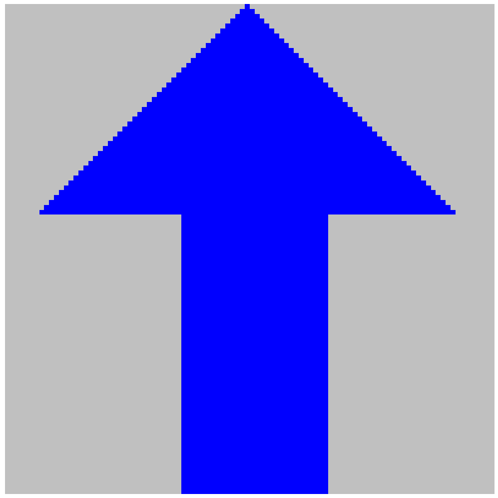

UPFLOW

water movement in a soil profile from a shallow water table to the topsoil (capillary rise)

Reference Manual
Version 3.2

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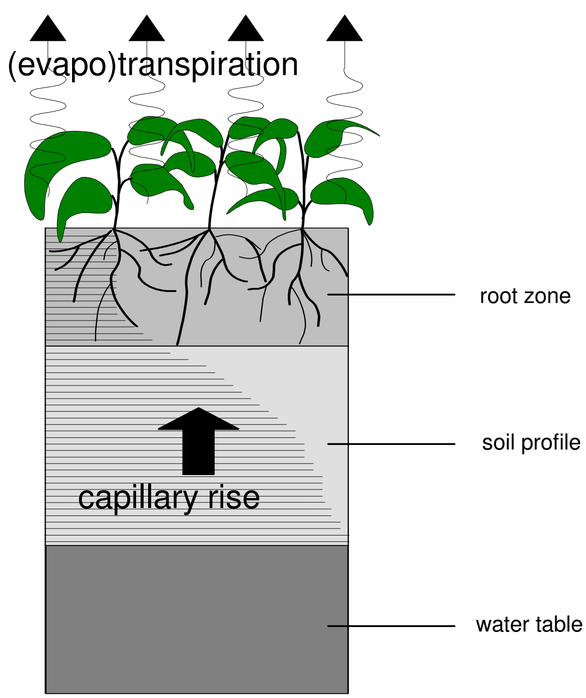


1. UPFLOW – software program

UPFLOW (Raes et al., 2003) estimates the amount of water that will move in a soil profile from a shallow water table to the topsoil for the specified environmental conditions. A steady state condition is assumed, whereby the calculated flux is in equilibrium with the evaporative demand and the soil water conditions in the top soil.

UPFLOW is a software tool developed to estimate the expected upward flow from a shallow water table and to evaluate the effects of environmental conditions on the upward flow. The hierarchical structure of the Menus is given in Figure 1.

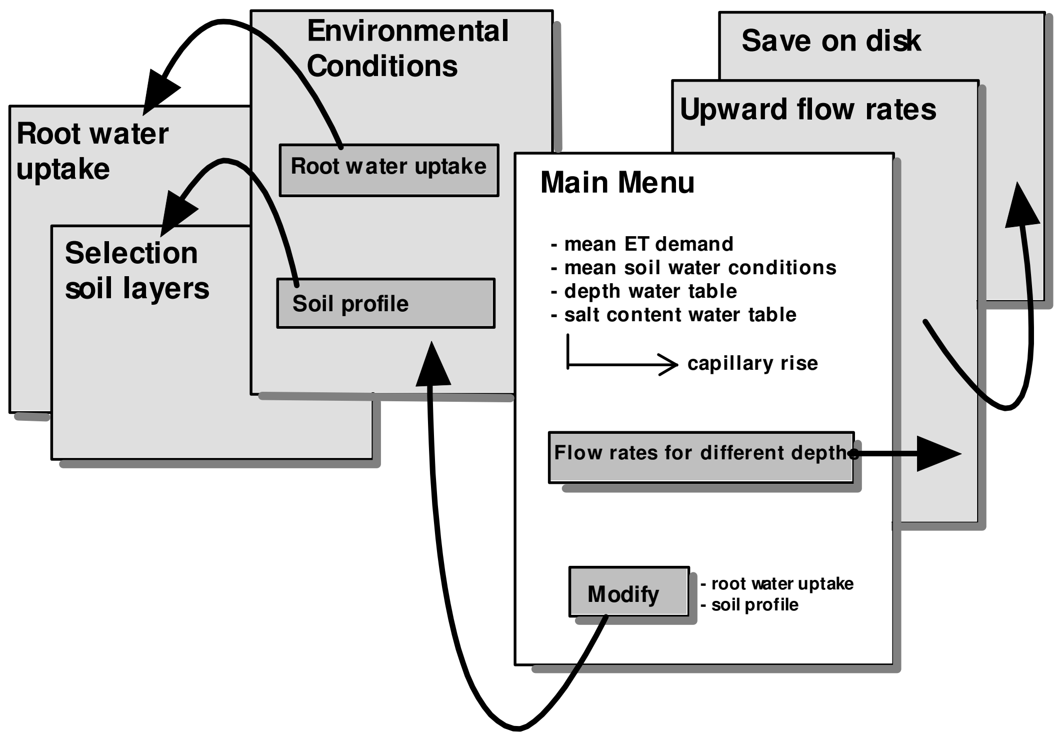


Figure 1.
Hierarchical structure of the Menus

2. Input

The environmental conditions (Fig. 2), specific for a certain period, are given by:

1. the average evaporative demand [mm/day] from the atmosphere during the period under consideration. Since a steady state condition is assumed, the upward flow from the water table to the top soil can never be larger than the evaporative demand;
2. the average soil water content [volume %] that is maintained in the topsoil during that period. If the top soil is too wet, water cannot flow upwards;
3. the depth [m] of the water table below the soil surface. If the water table is too deep, water cannot be transported upwards;
4. water extraction characteristics of the plant roots;
5. the soil profile (thickness and characteristics of successive soil layers);
6. the salt content [dS/m] of the water table.

