1/1

SOFTWARE RELEASE NOTICE

1. SRN Number: GHGC-SRN-185	
2. Project Title: Unsaturated and Saturated Flow under Isothermal Conditions	Project No. 20.01402.861
3. SRN Title: KINEROS2 V1.0	
4. Originator/Requestor: Randy Fedors	Date: 10/18/2001

5. Summary of Actions

- ☐ Release of new software
- ☐ Change of access software
- ☐ Release of modified software:
  - ☐ Enhancements made
  - ☐ Corrections made
- ■ Software Retirement

6. Validation Status

- ☐ Validated
- ☐ Limited Validation
- ☐ Not Validated — Explain: ______________________

7. Persons Authorized Access

Name	Read Only/Read-Write	Addition/Change/Delete

8. Element Manager Approval: English Pearcy [signature] Date: 10/23/2001

9. Remarks:

CNWRA Form TOP-6 (09/01)

SOFTWARE RELEASE NOTICE

01. SRN Number: **GHGC-SRN-185**

02. Project Title: **Unsaturated and Saturated Flow under Isothermal Conditions**

Project No.: **20-1402-861**

03. SRN Title: **KINEROS2 Version 1.0**

04. Originator/Requestor: **Randy Fedors** — Date: **1/26/99**

05. Summary of Actions

- ■ Release of new software
- ☐ Release of modified software:
  - ☐ Enhancements made
  - ☐ Corrections made
- ☐ Change of access software
- ☐ Software Retirement

06. Persons Authorized Access

Name	Read Only/Read-Write	Addition/Change/Delete
Randy Fedors	**RO**	A
Jim Winterle	**RO**	A
Amit Armstrong	**RO**	A
Debra Hughson	**RO**	A
David Farrell	**RO**	A
Gordon Wittmeyer	**RO**	A

07. Element Manager Approval: **English Pearcy** [signature] Date: 1/27/99

08. Remarks: NONE [signature] 1/28/99

CNWRA Form TOP-6 (05/98)

NOTE: KINEROS2 Version 1.0 was carried on the mastery Directory of SKE Software as "in process," but we actually had it controlled in January 1999. [signature] 6/9/99

SOFTWARE SUMMARY FORM

01. Summary Date: **1/26/99**	02. Summary prepared by (Name and phone) **Randy Fedors (210) 522-6818**		03. Summary Action: **NEW**
04. Software Date: **2/18/99**	05. Short Title: **KINEROS2**		
06. Software Title: **KINEROS2 Version 1.0**			07. Internal Software ID: **N/A**
08. Software Type: ☐ Automated Data System ■ Computer Program ☐ Subroutine/Module	09. Processing Mode: ■ Interactive ☐ Batch ☐ Combination	10. Application Area a. General: ■ Scientific/Engineering ☐ Auxiliary Analyses ☐ Total System PA ☐ Subsystem PA ☐ Other b. Specific:	
11. Submitting Organization and Address: CNWRA/SwRI 6220 Culebra Road San Antonio, TX 78228		12. Technical Contact(s) and Phone: **David Woolhiser (970) 482-7810**	
13. Software Application: **Surface water modeling of event-based precipitation over a water shed including infiltration, runoff, and soil erosion.**			
14. Computer Platform **1BM compatible**	15. Computer Operating System: **Windows 95** **Windows NT**	16. Programming Language(s): N/A	17. Number of Source Program Statements: N/A
18. Computer Memory Requirements: **4 MB**	19. Tape Drives: N/A	20. Disk Units: **10 MB**	21. Graphics: **Windows DOS emulator**
22. Other Operational Requirements: **Helvb.fon file in directory if output graphics are desired.**			
23. Software Availability: ■ Available ☐ Limited ☐ In-House ONLY		24. Documentation Availability: ■ Available ☐ Preliminary ☐ In-House ONLY	
25. Software ~~Developer~~: Randall W. Fedors		Date: 1/27/99	

Acquired Software, so R. Fedors is not the developer. BSM 1/28/99

3/47

TO: Bruce Mabrito
FROM: R. Fedors
SUBJECT: TOP-018 for KINEROS2
DATE: January 26, 1999

KINEROS2 is a widely distributed, off-the-shelf program for surface water modeling. It is a KINematic runoff and EROSion model for event-based modeling of interception, infiltration, surface runoff, and erosion from small watersheds due to precipitation. Watersheds are divided into assemblages of planes and channels for which a rain event and subsequent runoff is routed through the watershed. Water lost to evapotranspiration or infiltration (two-layer soils) are tracked in each plane and channel.

KINEROS2, version 1.0, is the current version of the KINEROS model first released by the U.S. Department of Agriculture, Agricultural Research Service (Woolhiser et al., 1990). The compiled version received from the Agricultural Research Service is dated February 18, 1998 and runs under Windows95 and WinNT (Microsoft). The improvements added in the upgrade from KINEROS to KINEROS2 are described in Smith et al. (1995) and Smith (1996). The primary improvement was the addition of the physically-based 2-layer infiltration module. Since the input file has changed significantly from the earlier version, a separate description is provided.

The installation test examples were provided by one of the authors of the code. Only the compiled, (executable) version of the code was provided, hence no modifications are possible. The program is labeled kin.exe. In the installation test, the primary input file or control file is labeled kin2.fil. This file contains control flags for the simulation and the names of the other input files: (i) the precipitation event; and (ii) the geometry information for the planes and channels. The name of the output file is also contained in the control file. The program is started by typing the name of the executable in at a DOS prompt followed by the name of the control file. Alternatively, the program may be started by clicking on the program executable in the Windows environment and typing the information requested at the prompts; this information is the same as what is in the control file (the control file is not used in the latter method). The installation was successfully completed and the results compared exactly with the output sent by D. Woolhiser, one of the authors of the code. The program, instructions, and input files are contained on disk 1. The output files are contained in diskette 2.

