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APPENDIX I

Computer simulation of the raindrop induced flow transport over cohesive and non-cohesive surfaces

The computer model developed here attempts to simulate the events that occur when drop impacts produce RIFT on a small planar surface such as that used in the experiments described in chapter 3. It operates to either simulate the movement of a labelled material from a source area such as described in section 3.2.2G (source mode) or the movement of particles detached and deposited on the surface of a soil (cohesive mode).

Fig.2.1(B) provides a schematic cross section of particle movement resulting from a drop impact in RIFT. The computer model is based on this scheme but some modifications have been made in order to provide a relatively simple model that illustrates the processes rather than provide an accurate prediction of what occurs in the natural system. In the model, a 100mm by 240mm area is used but the model wraps the side edges of the area around so that the effective width modelled is much greater than 100mm. The model considers this area to be made up of 1mm square elements. Insufficient memory space is available in MS-DOS based PC systems to simulate RIFT on the 500mm by 500mm area used in the experiments in chapter 3. The model uses the computer's inbuilt random number generator to determine the position of the drop impact within the 100m by 240mm area.

When a drop impact occurs, the model assumes that the area of the bed disturbed is square rather than circular in shape. The sides of the square are 9mm long. In the source mode, only pre-detached particles sitting on the bed are lifted up into the flow to form a cloud of particles. Particles other than those coming from the source area are ignored. In the cohesive mode, particles are detached from the soil matrix if there are insufficient pre-detached particles sitting on the bed to fill the cloud. Energy is assumed to be used in lifting the pre-detached particles and only energy that is left over from this process is used to detach particles from the cohesive layer. In the model, it is assumed that, for the situation where no pre-detached particles exist, the cohesive layer can yield a predetermined proportion of the value of D_{pd} produced when the non-cohesive layer completely shields the cohesive layer.

In Fig.2.1(B), the cloud is depicted as being hemispherical. In the model, the base of cloud is considered a square with 18mm sides. Visual observation of the clouds that occurred during the experiments with different coloured sands reported in section 4.2.5 indicated that their maximum widths were about 20mm. The model also assumes the particles remain suspended for 0.6s. Again, this is consistent with the observations reported in section 3.2.2G. Flow velocity is user selectable.

The surface is assumed to be made up of 0.2mm sized particles giving a population density of 25 particles mm^{-2} for each layer. Each drop impact is assumed to disturb 4 layers of pre-detached particles so that a maximum of 100 particles can be lifted from each square millimetre disturbed. Since the eroded particles are deposited on the surface, and little or no mixing occurred with the underlying material in the experiments reported in section 3.2.2G, the model assumes that the source material is freely available to be lifted into the cloud when the model operates in the source mode. When operating in the cohesive mode, the ratio of the mass of material lifted when there are no detached particles to the mass of material lifted when the surface is completely covered by detached particles is user selected.

Program: DRPRIFTV

```

1 REM      DRPRIFTV      updated   10/5/91
2 REM This program loads previous data if available. In this situation
4 REM it loads the # of previous drop impacts, detached/ non-detached
5 REM particle ratio (det), particle residence time and flow vel.
6 REM These variables are set by the user on a first time run.
7 REM
500 disturbed = 8: CLOUDS = 17: MASS = 100: source = 15: drops = 2000
501 XM = 239: YM = 99: p5 = .5: DXY = INT(disturbed / 2): pup = MASS
502 CXY = INT(CLOUDS / 2): TRAVEL = 12: one = 1: TWO = 2: TWOP5 = 2.5
503 XMAX = 75: LAYER = 25: TENPCENT = pup / 10: det = .2
504 SP$ = "                                "
505 xoff = disturbed / 2: xt = XM - xoff: restime = .6: flowvel = 20
510 DIM Target%(XM, YM), IMPACT%(disturbed, disturbed), CLOUD%(CLOUDS, CLOUDS)
515 DIM XX%(drops), YY%(drops)