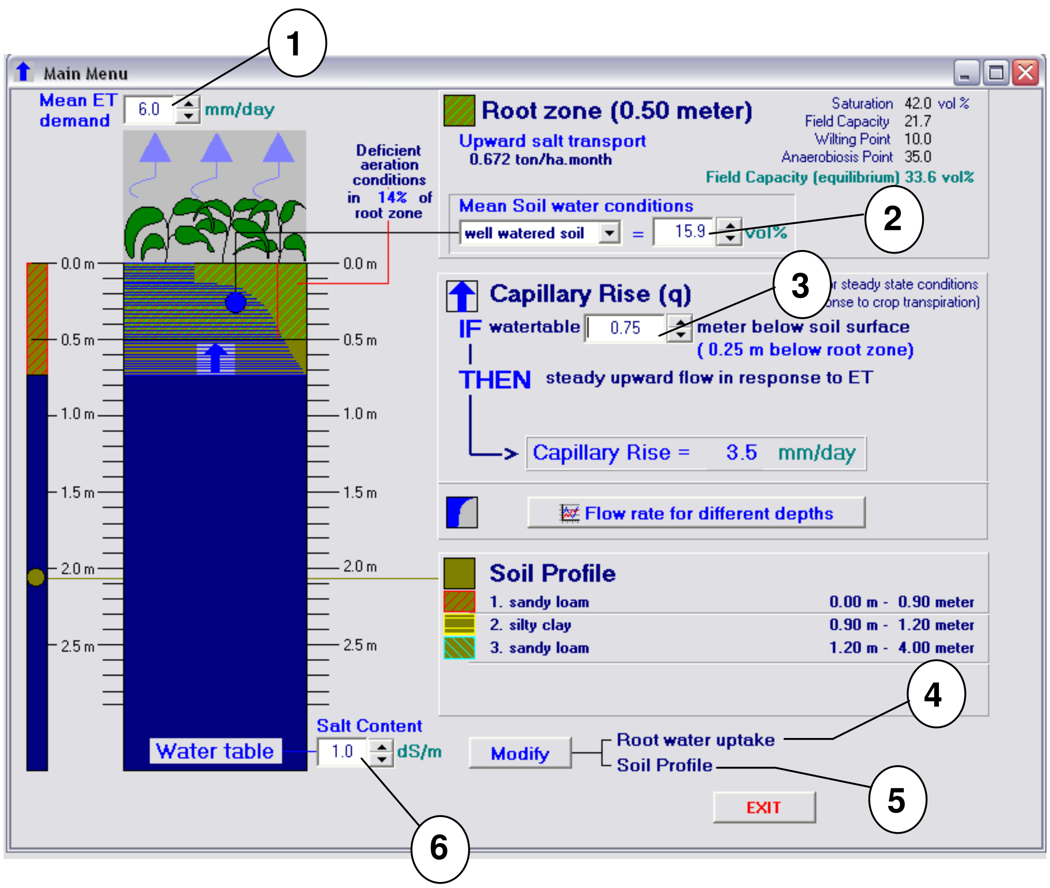


Figure 2.
Input fields in Main menu of UPFLOW

3. Output

For the given environmental conditions, UPFLOW displays:

- **For the specified depth of the water table (Fig. 3)**

1. the expected steady upward flow [mm/day] from the water table to the topsoil in equilibrium with the evaporative demand;
2. the soil water content [vol%] in the top soil when no water flow occurs. This is referred to as field capacity in equilibrium with the water table;
3. the amount of salt transported upward during the given period [ton/ha.month], when the water table contains salts;
4. the degree of water logging [%] in the root zone (if any). Water logging will reduce crop transpiration and might as such limit the capillary rise since steady state conditions are assumed;
5. a graphical display of the soil water profile above the water table;

- **For various depths of the water table (Fig. 4 and 5)**

6. the upward flow rate for different depths of the water table. By altering the average evaporative demand and soil water content in the top soil (Fig. 4, fields 1 and 2), the effect of those environmental conditions can be assessed. With the 'Save on disk' command (Fig. 4, field 3), the results can be saved (Fig. 5).

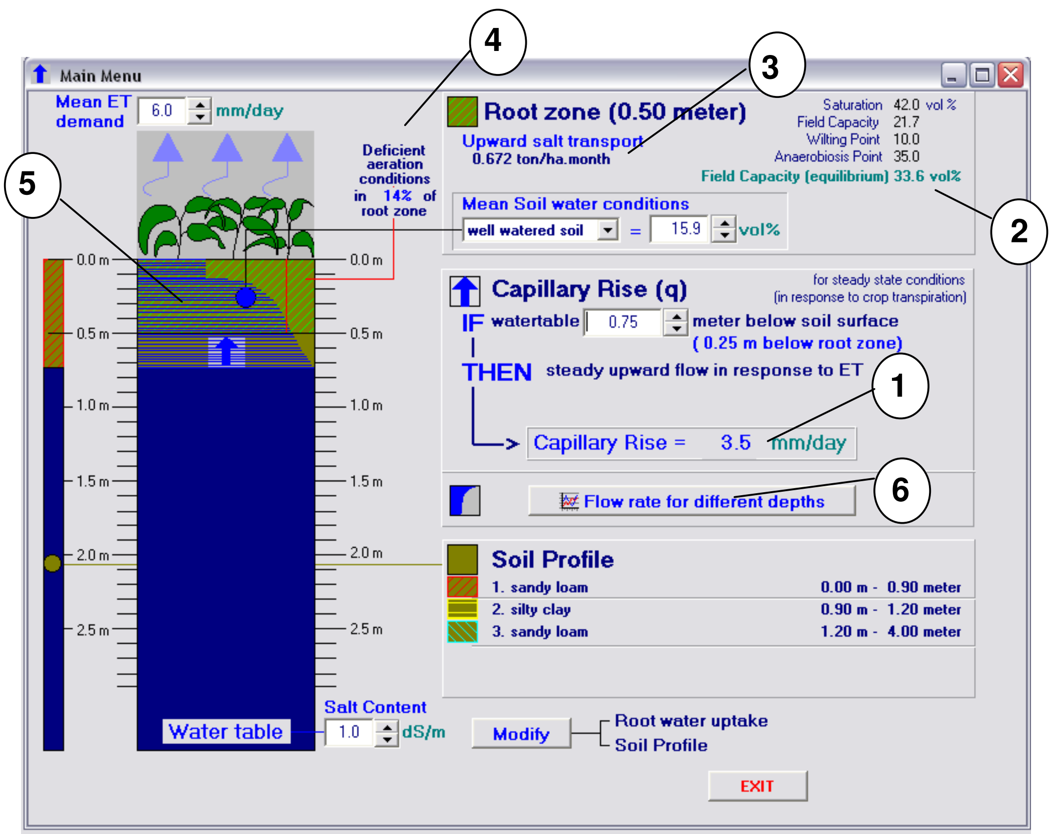
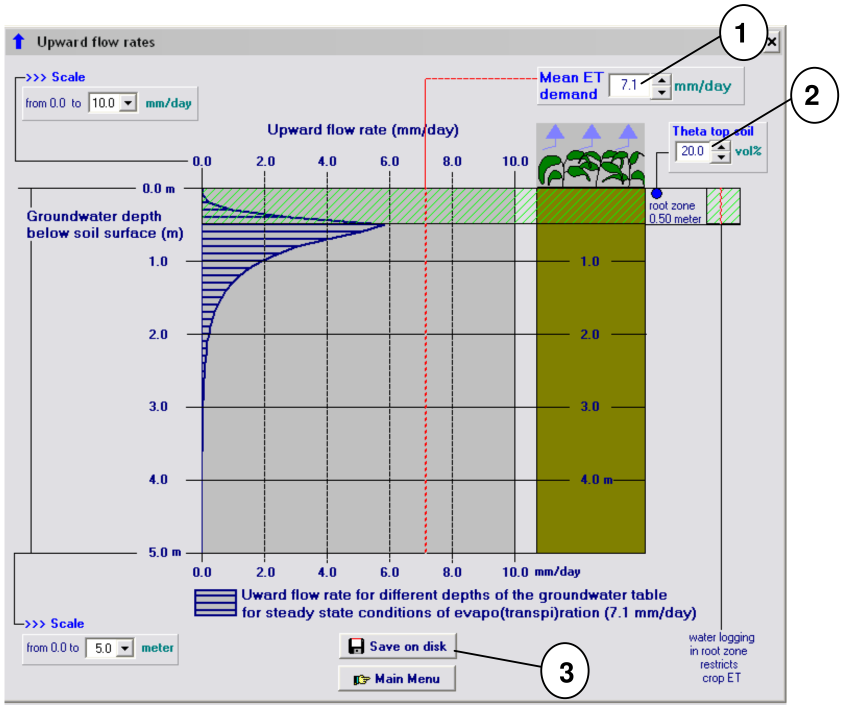