The following documents are provided for the TOP-018 folder:

Woolhiser, D.A., R.E. Smith, and D.C. Goodrich. 1990. KINEROS, A Kinematic Runoff and Erosion Model, U.S. Department of Agriculture, Agricultural Research Service, ARS-77, 130 pages. (cover page, abstract, and table of contents are provided).

Smith, R.E., D.C. Goodrich, D.A. Woolhiser, and C.L. Unkrich. 1995. KINEROS - A Kinematic Runoff and Erosion Model, in Computer Models of Watershed Hydrology, ed. V.P. Singh, Water Resources Publications, Highlands Ranch, CO, chapter 20, p. 697-732.

Smith, R.E. 1996. The Soil Infiltration Model in KINEROS2: Preliminary Documentation, draft copy, also as electronic file=2layinf.doc on disk.

KINEROS2 - Program Input, also as electronic file progdoc.asc on disk.

Readme.asc file with instructions for installation test runs from D.A. Woolhiser, one of the authors of the program.

Two diskettes with program, program instructions, example input files, and output files.

file: 2layinf.doc

1996

26/47

The Soil Infiltration Model in KINEROS2: preliminary documentation

R.E. Smith

Introduction

KINEROS2 contains a new soil infiltration model which allows more detailed specification of the soil profile for each hydrologic element, including specification of the characteristics of the bed for an infiltrating channel. The additional detail is not required, however, and a simple single soil layer can be specified as for KINEROS. The new formulation allows either a one or two layer soil profile, a new physically-based approximation for the redistribution of soil water, including recovery of infiltration capacity during a hiatus, and a method that more accurately determines infiltration rates following a hiatus. Only one other parameter is required for the redistribution algorithm. Further, at the user's option, the ensemble effect of normally occurring spatial variation in soil hydraulic conductivity, K_s, can be simulated by providing a value for the coefficient of variation for this parameter, CvK.

The soil infiltration model is an extension of the model used in KINEROS, which describes infiltration capacity f_c as a function of infiltrated depth I. Independent (practically) of the pattern of rainfall rate (r) prior to a given time, the infiltration capacity during rainfall is a function of the total depth which has been infiltrated at values of $r>Ks$ prior to that time. Periods when $r<K_s$ are now dealt with realistically in KINEROS2.

1 General Infiltration Properties

<u>1.1 Describing the soil profile</u>. KINEROS required 3 basic parameters to describe the infiltration properties of a soil: the field effective saturated hydraulic conductivity, K_s, the integral capillary drive G, and the porosity ϕ. To allow estimation of the soil redistribution behavior, KINEROS2 asks for one additional parameter, λ, which is called the *pore size distribution index*, so named by Brooks and Corey (1964), whose simple description of the soil hydraulic characteristics is adopted for use in this model. As indicated above, there is an optional parameter CvK, which describes the random variation in space of the hydraulic properties of the soil. For a two layer profile, the above parameters will be indexed with a 1 or 2 to indicate that they apply to the upper or lower soil layers, respectively. KINEROS2 requires 4 parameters to describe the second soil layer: the upper soil layer depth, z_1; values for K_{s2}, G_2, and ϕ_2; plus a value for λ_2 to be used in redistribution calculations. As in KINEROS there is another optional parameter that allows even more explicit characterization of a soil profile, the content of large rocks, which represent solid volume of larger than capillary size which restricts storage. A value for ROCK may be entered for each layer of a 2 layer profile.

As for KINEROS, there is an event-dependent variable: the initial relative saturation of the upper soil layer, SI. Relative saturation is a scaled value of water content, where a value of 1 is equal to a water content equal to the porosity, ϕ. Water content by volume is θ, where $\theta = \phi S$, and there is a natural upper limit to S which is less than 1 (parameter S_{max}). θ_s is used here for ϕS_{max}.

1.2. General model relationships. We define *infiltrability*, following Hillel(1971), as the limiting rate at which water can enter the soil surface. This is more often called infiltration capacity, but capacity is not a dynamic term. The general one-layer model for infiltrability, f_c, as a function of infiltrated depth, I, is (Parlange et al., 199)

$$f_c = K_s \left[1 + \frac{\alpha}{\exp(\alpha I/B) - 1} \right] \quad (1)$$

where B is $(G+h_w)(\theta_s - \theta_i)$, combining the effects of net capillary drive, G, surface water depth, h_w, and unit storage capacity, $\Delta\theta_i = (\theta_s - \theta_i)$. The parameter α represents the soil type: α is near 0 for a sand, in which case Eq. (1) approaches the Green-Ampt relation; and α is near 1 for a well-mixed loam, in which case Eq. (1) represents the Smith-Parlange infiltration equation. Most soils are best described by a value of α near 0.85, and this value is assumed in KINEROS2. While α is fixed in K2, the equation used is in principle quite general and physically-based.

There are some fundamental properties of the infiltrability relation. It is useful to observe the relation in scaled terms. For this purpose one may define (taking h_w=0)

$$f_* = \frac{f - \bar{K}_s}{\bar{K}_s} \quad (2)$$

$$I_* = \frac{I}{G\Delta\theta} \quad (3)$$

$$t_* = t\frac{\bar{K}_s}{G\Delta\theta} \quad (4)$$

It follows that rainrate r is scaled exactly as f, that is, $r_* = (r - \bar{K}_s)/\bar{K}_s$. Bars are used with K_s to indicate areal mean values. Below, we will deal with the spatial variation of this parameter. Using this scaling, Eq.(1) becomes

$$f_{c*} = \frac{\alpha}{\exp(\alpha I_*) - 1} \quad (5)$$

Figure 1 illustrates Eq. (1) in scaled coordinates. For values of I_* smaller than about 0.1, infiltration is dominated by capillary gradient in the soil, and unaffected by gravity or α, so that the indicated asymptote is the gravity-free relation $f_* = 1/I_*$. The large I or long-time asymptote ($I_* > 10$) is K_s and is also independent of the value of α.

