01    .191E+01
   13.500    .000E+00    .000E+00    .000E+00    .287E-02    .560E+00
   14.250    .000E+00    .000E+00    .000E+00    .267E-03    .135E+00
   15.000    .000E+00    .000E+00    .000E+00    .000E+00    .268E-01
```

2.09. Printing Results

Output profiles will be printed in graphical and tabular form, along with a summary of all input data. Printing requires the use of the Microsoft Windows Print Manager and uses the default setup for your printer. If you are having problems printing under SepTTS, check the printer settings under Windows (Main/Control Panel/Printers) to set the proper configuration. Basically, if other applications can print under Windows, then SepTTS will also print.

2.10. Saving Results

A limited set of output data can be saved as an ASCII, comma-delimited file for use in database and spreadsheet software. The output consists of tabular profile data for the unsaturated and saturated zones. Before saving the file, SepTTS will prompt you for the filename under which to save the data. To save the data, press the OK button.

2.11 Saving and Loading Input

A combo box in the middle of the Worksheet (Figure 11) allows a user to load default scenarios for septic system behavior. The four default scenarios are for a generic US system, a best case system, a worst case system, and a typical system in Ontario, Canada. Each scenario contains the values for all model parameters (Hydraulic, Chemical Compound, Pre-Calculation, and Plotting (Table 1).

Figure 11

Table 1. Parameter Values for Default Scenarios

Variable	US	Ontario	Best	Worst
Effective Porosity (n)	0.4	0.4	0.4	0.4
Saturated Zone Sediment Bulk Density (ρ_b; kg/l)	1.2	1.8	1.2	1.2
Dispersion Coefficient (D; m^2/d)	0.007	0.007	0.007	0.007
Hydraulic Conductivity (V_H; m/d)	20	20	20	20
Hydraulic Gradient (G_H; m/m)	0.001	0.001	0.001	0.001
Effective Porosity (ϕ)	0.4	0.4	0.4	0.4
Relative Saturation (S_w)	0.375	0.375	0.375	0.375
Unsaturated Zone Sediment Bulk Density (ρ_b; kg/l)	1.2	1.8	1.2	1.2
Unsaturated Zone Depth (m)	1	2	1.22	0.61
Effective Area of Tile Field (A_e; m2)	10	10	13	7
Volume of Septic Tank V; m3)	3.78	1.89	5.68	1.89
Depth of Septic Tank (H; m)	1.52	0.61	1.82	1.21
Saturated Zone Biodegradation coefficient (K_{b3}; 1/d)	0.014	0.014	0.014	0.014
Saturated Zone Distribution Coeficient (K_{d2}; l/kg)	1.8	1.8	1.8	1.8
Unsaturated Zone Biodegradation coefficient (K_{b2}; 1/d)	0.09	0.09	0.09	0.09

Table 1. Continued

Variable	US	Ontario	Best	Worst
Saturated Zone Distribution Coeficient (K_{d2}; l/kg)	1.4	1.4	1.4	1.4
Septic Tank Biodegradation coefficient (K_{b2}; 1/d)	0	0	0	0
Septic Tank Distribution Coeficient (K_{d3}; l/kg)	15	15	15	15
Setpic Tank Settling Coeficient (V_s; m/d)	0.058	0.058	0.058	0.058
Total Suspended Solids in Septic Tank (M; kg/l)	200	200	200	200
Distance away from tile field (x; m)	15	15	15	15
Duration of simulation (t; d)	1200	1200	1200	1200
Family size (F; cap)	4	4	2	6
Water Use per Capita (Q_c; l/d/cap)	170	187	153	187
Product use per capita (U_c; gm/d/cap)	22.3	22.3	20.1	24.5
Percent Ingredient in product (r)	4.8	4.8	4.8	4.8

Although all model parameters can be used through default values, it is assumed that a user may wish to alter these values and create new model scenarios. In such cases, it is possible (using the **Save Input** option) to save all input parameters to a file. The file extension on all SepTTS input data is SIF. For example, file name "RUN1" would be renamed to "RUN1.SIF"

The complementary function to **Save Input** is **Load Input**. The **Load Input** button is not activated unless the "User Define" option is selected from the combo box next to the button.

GLOSSARY AND CROSS REFERENCE OF MODEL PARAMETERS

Section	Parameter	Description	Location in Interface:	Derived From:
Household	C_{in}	Effluent conc. from house to septic tank (mg/l)		r, U_c, Q_c
	Q	Flow from house to septic tank (m³/d)		Q_c, F
	F	Family size (cap)	Worksheet	
	U_c	Product use per capita (gm/d-cap)	Worksheet	
	Q_c	Wastewater flow per capita (l/d-cap)	Worksheet	
	r	Percent ingredient in product	Worksheet	
Septic Tank	C	Septic tank effluent concentration (mg/l)		$C_{in}, k_{b1}, f_d, \tau, k_s, f_p$
	k_{b1}	Biodegradation rate constant (1/d)	Compound	
	f_d, f_p	Fraction of dissolved & particulate adsorbed chemical		K_{d1}, M
	τ	Hydraulic retention time (d)		V, Q
	k_s	Settling rate (1/d)		V_s, H
	K_{d1}	Distribution coefficient to suspended solids in septic tank (l/kg)	Compound	
	M	Suspended solids in septic tank (kg/l)	Compound	
	V	Volume of septic tank (m³)	Hydraulic	
	V_s	Settling coefficient (m/d)	Compound	
	H	Septic tank depth (m)	Hydraulic	

Section	Parameter	Description	Location in Interface:	Derived From:
Unsaturated	$C(z)$	Concentration of chemical at depth z from tile field (mg/l)		C, λ, z
	z	Depth from tile field (m)	Hydraulic	
	λ	Loss or removal rate (1/m)		R, k_{b2}, u_z
	R	Retardation factor		$\rho_b, K_{d2}, \phi, S_w$
	k_{b2}	Biodegradation rate constant in unsaturated zone (1/d)	Compound	
	u_z	Water velocity in downward direction (m/d)		Q, A, ϕ, S_w
	ρ_b	Sediment bulk density (kg/l)	Hydraulic	
	K_{d2}	Distribution coefficient (l/kg)	Compound	
	ϕ	Effective porosity	Hydraulic	
	S_w	Relative saturation	Hydraulic	
	A_t	Area of the tile field (m^2)	Hydraulic	

Section	Parameter	Description	Location in Interface:	Derived From:
Saturated	C (saturated)	Chemical conc. in the saturated zone (ug/l)		v, u, R, E, k_{b3}, x, t
	R	Retardation factor for saturated zone		ρ_b, K_{d3}, n
	v	Water velocity (m/d)		V_H, G_H, n
	u	Effective velocity of compound (m/d)		v, k_{b3}, E
	D	Dispersion coefficient (m^2/d)	Hydraulic	
	k_{b3}	Biodegradation rate constant (1/d)	Compound	
	ρ_b	Sediment bulk density (kg/l)	Hydraulic	
	K_{d3}	Distribution coefficient (l/kg)	Compound	
	n	Effective porosity	Hydraulic	
	V_H	Hydraulic conductivity (m/d)	Hydraulic	
	G_H	Hydraulic gradient (m/m)	Hydraulic	
	x	Distance from tile field (m)	Plotting	
	t	Time (d)	Plotting	

REFERENCES

The primary reference for this model is:

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Secondary sources that are referred to in the model's help screens:

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