Figure 3.
Output fields in Main menu of UPFLOW

(a) cropped soil



(b) bare soil

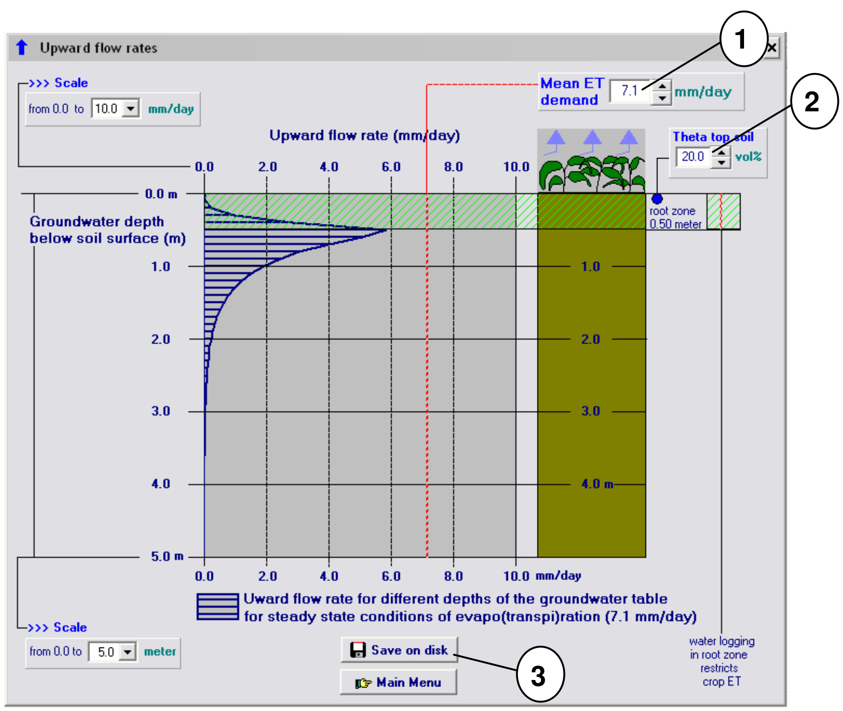


Figure 4.
The upward flow rate for different depths of the water table for (a) a cropped soil and (b) a bare soil

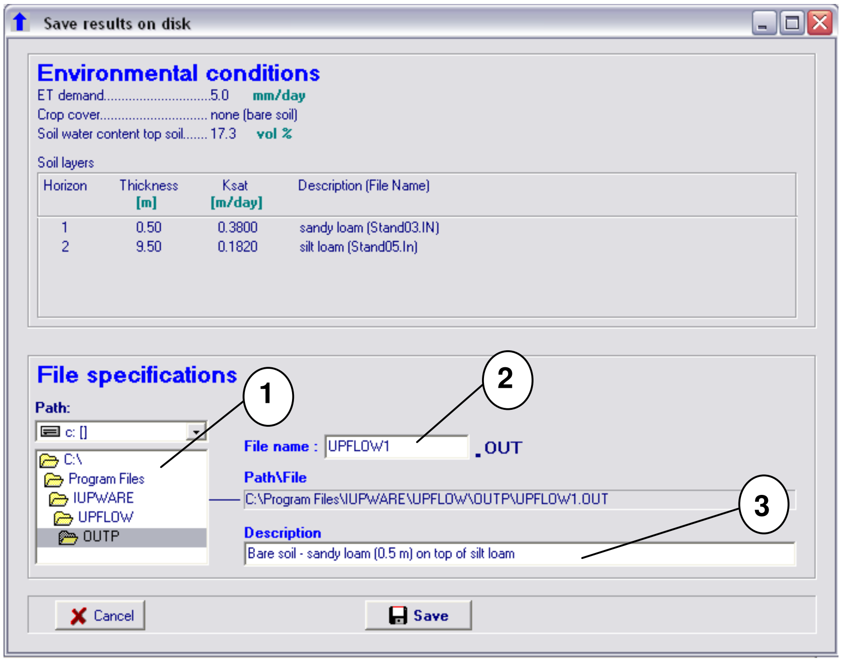


Figure 5.
Specifying the Path (1), File Name (2) and Description (3) for the output file

The results are saved in a text file (with extension 'OUT') in the folder specified (Field 1, Fig. 5). The default path is the OUTP subdirectory of the directory where UPFLOW is installed, but an other directory can be selected as well.

Before saving the results, the user can alter the default file name (Field 2, Fig. 5), and add a description (Field 3, Fig. 5). Next to the table containing the upward flow rates for different depths of the groundwater table, a description of the environmental conditions is specified in the output file. An example of an output file is given in Appendix 3.

4. Water extraction by plant roots

UPFLOW calculates the amount of water that will move upward from the water table to that point in the root zone where it is completely extracted by plant roots. The calculation procedure estimates the zone where the water is extracted by considering the root extraction rate. If the soil is not cultivated, the water will be transported to the soil surface where it evaporates.