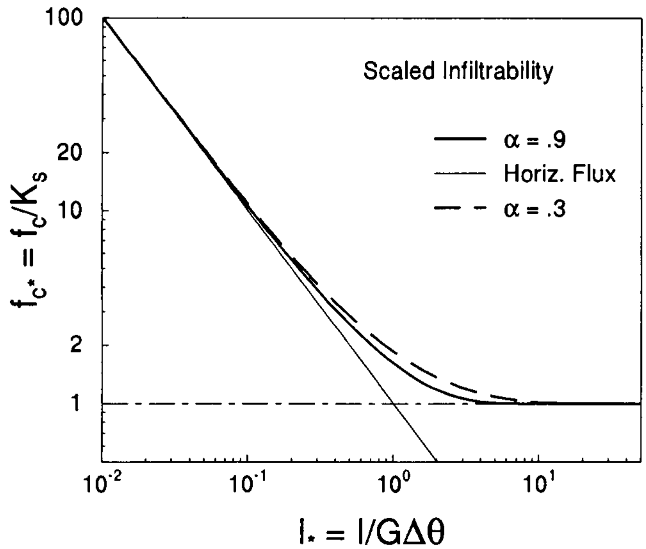


Figure 1 Scaled basic infiltration relation, Eq. (5).

The net capillary drive parameter G is defined as

$$G = G(0) = \int_{-\infty}^{0} \frac{K(h)}{K_s} dh \tag{6}$$

When G is used without a subscript, it is assumed that the upper limit in Eq. (6) is 0, as shown here. For redistribution, as presented below, the upper limit is changed for a different use of this integral parameter. In KINEROS2, for simplicity, the relation K(h) is taken from the soil characteristic relation of Brooks and Corey, which is

$$\frac{K(\psi)}{K_s} = \left(\frac{\psi_B}{\psi}\right)^{2+3\lambda} \tag{7}$$

By integrating Eq. (6) using this relation, one can determine that

$$G = \psi_B \frac{2 + 3\lambda}{1 + 3\lambda} \qquad \textbf{(8)}$$

From this, the parameter ψ_B may be obtained from an estimate of G and λ. Values of λ and G for a range of soil textures, which may provide guidelines in cases without direct measurements, are given in Table 1.

1.3 Simulating Rainfall Infiltration (uniform soil). Some initial portion of rainfall r(t) increases the infiltrated depth, I, without causing runoff, since the value of f_c for small I is very large. When I increases until r begins to exceed f_c, ponding occurs and Eq. (1) is used to predict f and the rainfall excess, r-f. Any rainfall depth I is accompanied by a wetted soil depth with a downward-moving lower 'front' at depth $z = I/\Delta\theta_i$.

2. Two-Layered Soil Profiles

A two-layer profile, with upper soil depth z_1, can have either the upper layer or the lower layer acting as the most restrictive or limiting layer. This is a function in general of the relative values of K_{s1} and K_{s2}, with the layer having the lowest value generally the most restrictive. A special case exists for short time infiltration (only under very high rainfalls and shallow surface layers) where the two soils may act identically if the products $(G_1)(K_{s1})$ and $(G_2)(K_{s2})$ are equal [Smith, 1990].

2.1 Restrictive Upper Layer. This is a common case for a *crusted* soils, where the upper layer is not only restrictive, but is relatively thin. However, a thin layer is not required by the model used here. In this case, while K_{s1} is less than K_{s2}, there always exist a rainfall intensity or pattern of intensities for which ponding and runoff will occur after the wetting front passes beyond the upper layer, as well as cases where ponding will occur prior to the wetting front filling the upper layer. We define a critical depth of rainfall just sufficient to fill the upper soil layer as I_c, where $I_c = \phi(S_{max} - SI)z_1 = (\theta_s - \theta_i)z_1$. There exists then one flux value for which ponding will occur just as $I=I_c$, and we refer to that value as r_c. For larger values of r, ponding will occur in the upper layer, and ponding can be simulated just as for a single soil profile. For smaller r, the front will move into the second layer prior to ponding.

When the wetting front enters the second layer, both the profile effective values for K_s, now referred to as $K\infty$, and effective value of G, called G_e, will change. The soil capillary head ψ is continuous across the layer interface before and after wetting. When the first layer is passed, the value of $K\infty$ is assumed to change directly to the asymptotic value. This may be found by solving the steady flow equation across the layer interface [Smith, 1990], resulting in

$$z_1 = \int_{\psi_c}^{0} \frac{K_1(\psi)d\psi}{K_2(\psi_c) - K_1(\psi)} \quad \textbf{(9)}$$

This equation is solved iteratively based on the relations $K(\psi)$, Eq. (7), for each layer, to obtain the values of both ψ_c and $K_2(\psi_c)$. Since there is a unit gradient in the second layer at steady flow, $K_2(\psi_c)$ is equal to $K\infty$.