The amount of water that plant roots can extract from a given soil volume is given by the root extraction rate Smax (Feddes et al., 1978). Because of the proliferation of roots in the upper root zone, Smax is usually much larger in the top than in the bottom of the root zone. A compilation of literature data for cereals, grass and deciduous trees (Diels, 1994; Hubrechts et al. 1997; Van de Moortel et al., 1998) indicates that the relation between Smax and soil depth is exponential. Smax might be as large as 0.030 to 0.040 m^3(water) per m^3(soil) per day at the top, about 0.010 $m^3.m^{-3}.day^{-1}$ in the middle of the root zone, and as small as 0.002 to 0.001 $m^3.m^{-3}.day^{-1}$ at the bottom of the root zone. This corresponds with a water uptake of 3 to 4 mm/day per 0.1 m soil depth at the top, 1 mm/day per 0.1 m in the middle and 0.2 to 0.1 mm/day per 0.1 m at the bottom of the root zone.

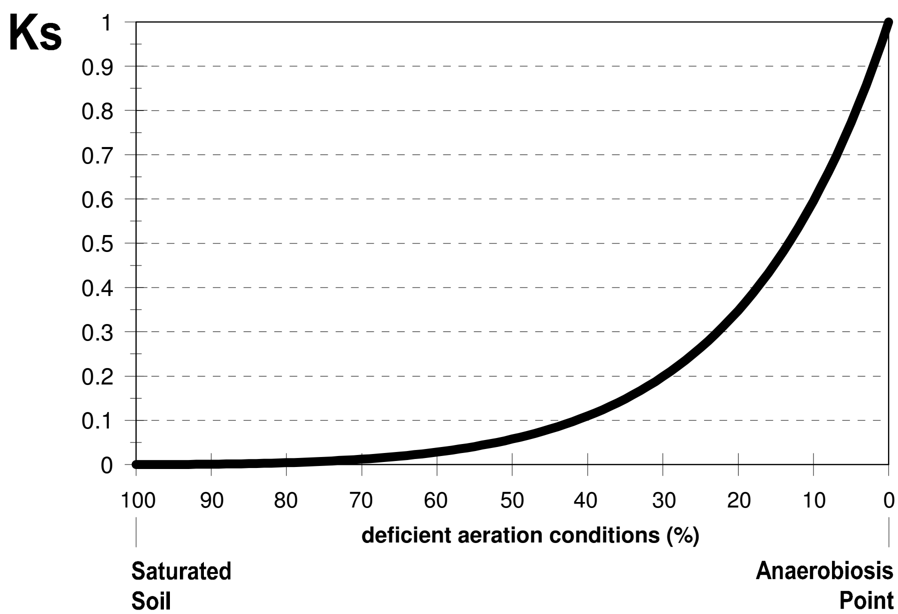


Figure 6.
Variation of the water stress coefficient Ks
for various deficient aeration conditions in the root zone

When the root zone is waterlogged, the water uptake is hampered. This is simulated in UPFLOW by multiplying Smax with a water stress coefficient (Ks) that is smaller than or equal to one. Once the aeration conditions in the root zone are deficient, Ks decreases exponentially from one to zero (Fig. 6). The anaerobiosis point at which deficient aeration conditions exist is crop specific. Most crops require well-aerated conditions in the root zone and are rather sensitive to reduced soil aeration. From calculations on the necessary transport of oxygen towards the roots of normal growing plants, researchers (see Feddes et al., 1978) derived that a gas filled porosity of about 0.05 to 0.10 $m^3.m^{-3}$ is required. In good structured soils the soil water content at the anaerobiosis point will be about 5 vol% or less below the soil water content at saturation (θsat). In poorly structured soils, the soil water content at the anaerobiosis point might be 10 vol% lower than θsat.

The user alters the water extraction rate of the plant roots in the 'Root water uptake' Menu (Fig. 7) by modifying:

1. the values for the root water uptake under optimal soil water conditions (Smax) at the top, middle and bottom of the root zone,
2. the soil water content at which the aeration conditions in the root zone becomes deficient (anaerobiosis point).

Indicative values for Smax and the anaerobiosis point for a number of various crop types are available in UPFLOW. To use those values, select the particular crop type in the 'Environmental Conditions' Menu. The user can adjust the indicative values at run time or import values for different crop types (see Appendix 1).

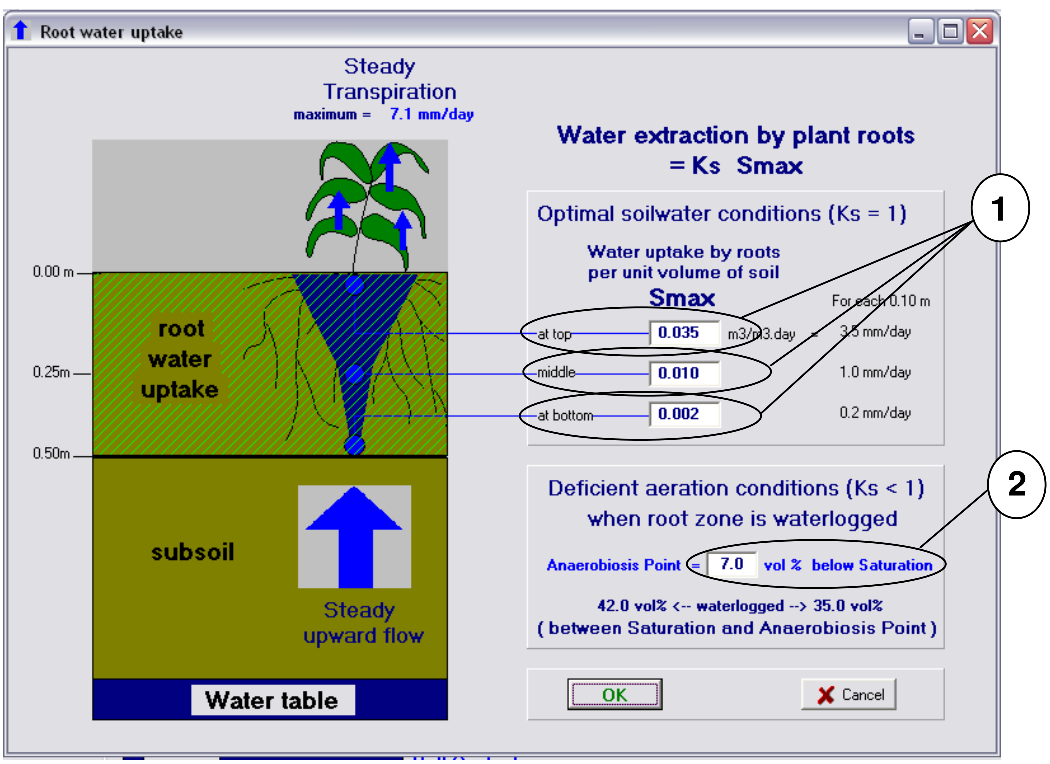


Figure 7.
Input fields for water extraction rate of plant roots in UPFLOW

5. Environmental conditions

Besides the depth of the water table, the upward flow in a given soil profile is determined by the evapotranspiration demand of the atmosphere and the soil water content in the topsoil. Since a steady state condition is assumed the evapotranspiration demand and soil water content refers to average values during a particular period.