The value of G_e is transitional, based on the depth that the wetting front has moved into the second layer. Just at the time the wetting front passes the interface, a "matching" value of G is found, called G_a, such that infiltration capacity predicted using G_a and K_s2 just matches the value r_c, defined above, which uses G_1 and K_{s1}. Conversely, at very large times, $G_e = G_2$, since the wetting front is entirely in the second soil and the effect of the upper layer on G is negligible. The value of G_e at any intermediate time is a weighted sum of the two values G_a and G_2:

$$G_e = \omega G_a + (1 - \omega) G_2 \quad \textbf{(10)}$$

where ω is a weighting function which decreases exponentially as the wetting front moves into the second soil:

$$\omega = \exp[-b*(I/I_c - 1)] \quad \textbf{(11)}$$

Coefficient b varies somewhat depending on the relative values of K_{s1} and K_{s2}. This relation and the value range of coefficient b (included in KINEROS2 code) have been established by analysis of experiments using a numerical solution to Richards' equation.

2.2 Restrictive Lower Layer. ($K_{s2} < K_{s1}$) Similar to the case for a restrictive upper layer, and also depending on relative values of soil parameters and rainfall rate, ponding can occur with the wetting front in either layer. However, unlike the previous case, the long term final infiltration rate is always K_{s2}, and unlike the previous case, parameters change rather suddenly upon the encounter of the wetting front with the second layer. G_a is G_1 when the wetting front is in the upper layer, and G_a is G_2 when in the lower layer. Further, there can be ponding caused by the lower layer for cases where the rainfall is less the K_{s1}, when ponding can not occur in the upper layer. For this case, which is called saturation runoff, the upper layer must fill with water that cannot enter the lower soil before surface ponding and runoff occur.

3. Soil Water Redistribution.

Many rainfall events consist of more than one period of runoff producing rainfall, with an intervening period during which significant drying of the soil can occur. Until recently the recoveriy of infiltrability during this period was crudely approximated or else ignored. The redistribution/reinfiltration method used in KINEROS2 is described in Smith *et al.* (1993) and Corradini *et al.* (1994). By equating the downward flux movement at the wetting front with the reduction in water content in an assumed pseudo-rectangular wetted region containing water of depth I, an equation may be written for the change in water content at the surface, θ_o:

$$\frac{d\theta}{dt} = \frac{\Delta\theta_{io}}{I}\left[r - K_i - \left(K(\theta_o) + \frac{\beta p K_s \Delta\theta_{io} G(\theta_i,\theta_o)}{I}\right)\right] \qquad \mathbf{(12)}$$

in which $\Delta\theta_{io}$ is θ_o-θ_i, the water content of the redistributing portion,
θ_i is the original water content, below the redistribution front,
r is the rate of input at the surface during redistribution (which may be small negative- evaporation, positive, or 0),
β is a shape factor,
p is an effective depth factor, and
$G(\theta_i,\theta_o)$ is the effective capillary drive of the shrinking wetting front, which is reduced relative to that of an infiltrating G due to the fact that θ_o is less than θ_s.

This equation is easily solved during simulation by the Runge-Kutta method. For two-layer soils, where the redistributing block includes both soil layers, the reduction of θ in both layers is treated by linking them with an assumed common value of ψ across the interface, and using $K_s = K_{s2}$ and $G(\theta_i,\theta_o) = G_2(\theta_i,\theta_o)$ in Eq. (12).

4. Rainfall Prewetting. Another normal phenomenon in actual rainfall patterns that is not dealt with by other infiltration models is the effect of initial, slow rainfalls which may preceed a runoff-producing period, in which the effective "initial" soil water content used in the infiltration calculations is changed. KINEROS2 uses a method based on soil dynamic studies to estimate the change in effective θ_i due to an initial slow rainfall ($r < K_s$). The method is similar to that for redistribution, and is based on the soil properties and the relative value of rainrate (Corradini et al., 1994). Further, there may be a short initial pulse of higher rainrates which would produce runoff, but does not last long enough, and a hiatus intervenes. For this, a similar method is used to estimate the resulting wetting depth and θ_o that best describes the water then to be redistributed as described above. All of these methods insure that a more accurate estimate of runoff from any rainfall pattern is obtained.

5. Expanded Infiltration Expressions.

5.1 Very Wet Initial Conditions. After a relatively short period of redistribution, the soil profile will be relatively wet, which creates a condition that violates the assumptions of most infiltration models. Not only is the initial water content of the upper soil quite high, but the total infiltration flux must include the relatively steady flux of the water already in the profile. A modification of Eq. (1) (Smith *et al.*, 1993) deals relatively accurately with wet initial conditions. In the wet case, $I' = (I - K_i t')$ is used for I, where K_i is the hydraulic conductivity of the initial soil profile, $K(\theta_i)$, and t' is the time from start of wetting or rewetting.

5.2 Heterogeneous Areas The variation of K_s over an area in its interaction with the value of r determines the apparent overall areal value of K_s. When K_s has a random distribution, especially considering the tail of the distribution, there will for a finite r always be some points having $K_s >$ r. The portion of area thus not contributing to runoff will increase with decreasing r, and the result will be an areal effective K_s, which we will call K_e, that increases with r. This value can be expessed as follows:

$$K_e = \left[1 - P_k(r)\right] r + \int_0^r k p_k(k)\, dk \qquad \textbf{(13)}$$

in which P_k is the CDF of K_s, and p_k is the corresponding PDF. Figure 2 illustrates the relation between r*, K_e and $Cv(K_s)$ for a lognormal PDF.