▪ Evapotranspiration demand

Since the water flow inside the soil profile is assumed to be steady, the capillary rise from the water table to the topsoil can never exceeds the evapotranspiration demand (ET) of the atmosphere. UPFLOW calculates the upward flow that responds to the specified average ET demand for the given period (Fig. 2, field 1). Procedures to estimate mean soil evaporation or crop evapotranspiration for a given period from climatic, soil and crop parameters are given by Allen et al. (1998).

▪ Soil water content in the topsoil

To move water upward a potential gradient is required in the soil profile. As such the matric potential in the topsoil should be lower than its value at the water table. A deep water table requires a huge potential gradient and hence a very dry topsoil to move water upward. Given the soil water content in the top soil (Fig. 2, field 2), UPFLOW selects the maximum flux that can be transported upward by keeping the soil water content larger then or equal to the given value.

The specified soil water content, is the mean soil water content that is expected in the topsoil under the climatic conditions (rainfall and ET) and the applied irrigation schedule (dose and interval) for a particular period. During periods where rainfall is excessive, the soil water content in the topsoil will be at or above field capacity and no water can move upward. During periods where rainfall and irrigation are largely insufficient to cover the evapotranspiration demand of the atmosphere, the mean soil water content in the topsoil will be close to wilting point. Under irrigation conditions the average soil water content in the root zone will be between field capacity and wilting point. Frequent irrigations will result in a relative wet root zone with a mean soil water content close to field capacity, while infrequent irrigations will result in a drier root zone where the mean soil water content is closer to wilting point.

▪ Salt content of the water table

In irrigated agriculture, many salinity problems are associated with or strongly influenced by a shallow water table (Ayers and Westcot, 1985). The amount of salts that will accumulate in the topsoil depends on the quality and quantity of the water that move upward. Given the salt content of the water table (Fig. 2, field 6) UPFLOW calculates for the given environmental conditions, the amount of salts that will accumulate in the topsoil in one month. When the build-up of salts in the root zone is important and no leaching by rainfall or excess irrigation water is applied, the salt concentration might affect crop yield (De Nys et al. 2005; Geerts et al., 2008).

The water salinity is expressed by its Electrical Conductivity (EC) which is expressed in deciSiemen per meter (One dS/m is equivalent to one mmho/cm). Classification of water in terms of total salt concentration is given in Table 1.

Table 1. Classification of saline water (Source: Rhoades et al., 1992)

Water class	Electrical Conductivity	Salt Concentration	Type of water
	dS/m	g/l	
Non-saline	< 0.7	< 0.5	Drinking and irrigation water
Slightly saline	0.7 – 2	0.5 – 1.5	Irrigation water
Moderately saline	2 – 10	1.5 – 7.0	Primary drainage water
Highly saline	10 – 25	7.0 – 15.0	Secondary drainage water
Very highly saline	25 – 45	15.0 – 35.0	Very saline groundwater
Brine	> 45	> 35.0	Seawater

6. Characteristics of the soil profile

▪ Soil profile

The soil is seldom uniform in depth and often several soil layers with distinct physical and chemical soil properties can be distinguished in the soil profile. The amount of water that can be transferred from the shallow water table to the topsoil depends largely on the physical properties of the individual layers and on the vertical successions of the horizons within the soil profile.

If the soil profile is not homogeneous, the user specifies for each soil layer, its thickness in the 'Environmental Conditions' Menu, selects a representative soil water retention curve from a list and specifies a value for the saturated hydraulic conductivity in the 'Soil layer selection' Menu (Fig. 1). Up to 5 distinct soil layers can be considered in the soil profile. The root zone, to which the water flows, is considered homogeneous and cannot be divided into soil layers.

▪ Soil water retention curve

A soil water retention curve (Fig. 7) describes the relationship between the soil water content (θ) and the corresponding soil matrix potential (h). UPFLOW contains two sets of 12 soil water retention curves. Each curve describers the θ-h relationship for one of the twelve different soil texture classes. In one set (Parameters), the curves are characterised by the Van Genuchten parameters while in the other set (Curves) each soil water retention cure is described by θ-h values for various soil water contents. Although, the two sets of 12 soil water retention curves embedded in the program are considered as representative and believed to give a good picture of the general trend that can be expected for the given textural class, the user can import other curves in the program (see Appendix 2).

Set 1: Van Genuchten Parameters

Van Genuchten (1991) describes the relationship between soil water content (θ) and the corresponding soil matrix potential (h) by means of the following equation:

$$\theta(h) = \theta_r + (\theta_s - \theta_r)\frac{1}{\left[1+\left|\alpha\, h^n\right|\right]^m} \qquad \text{(Eq. 1)}$$

where 2_r and 2_s are the residual and saturated soil water content [$m^3.m^{-3}$], h the soil matric potential [m], α an empirical parameter [m^{-1}] whose inverse is often referred to as the air entry value or bubbling pressure, n and m empirical parameters affecting the shape of the retention curve. The default set of θ-h relations contain the class average values of the Van Genuchten water retention parameters (Tab. 2) presented by Schaap et al. (1999).

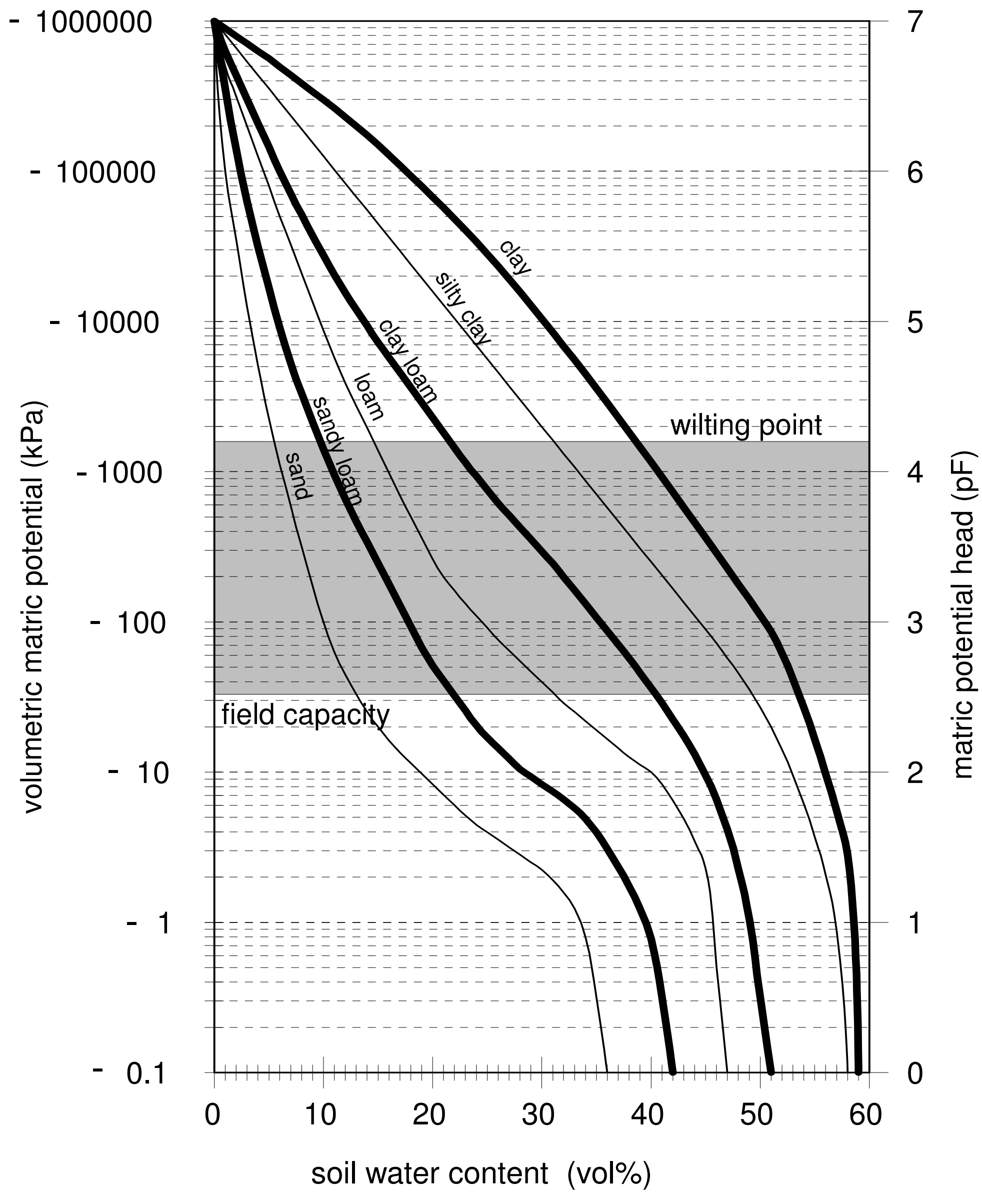


Figure 8.
Soil water retention curves for various soil types

Table 2. Class average values of the Van Genuchten water retention parameters (Schaap et al. 1999).

Textural class	θ_r	θ_s	α	n
	$cm^3.cm^{-3}$	$cm^3.cm^{-3}$	cm^{-1}	-
Sand	0.053	0.375	0.035	3.18
Loamy sand	0.049	0.391	0.032	1.76
Sandy loam	0.039	0.388	0.026	1.45
Loam	0.062	0.400	0.0098	1.48
Silt loam	0.065	0.439	0.0049	1.67
Silt	0.050	0.489	0.0066	1.68
Sandy clay loam	0.065	0.384	0.017	1.34
Clay loam	0.083	0.444	0.012	1.44
Silty clay loam	0.090	0.484	0.0076	1.53
Sandy clay	0.128	0.380	0.025	1.22
Silty clay	0.115	0.476	0.014	1.33
Clay	0.100	0.457	0.011	1.27

Set2: θ-h values for various soil water contents

The set of θ-h relationships were constructed by considering indicative values for the relative proportion of sand, silt and clay and for organic matter (Tab. 3) for each of the 12 different soil textural classes. For each soil texture class, the soil water content at saturation, field capacity (matric potential –33 kPa or pF 2.5) and wilting point (matric potential –1.5 MPa or pF 4.2) were estimated by means of procedures given by Rawls et al. (1982) and Saxton et al. (1986). Subsequently, smooth lines were plotted true the points. In Fig. 8, some of the 12 water retention curves are plotted.

Table 3. Indicative values for soil water content at Saturation (θ_{Sat}), Field Capacity (θ_{FC}) and Wilting Point (θ_{WP}) derived from soil texture and organic matter (OM).

Textural class	%sand	%clay	%OM	θ_{Sat}	θ_{FC}	θ_{WP}
	mass%	mass%	Mass%	$m^3.m^{-3}$	$m^3.m^{-3}$	$m^3.m^{-3}$
Sand	90	5	0.8	0.36	0.13	0.06
Loamy sand	82	7.5	1	0.38	0.16	0.08
Sandy loam	65	10	1.5	0.41	0.22	0.10
Loam	40	18	2	0.46	0.31	0.15
Silt loam	21	14	2	0.46	0.33	0.13
Silt	8	6	2	0.43	0.33	0.09
Sandy clay loam	60	27.5	2.3	0.47	0.32	0.20
Clay loam	33	34	2.3	0.50	0.39	0.23
Silty clay loam	10	34	2.3	0.52	0.44	0.23
Sandy clay	52	42	2.4	0.50	0.39	0.27
Silty clay	8	50	2.5	0.54	0.50	0.32
Clay	18	65	2.6	0.55	0.54	0.39

▪ Relation between hydraulic conductivity and soil matric potential

The hydraulic conductivity expresses the property of the soil to conduct water through the soil. When the soil is saturated all pores are filled with water and the value for the hydraulic conductivity is at its maximum (Ksat). Since in an unsaturated soil the water flow is restricted to the water filled portion of the pore volume, the hydraulic conductivity will be smaller than Ksat. Since the large, more highly conductive pores, are drained first, the hydraulic conductivity in unsaturated soil decreases very sharp as a soil desaturates (Fig. 9).