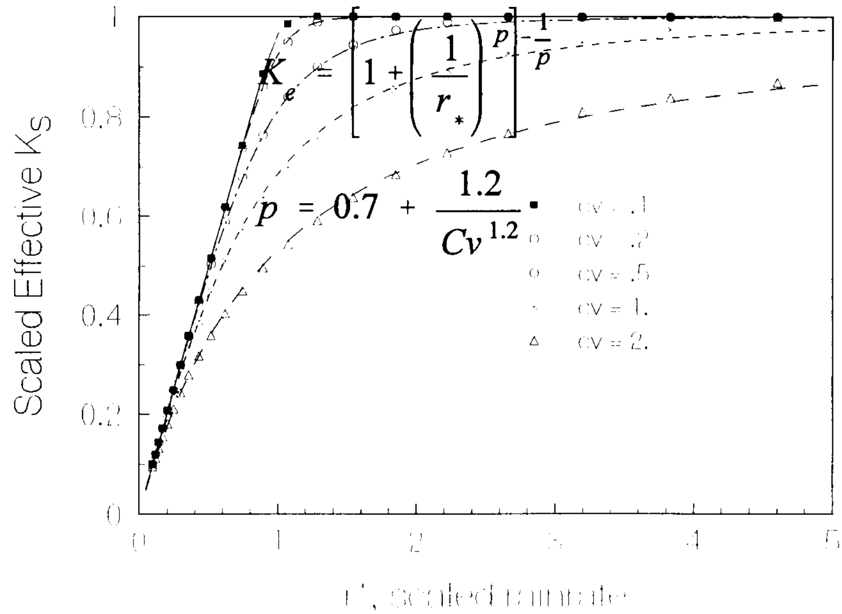
Simulation experiments with a runoff surface whose values of K_s are lognormally distributed have been performed to establish a relationship for infiltration of the heterogeneous surface as a whole. Define $\bar{K}$ in Eqs (2) and (4) as the areal expected value or mean of K_s, and define $Cv(K_s)$ as the coefficient of variation, or $\sigma(K_s)/K_e$, where σ() is the standard deviation. Numerical experiments have demonstrated that the surface ensemble behavior can be described by an equation based on Eq. (5) which can be written in scaled terms (based on K_e) as

$$\frac{f_{c*} - 1}{r_* - 1} = \left\{1 + \left[\frac{r_* - 1}{\alpha}\left(\exp(\alpha I_*) - 1\right)\right]^C\right\}^{-\frac{1}{C}} \qquad \textbf{(14)}$$

in which C is a parameter greater than 1, whose values are directly related to the scaled rainrate r* [r/K_e)] and the $Cv(K_s)$. Figure 3 illustrates the estimation of C as a function of $Cv(K_s)$ and r*. The estimating equation shown in Figure 3 for C(r*,Cv) is

$$C = 1 + \left[.75(Cv)^{-1.3}\right]\left[1 - \exp(0.1 - r_*)\right] \qquad \textbf{(15)}$$

and the estimating equation for K_e shown in Figure 2 is



$$K_e = \left[1 + \left(\frac{1}{r_*}\right)^p\right]^{-\frac{1}{p}} \qquad (16)$$

$$p = 0.7 + \frac{1.2}{Cv^{1.2}}$$

Figure 2. Relation of effective ensemble K_s to coefficient of variation of K_s and scaled rainrate.

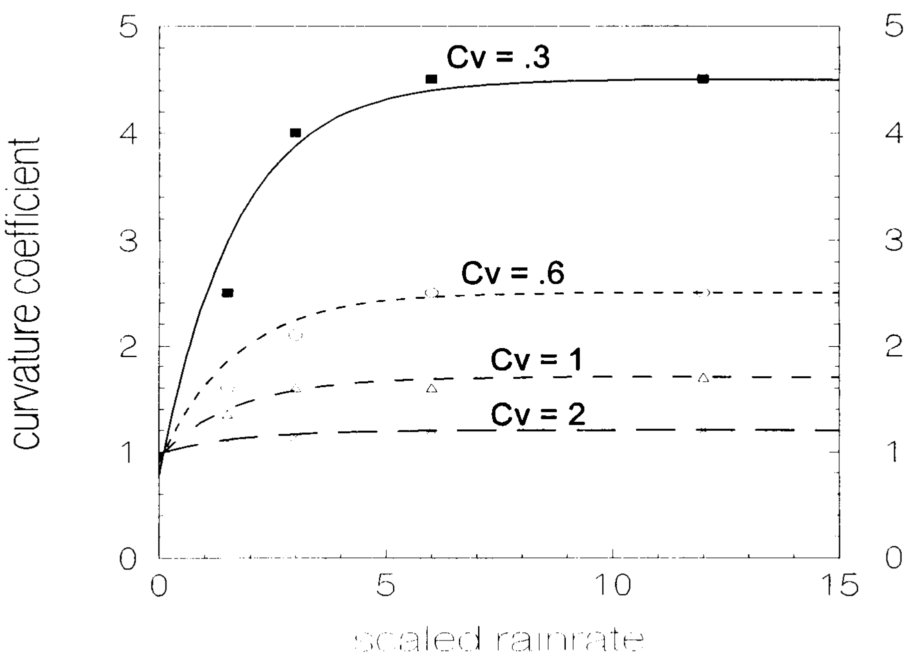


Figure 3. Variation of the coefficient C with scaled rainrate and $Cv(K_s)$

5.3 Rewetting Conditions The conductivity of the water initially in the soil, K_i, is normally negligibly small and is then neglected. For rewetting conditions, however, K_i and G are estimated by the model based on the soil parameter λ and the value of θ_i , and infiltration is treated as described in 5.1 above. Rewetting parameters apply until the rewetting "front" moves to the depth of the original wetted front. After that, original values of θ_i and G apply, as the original wetting "front" is rejoined (for more details see Corradini *et al.* 1994).