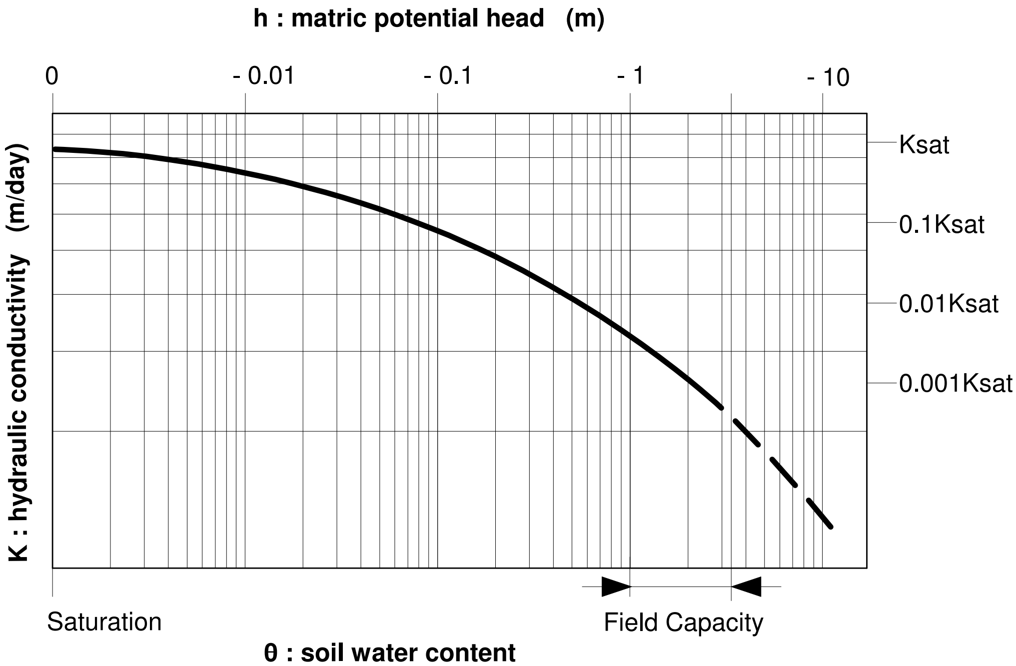


Figure 9.
Hydraulic conductivity as a function of matric potential and soil water content (log-log scale).

The functional relation between the hydraulic conductivity (K) and soil matric potential (h) required to perform the integration in Eq. 2 (see 7. Calculation procedures) is derived at run time once the user has specified the value for the saturated hydraulic conductivity (Ksat). The K-h relation is given by Mualem's model (Mualem, 1976; Van Genuchten et al. 1991) if Set 1 (Parameters) is used for the θ-h relationship or obtained from the water retention curve by the method described by Kunze et al. (1968) and Jackson (1972) if Set 2 (Curves) are used. In order to perform the calculations, values for the saturated hydraulic conductivity are required.

Unfortunately, typical Ksat values for the various soil textural classes do not exist. Even for a very specific soil, it is not uncommon to measure rather important variations for Ksat in space and time as a result of variations in soil structure, bulk density, biological activity and soil management. Since equations that predict hydraulic conductivity from readily available soil parameters (Ahuja et al., 1989; Williams et al., 1993; Suleiman and Ritchie, 2001) do not consider all relevant parameters the equations can only give an order of magnitude. Therefore, UPFLOW offers the possibility to the user to adjust the displayed Ksat value at run time, before the K-h relation is derived. If Ksat is larger than the listed values, more water can be transported upwards. If Ksat is smaller, the capillary rise will be less important. Indicative values for Ksat are presented in Table 4.

Table 4. Indicative values for the saturated hydraulic conductivity (Ksat)

Textural class	**Saturated hydraulic conductivity**
	mm/day
Sandy soils (sand, loamy sand)	500 – 2,000
Loamy soils	
- sand loam	200 – 1,000
- loam, silt loam, silt	100 – 750
- sandy clay loam, clay loam, silty clay loam	5 – 150
Clayey soils (sandy clay, silty clay, clay)	1 – 50

7. Calculation procedures

▪ Steady upward flow

The steady upward flow from a shallow water table to the topsoil is estimated by means of a calculation procedure presented by De Laat (1980; 1995). By assuming a constant flux from a shallow water table to the top soil, De Laat rewrote and integrated the Darcy equation as

$$z = -\int_0^h \frac{K(h)}{q + K(h)} dh \qquad \text{(Eq. 2)}$$

where z [m] is the vertical co-ordinate, q the constant upward flux [$m^3.m^{-2}.day^{-1}$] of water, h the soil matric potential per unit weight of water (head) [m], and K(h) the hydraulic conductivity [$m.day^{-1}$]. The reference level is chosen at the stationary phreatic surface at which level z and h are zero. The vertical co-ordinate and the flux are both taken positive upward. If the functional relation between K and h is known, the soil matric potential at specific points above the water table can be calculated for particular steady upward flows by means of Eq. 2. The obtained relation between the height above the water table (z) and the matric head (h) is called a pressure profile. Given the relation between the soil water content (θ) and the matric head (soil water characteristics curve) the pressure profiles are easily transformed in moisture profiles.

Given the K-h and θ-h relation for the various soil layers of the profile above the water table, UPFLOW calculates for various fluxes the corresponding pressure and soil moisture profiles. Moisture profiles whereby the soil water content in the topsoil drops below the specified mean water content are rejected. To guarantee a steady state condition, the amount of water that is transported upward will have to be removed with the same rate from the topsoil by evapotranspiration. As such the upward flow can never exceeds the specified average evapotranspiration demand. Given the above restrictions, the maximum upward flow that can be expected under the specified environmental conditions is obtained and displayed (Fig. 3, field 1), and the corresponding moisture profile is plotted (Fig. 3, field 5).

▪ Field capacity at equilibrium

For the specified depth of the water table, UPFLOW displays also the soil water content that can be expected in the topsoil when the water content in the specified soil profile is in equilibrium with the water table (Fig. 3, field 2). This so-called 'field capacity at equilibrium' is calculated by means of Eq. 2 by assuming a very small value for q (0.1 mm/day). Water can only move upward if the topsoil is drier than the calculated field capacity at equilibrium. If it is wetter, water will drain from the topsoil to the subsoil.

▪ Water logging in the root zone

The closer the water table is to the soil surface, the more the root zone becomes waterlogged. The degree of water logging (Fig. 3, field 4) is derived from the calculated mois

.ture profile. If at a particular area in the root zone the soil water content is above the anaerobiosis point, the soil is assumed to be waterlogged in that area. Water logging will result in deficient aeration conditions and will hamper root water uptake. If all over the root zone the soil water content is above the anaerobiosis point, the root zone is fully waterlogged and the transpiration rate becomes zero. Since steady state conditions are assumed, water logging of the root zone reduces capillary rise, and inhibits any upward flow when the root zone is fully waterlogged.

▪ Salt transport

If the salt content of the water table is known, Eq. 2 can also be used to predict the amount of salts that move upward by means of capillary rise (Fig. 3, field 3).The salts dissolved in the soil solution will accumulate in the root zone as more and more water is removed by evapotranspiration. In the calculation procedure, the assumption is made that 1 dS/m is equal to 640 mg/litre (Abrol et al., 1988; ASCE, 1996).