5.4 Estimation of New Parameter (λ). The additional parameter for water redistribution in KINEROS2 that is not required in KINEROS is the pore size distribution index, λ. Table 1, below, is taken from the statistical study of soils by texture of Rawls, et al. (1982). This provides a guideline for user estimation of the new parameters. Note that there is significant variation within textural classes, and that, while λ is consistently larger for coarser soils and smaller for clays, there is no consistency for soils with medium textures. It should be remembered that as a *distribution* index, this parameter should be expected to be smaller for soils with a large range of particle sizes, and larger for soils which are relatively uniform in particle size, whatever the mean size may be. This table also provides some guidance for estimating S_{max}, by using the ratio of θ_s to porosity, n.

References

Corradini, C. F. Melone, and R.E. Smith, 1994. Modeling infiltration during complex rainfall sequences, **Water Resources Research** **30**(10):2777-2784.

Hillel, D. 1971. Soil and water - physical principles and processes. Academic Press, NY, 299 p.

Parlange, J.-Y., I. Lisle, R.D. Braddock, and R.E. Smith. 1982. The three-parameter infiltration equation, **Soil Science** **133**(6):337-341.

Rawls, W.J, D.L. Brakensiek, and K.E. Saxton. 1982. Estimation of soil water properties. **Trans. ASAE** **25**:1316-1320.

Smith, R.E., 1990. Analysis of infiltration through a two-layer soil profile. **Soil Science Soc. of America J.** **54**(5):1219-1227

Smith, R.E., C. Corradini, and F. Melone. 1993. Modeling infiltration for multistorm runoff events. **Water Resources Research** **29**(1):133-144.

Smith, R.E., and J.-Y. Parlange, 1978. A parameer-efficient hydrologic infiltration model, **Water Resources Research, 14**(3):533-538.

Table 1. Estimation guide for soil hydraulic properties based on sample data, showing ranges for ±one standard deviation[1]

Texture Class	Sample Size Used[1]	Total Porosity, **n**	Residual Water Content, θ_r	Effective Saturation, θ_s	Pore Size Distribution, λ	Mean Capillary Drive[2], **G** (cm)
Sand	762	0.437 ±.063	0.020 ±.019	0.417 ± .063	0.69 ± .40	21.
Loamy Sand	338	0.437 ± .069	0.035 ± .032	0.401 ± .062	0.55 ± .32	28.
Sandy Loam	666	0.453 ± .102	0.041 ± .065	0.412 ± .129	0.38 ± .14	44.
Loam	383	0.463 ± .088	0.027 ± .047	0.434 ± .100	0.25 ± .17	63.
Silt Loam	1206	0.501 ± .081	0.015 ± .043	0.486 ± .092	0.23 ± .13	81.
Sandy Clay Loam	498	0.398 ± .066	0.068 ± .069	0.330 ± .095	0.32 ± .24	90.
Clay Loam	366	0.464 ± .055	0.075 ±.099	0.390 ± .111	0.24 ± .14	89.
Silty Clay Loam	689	0.471 ± .053	0.040 ± .078	0.432 ± .085	0.18 ± .14	116.
Sandy Clay	45	0.430 ± .060	0.109 ±.096	0.321 ± .114	0.22 ± .18	127.
Silty Clay	127	0.479 ± .054	0.056 ± .08	0.423 ± .089	0.15 ± 0.11	129.
Clay	291	0.475 ± .048	0.090 ± .105	0.385 ± .116	0.16 ± 0.13	143.

Notes:

1. Data from Rawls, et al., 1982
2. Obtained using mean class parameters and Eq.(7)

Readme.asc

KINEROS2 VERSION CALLED KIN.EXE D. Woolhiser 11/5/98

I received this version on 2/18/98 and used it on subsequent computer runs. It differs only slightly from the previous version in that the input file has an option to omit run time graphics.

The following is an annotated version of a control file: (name).FIL. Items in quotes are my annotations and do not appear in the file.

---

c:\CONSULT\SWRI\HILL2D\HL2M672L.PAR "The geometry and parameter file"
C:\PROGRA~1\BASICP~1\S2_3995B.PRE "The precipitation file"
C:\CONSULT\SWRI\THIRD50\HL223995.OUT "The name of the output file"
THREE PLANE CASCADE; THICK 67 = 200. RAIN OF 3/9-11/1995 "Message in out file"
2500 "Duration of run in minutes"
2 "Computational time increment in minutes"
N "Automatic adjustment of time step (Y/N)"
N "Erosion option (Y/N)"
N "Graphics (Y/N)"
N "Multiplier (Y/N)"

The file READ.ME is from Carl Unkrich of ARS and refers to material received on 5/11/96.

The file 2LAYINF.DOC describes the two layer infiltration routine. I think that it was originally a WORD PERFECT document.

The file PROGDOC.ASC is documentation for the KINEROS2 program of 5/11/96 It is slightly out of date, but documents the input form reasonably well.

The files with the extension .PAR are Solitario Canyon parameter files. The saturated hydraulic conductivity and relative saturation change seasonally. The file names refer to the season.
SJ_AD.PAR January - April
SM_JD.PAR May - June
SJ_OD.PAR July-October
SND.PAR November
SOLDD.PAR December

AVGJ_OD.PAR Average plane July-October

The file HELVB.FON must be in the same directory as KIN.EXE if you want graphic output.

Files with the extension .PRE are precipitation input files.
I usually use the convention *.out for output files.
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EXAMPLES

I have set up two examples you can run. The first example is a run of the average plane with rainfall input of PAUG4.PRE. If all the files on this are downloaded to the same directory, just enter KIN AVG.FIL <return>. The kineros2 program will begin and it will look for input information in the file AVG.FIL which contains dimensions and parameters for the average plane. You can get graphical output by entering F1 and F2. The output will go to file AVGAUG4.OUT.

The second example is for the entire Solitario Canyon Watershed for the storm PAUG4.PRE. Just enter KIN <enter>. The program will auotomatically look for input and output information in the file KIN.FIL. Output will be in file SOLAUG4.OUT. The graphics option is canceled for this run.

Note: You can get output hydrographs for any plane or channel element either in the .OUT file or in another file readable by any graphics program by entering the proper code (and file name if you want graphics) in the .PAR file.

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Progdoc.asc

KINEROS2 - PROGRAM INPUT

Table of Contents

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I. Parameter file

A. Input format

Input is arranged onto blocks, one block per element (except for compound channels), plus a "GLOBAL" block at the beginning. The input file must reflect the order in which elements are to be processed; the program will process blocks sequentially as it reads them. The name of each block identifies the type of element, and has the following structure:

```
BEGIN <BLOCKNAME>
  .
  .
  .
END
```

Within each block, parameter values can be specified using two types of constructs, "list" and "column." These types can be mixed within a block but not within a line.

List input is:

parameter = datum

or,

parameter = datum1, datum2, ...

where the data list may continue over successive lines. There may be more than one list on a line.

The column type of construct has parameter names on one line followed by at least one line of corresponding data:

```
parameter   parameter   ...

datum1      datum1      ...
datum2      datum2      ...
  .           .
  .           .
```

Acceptable delimiters include blanks and commas, and additional blanks and blank lines can be used to make the file more readable.

Following KINEROS tradition, ALL PARAMETER NAMES ARE IN UPPER CASE.

Numeric values can have a leading + or -, without intervening blanks.

Comments, preceded by an "!", can follow the data on the same line or be on a separate line.

Options are often inferred from the presence or absence of applicable parameters. For example, the absence of infiltration parameters tells the program that the surface is impervious.

B. Input parameters

Following are parameter names and descriptions listed by element type. They are also described in the KINEROS manual.

1. Global

The input file begins with a GLOBAL input block, in which parameters common to all elements are specified. The shortest permissable abbreviation are shown in parenthesis:

(U)NITS   METRIC or ENGLISH;

(C)LEN   CLEN is still CLEN, the "characteristic length". Set it equal to the longest channel segment or cascade of planes (see KINEROS manual);

The following need only be specified when routing sediment:

(T)EMPERATURE   degrees C or F;

(DI)AMETERS list representative diameters for up to 5 particle classes;

(DE)NSITIES list densities (g/cc) of the above particle classes;

Example:

```
BEGIN GLOBAL
 CLEN = 423,  UNITS = METRIC
 DIAMS = .005, .05, .25 ! mm
 DENSITY = 2.65, 2.60, 2.60 ! g/cc
 TEMP = 33 ! deg C
END GLOBAL
```

2. Overland flow

There are two parameters which appear in every element input block:

(ID)ENTIFIER Identification number - somewhat arbitrary, but must be an integer from 1 - 999999;

(PR)INT 0 = no printout for current element (default if PRINT is not specified),

1 = summary printout for current element,

2 = summary printout plus a listing of discharge and total sediment discharge at each time step,

3 = summary printout plus creation of a separate file with a listing of discharge, total sediment discharge and discharge by particle class, in a spreadsheet-importable format.

(FI)LE Name of file to create with PRINT = 3;

PLANE Input block name;

(UP)STREAM Identifier of the upstream plane element, if applicable;

(LE)NGTH Length in meters or feet;

(WI)DTH Bottom width in meters or feet;

(SL)OPE Bottom slope in meters or feet;

(MAN)NING Manning roughness coefficient;

(CH)EZY Chezy conveyance factor;

X Representative x coordinate;

Y Representative y coordinate;

(RE)LIEF Average microtopographic relief in mm or inches;

(SPA)CING Average microtopographic spacing in meters or feet;

Coordinates do not have to be specified if there is only one raingage.

If it is a pervious surface, the following parameters describe its infiltration characteristics:

(SA)TURATION Initial degree of soil saturation, expressed as a fraction of of the pore space filled;

(CV) Coefficient of variation of Ks {0,1};

(THI)CKNESS Thickness of upper soil layer (m or ft);

The following infiltration parameters can have two values, representing a two-layer soil:

(KS)AT Saturated hydraulic conductivity, mm/hr or in/hr;

G Mean capillary drive, mm or inches -- a zero value sets the infiltration at a constant value of Ks;

(DI)STRIBUTION Pore size distribution index. This is a new parameter used for redistribution of soil moisture during unponded intervals - probably not important in channels but the program will be expecting an entry;

(PO)ROSITY Porosity;

(RO)CK Volumetric rock fraction, if any (see note in current manual, p.69, about correcting Ksat for rock volume, if applicable);

If sediment is being routed, the following parameters are required:

(SP)LASH Rain splash coefficient;

(CO)HESION Soil cohesion coefficient;

(FR)ACTIONS List of particle class fractions -- must sum to one;

Example:

BEGIN PLANE

ID = 3, LEN = 1000, WID = 2000, SL = .05, MANNING = .04

CV = .8, THICK = 2, SAT = .2, PR = 1

RELIEF = .1, SPACING = .8

```
KS    G    DIST  POR   ROCK
0.4   20.  0.1   .35   0    ! upper layer
2.0   10.  0.1   .40   0    ! lower layer
```

FRACT = 0.2, 0.6, 0.2   SPL = 50, COH = 0.5

END PLANE

3. Channels

CHANNEL Input block name;

(UP)STREAM Identifier(s) of up to three upstream contributing elements;

(LA)TERAL Identifier(s) of up to two plane elements contributing lateral inflow. For a compound channel, the second of two planes listed will be associated with the overbank section. Alternatively, this plane can be specified in the overbank input block;

(LE)NGTH Length in meters or feet;