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Appendix 1.
Import of root water extraction parameters

In UPFLOW, plant root water extraction is described by root extraction rates (Smax) at the top, middle and bottom of the root zone. When the root zone is waterlogged, the water uptake is hampered. This is simulated in UPFLOW by multiplying Smax with a water stress coefficient (Ks) that is smaller than one once the aeration conditions in the root zone are deficient (Fig. 5). The anaerobiosis point at which deficient aeration conditions exist, the Smax values and the rooting depth are crop specific. The values can be adjusted by the user in the 'Root Water Uptake' Menu (Fig. 6). The user can also select standard values for rooting depth, Smax and the anaerobiosis point, or indicative values for some specific crops in the 'Environmental Conditions' Menu.

Indicative values for rooting depth, Smax and the anaerobiosis point are loaded at the start of each session from the 'Root.UP' file. As long as the user does not delete or rename the file and respect its structure, she/he can add values for other crops or update the specified values for existing crop types. The three top lines of the file (Tab. A1) gives information concerning the parameters that need to be specified. On the next lines the parameters are given for various crop types. The parameters that need to be specified are:

- rooting depth [m],
- Smax at the top of the root zone [$m^3.m^{-3}.day^{-1}$],
- Smax in the middle of the root zone [$m^3.m^{-3}.day^{-1}$],
- Smax at the bottom of the root zone [$m^3.m^{-3}.day^{-1}$],
- the soil water content below saturation when aeration conditions in the root zone becomes deficient [vol%],
- an asterisk (∗) followed by a string of characters describing the crop type (the asterisk indicates the beginning of the string).

Table A1. Example of 'Root.UP' file

```
Rooting    ---Smax [m3/m3.day]--  Aero  Type
Depth [m]  Top    Middle  Bottom [vol%] (characters)
X=========X=========X=========X=========X================================
0.50       0.035   0.010   0.002   7.0  *Crop cover (Default parameters)
0.00       0.000   0.000   0.000  00.0  *Bare soil (no crop cover)
2.20       0.008   0.003   0.001   5.0  *Deciduous Trees
1.20       0.020   0.005   0.001   5.0  *Cereals
0.50       0.040   0.020   0.010   5.0  *Grassland (Pasture)
```

Appendix 2.
Import of soil water retention curve

When describing a soil profile in UPFLOW, the user specifies for each soil layer its thickness, selects a soil water retention curve from a list and specifies the saturated hydraulic conductivity (Ksat). Before displaying the list of available soil water retention curves in the 'Soil layer selection' Menu, UPFLOW collects at run-time the files of soil water retention curves from its directory. Each soil water retention curve is a (ASCII) file with extension 'PAR' (Set1) or 'IN' (Set2). The user can add (use for example NOTEPAD), update and delete files as long as the user respects the structure and extension of the files. The files 'Stand03.PAR' and 'Stand03.IN' which are the default files MAY NOT be deleted.

Set 1: Van Genuchten Parameters

As an example a soil water retention curve file (file Stand03.PAR) is listed in Table A2.1. On the first line, the description of the soil layer is specified (maximum length is 40 characters). This description will be displayed at runtime and can be altered for the session. On the second line the saturated hydraulic conductivity (Ksat in m/day) is specified. This value will also be displayed at runtime as an indicative value and can be adjusted for the session. On the next lines, the parameters for the Van Genuchten Equation (Eq. 1) are specified. The empirical factor m is calculated by assuming that m = 1 – 1/n.

Table A2.1. Description and example of 'Stand03.PAR' file

1^{st} line : description of soil layer	sandy loam (Param)
2^{nd} line: Sat. hydraulic conductivity [m/day]	0.2234
3^{rd} line: Residual water content θ_r [$m^3.m^{-3}$]	0.0340
4^{th} line: Saturated water content θ_s [$m^3.m^{-3}$]	0.3640
5^{th} line: α, empirical parameter [cm^{-1}]	0.0192
6^{th} line: n, empirical parameter [-]	1.3394

Set2: θ-h values for various soil water contents

As an example a soil water retention curve file (file Stand03.IN) is listed in Table A2.2. On the first line, the description of the soil layer is specified (maximum length is 40 characters). This description will be displayed at runtime and can be altered for the session. On the second line the saturated hydraulic conductivity (Ksat in m/day) is specified. This value will also be displayed at runtime as an indicative value and can be adjusted for the session. On the next lines, various sets (maximum 60) of values for the volumetric soil water content (θ in vol%) and the corresponding matric head (h in meter) are specified. The sets are ranked from low to high soil water contents and each line may only contain one single set of values. The first set contains the values for an oven dry soil (0 vol% and h = -100000 m (pF 7.0)). The last line contains the values for the saturation condition (θsat in vol% and h = 0.0 m).

Table A2.2.Description and example of 'Stand03.IN' file

Description	Example
1st line : description of soil layer	sandy loam
2nd line: Sat. hydraulic conductivity [m/day]	0.50
3rd line: first set (θ [vol%] ; h [m]) of oven dry soil (θ = 0 vol% ; h = - 100000 m)	0 -100000
	6 -1000
	10 -152.96
	12 -66
	20 -5
…	22 -3.16
…	25 -1.78
…	28.3 -1
…	30.4 -0.79
…	32.5 -0.63
more (total of maximum 60) sets set (θ [vol%] ; h [m])	34 -0.501
…	35 -0.398
…	36 -0.302
…	37 -0.240
…	38 -0.168
…	39 -0.126
…	40 -0.079
	40.3 -0.063
	41.05 -0.0316
Last line: last set (θ [vol%] ; h [m]) of saturated soil (θsat [vol%] ; h = 0 m) Where θsat ≤ 60 vol%	42 0

Appendix 3.
Example of Output file

UPFLOW 3.2 (June 2009) - Output created on (date) : 27/05/2009 at (time) : 12:11:20

Description : Bare soil - sandy loam (0.5 m) on top of silt loam
1. ET demand : 5.0 mm/day
2. Soil surface: bare soil (no crop cover)
3. Soil water content top soil : 17.3 vol%
4. Soil profile:
--

Horizon	Thickness (m)	Ksat (m/day)	Description (File Name)
1	0.50	0.3800	sandy loam (Stand03.IN)
2	9.50	0.1820	silt loam (Stand05.In)

--

Capillary rise from a shallow water table
==

Depth watertable (m below surface)	Capillary Rise (mm/day)
5.00	0.02
4.90	0.02
4.80	0.02
4.70	0.02
4.60	0.03
4.50	0.03
4.40	0.03
4.30	0.03
4.20	0.03
4.10	0.03
3.99	0.04
3.89	0.04
…..	…..
0.59	3.50
0.57	4.00
0.55	4.63
0.54	4.88
0.53	5.00
…..	…..