(TY)PE "(S)IMPLE" or "(C)OMPOUND" -- default is simple;

QB Baseflow discharge at end of channel, if applicable, cu.m /s or cu.ft/s;

The following geometric parameters can have two values, representing its upstream and downstream sections, or a single value denoting the average:

(WI)DTH Bottom width in meters or feet;

(SL)OPE Bottom slope in meters or feet;

(MAN)NING Manning roughness coefficient;

(CH)EZY Chezy conveyance factor;

SS1 Bank side slopes (equivalent to ZL or ZR in the original KINEROS: right or left is immaterial to the routing
SS2 equations, except for compound channels, in which case SS2 refers to the overbank side);

(RW)IDTH If it is desired to account for rainfall on the channel area, this parameter specifies a representative width;

X Representative x coordinate;

Y Representative y coordinate;

Coordinates are specified only if RWIDTH is specified.
Coordinates do not have to be specified if there is only one raingage.

If it is a pervious channel, the following parameters describe its infiltration characteristics:

(WO)OL David Woolhiser's Mystery Function. Apparently he stumbled across it while deciphering ancient petroglyphs on a local rock formation (see current KINEROS manual);

(WCO)EFF Optional override of coefficient in the Woolhiser function -- default is 0.15;

(SA)TURATION Initial degree of soil saturation, expressed as a fraction of of the pore space filled;

(CV) Coefficient of variation of Ks {0,1};

(THI)CKNESS Thickness of upper soil layer, m or ft;

The following infiltration parameters can have two values, representing a two-layer soil:

(KS)AT Saturated hydraulic conductivity, mm/hr or in/hr;

G Mean capillary drive, mm or inches -- a zero value sets the infiltration at a constant value of Ks;

(DI)STRIBUTION Pore size distribution index. This is a new parameter used for redistribution of soil moisture during unponded intervals - probably not important in channels but the program will be expecting an entry;

(PO)ROSITY Porosity;

(RO)CK Volumetric rock fraction, if any (see note in current manual, p.69, about correcting Ksat for rock volume, if applicable);

If sediment is being routed, the following parameters are required:

(CO)HESION Soil cohesion coefficient;

(FR)ACTIONS List of particle class fractions -- must sum to one;

A compound channel element has an additional input block for the overbank section, with the same geometric, infiltration and sediment parameters as above except LENGTH, SS1 and SS2. Additional parameters are:

OVERBANK Input block name;

(LA)TERAL Identifier of a plane element contributing lateral inflow;

The following parameters can refer to upstream, downstream sections or the average:

SS3 Bank slope;

SSL Lateral bottom slope (towards main section);

(THR)ESHOLD Threshold depth for spillover, m or ft;

(RW)IDTH If it is desired to account for rainfall on the overbank area, this parameter specifies a representative width;

```
 \                                    /
  \                  <-- SSL --        / SS3
   \         ___    ___________________________/
 SS1 \        |   /        WIDTH (overbank)
     \       THR  / SS2
      \______________|___/
          WIDTH
```

Example:

```
 BEGIN CHANNEL

  ID = 4,  UP = 1,  LEN = 114.9,  PR = 1,  LAT = 2

  WIDTH   SLOPE   MANNING   SS1   SS2
   6.2   .0077     .02      .38   .11

  SAT = .3

  KS    G    POR    ROCK    DIST
  21   4.6   .44     0       .7

  COH = 0.1,  FRACT = 0.2, 0.6, 0.2

  TYPE = COMPOUND

 END
!---------------------------------------------
 BEGIN OVERBANK

   LAT = 3
```

WIDTH	SLOPE	MANNING	SS3	SSL	THRESH
22.8	.0077	.033	.013	.0077	.13

SAT = .3

KS	G	POR	ROCK	DIST
3.2	6.3	.34	0	.7

COH = 0.1, FRACT = 0.5, 0.5

END

4. Injection

INJECT Input block name;

(F)ILE Data to inject -- a listing of time (min) and discharge (cu.m/s or cu.ft/s) pairs plus up to 5 columns of corresponding sediment concentrations by particle class;

(O)FFSET An optional positive time offset in minutes;

Example:

```
BEGIN INJECT

ID = 1, FILE = EX1.INJ, PR = 1

END INJECT
```

II. Rainfall file

Each set of raingage data is entered in a separate input block:

?????? Input block (gage) name (alphanumeric);

(N)UMBER Number of data pairs;

(T)IME Time in minutes (column or list);

(D)EPTH Accumulated depth in mm or inches;

(I)NTENSITY Intensity in mm/hr or in/hr -- input can be in either depth or intensity;

X X coordinate -- optional if there is only one gage;

Y Y coordinate;

Example:

```
 BEGIN RG001

  N = 6

   TIME      DEPTH
!  (min)     (in)

    0.0      0.00
   15.0      0.05
   35.0      2.40
  105.0      2.42
  115.0      3.02
  130.0      3.02

 END
```

III. Run-time input

Upon execution, the following questions will be posed...

```
  Parameter file:
   Rainfall file:
     Output file:
     Description:
  Duration (min):
 Time step (min):
    Adjust (y/n):
  Sediment (y/n):
```

Under some conditions the rainfall file is optional (for example, when using injected inflow exclusively).

The computational time step can be adjusted automatically by the program to maintain numerical accuracy as put forth by the Courant condition -- final output will still be at the user-specified time step. If this option is not chosen the program will still monitor the time step criteria and report a distribution based on three levels: 100, 75 and 50 percent. The time step listed at the 50 percent level would be sufficient for accuracy 50 percent of the time, the time step for the 75 percent level would be sufficient 75 percent of the time, and the time step listed at 100 percent would be sufficient throughout the simulation.