```

```

520 INPUT "source(1) or cohesive(2) mode"; optype
530 IF optype < 1 OR optype > 2 THEN 520
535 INPUT "name for data files (4 chars max)"; filen$
536 IF LEN(filen$) > 4 THEN 535
540 IF optype > 1 THEN 600
550 det = 0: reps = 1
560 FOR ix = 0 TO source - 1: FOR iy = 0 TO YM: Target%(ix, iy) = 500: NEXT:
NEXT
570 filex$ = "sx" + filen$
580 GOTO 900
600 INPUT "How many reps of 2000 drops (<27)"; reps
610 filex$ = "cx" + filen$
900 CLS : PRINT "generating drop impact positions"
901 LPRINT "Running "; LEFT$(filex$, 2); " mode": LPRINT "Data Files = ";
filex$: GOSUB 5010
902 REM
903 FOR ZZ = 1 TO reps
904 dropfile$ = filex$ + CHR$(64 + ZZ) + ".drp": OPEN "o", #2, dropfile$
905 LPRINT "started simulation at", TIME$, DATE$
906 PRINT #2, det, restime, flowvel
910 FOR T = 1 TO drops: PRINT "*";
1000 REM find impact point in x,y coordinates of xm,ym sized grid
1010 XX%(T) = INT(RND(1) * xt + xoff + p5): YY%(T) = INT(RND(1) * YM + p5)
1011 NEXT: PRINT : CLS
1014 FOR T = 1 TO drops: x = XX%(T): y = YY%(T)
1015 LOCATE 1, 1: PRINT SP$; SP$
1016 LOCATE 1, 1: PRINT "Drop #="; T; "          x="; x; "      y="; y
1020 REM calc coordinates for left corner of disturbed area
1030 DLX = x - DXY: DLY = y - DXY
1035 FOR ix = 0 TO CLOUDS: FOR iy = 0 TO CLOUDS: CLOUD%(ix, iy) = 0: NEXT:
NEXT
1040 REM get particles from distb area and put in cloud randomly.
1045 distarea = 0: dp = 0
1050 FOR ix = 0 TO disturbed
1060 XX = ix + DLX: IF XX > XM THEN 1160
1065 FOR iy = 0 TO disturbed
1070 YY = iy + DLY: IF YY < 0 THEN YY = YM + YY + 1
1080 IF YY > YM THEN YY = YY - YM - 1

```



```

1085 IF Target%(XX, YY) < pup THEN Target%(XX, YY) = Target%(XX, YY) +
INT((pup - Target%(XX, YY)) * det)
1090     np = Target%(XX, YY)
1091     IF np > pup THEN np = pup
1092     Target%(XX, YY) = Target%(XX, YY) - np: dp = dp + np: distarea =
distarea + one
1093 NX = INT(np / 4): NY = np - NX * 4
1094 FOR A1 = 0 TO 1: CLOUD%(ix * TWO + A1, iy * TWO) = NX: CLOUD%(ix * TWO +
A1, iy * TWO + 1) = NX
1095 NEXT
1100     FOR NN = 1 TO NY
1120         XC = INT(RND(1) + p5) + TWO * ix: YC = INT(RND(1) + p5) + TWO * iy
1130         CLOUD%(XC, YC) = CLOUD%(XC, YC) + one
1140     NEXT
1150 NEXT
1160 NEXT
1165 propdp = dp / distarea / pup
1170 drnum = drnum + one: PRINT #2, drnum; x; y; propdp
1200 REM calc coordinates for upstream left corner of deposit
1210 CLX = x - CXY + TRAVEL: CLY = y - CXY: XDOWN = x + CXY + TRAVEL
1220 FOR ix = 0 TO CLOUDS: XX = CLX + ix: IF XX < 0 OR XX > XM THEN 1261
1230 FOR iy = 0 TO CLOUDS: YY = CLY + iy: IF YY < 0 THEN YY = YM + YY + 1
1240 IF YY > YM THEN YY = YY - YM - 1
1250 Target%(XX, YY) = Target%(XX, YY) + CLOUD%(ix, iy)
1260 NEXT
1261 NEXT
1262 IF T = drops THEN 1269
1263 key1$ = key$: key$ = INKEY$: IF key$ = "d" THEN IF key1$ <> "d" THEN 1269
1264 GOTO 2000
1267 IF y < 30 OR y > 67 THEN 2000
1268 IF x > 83 OR x > XMAX THEN 2000
1269 LOCATE 1, 1: PRINT "Drop #="; T; "                x="; x; "    y="; y
1270 FOR YI = 39 TO 60: A$ = ""
1280 FOR XI = 78 TO 0 STEP -1: PCENT = INT(Target%(XI, YI) / TENPCENT)
1289 IF PCENT < 10 THEN B$ = CHR$(48 + PCENT): IF PCENT = 0 THEN B$ = " "
1290 PX = INT(PCENT / 10): IF PX > 0 THEN B$ = CHR$(64 + PX): IF optype < 2
THEN B$ = "*"
1310 A$ = A$ + B$

```

```

1320 NEXT: PRINT A$: NEXT: IF XMAX < XDOWN THEN XMAX = XDOWN
2000 NEXT T: NI = NI + drops
2001 LPRINT "ended simulation at", TIME$, DATE$: LPRINT NI; "impacts
simulated"
2002 LPRINT "-----"
-----"
2003 LPRINT : LPRINT : LPRINT : LPRINT
2004 CLOSE #2
2005 REM store display for 1mm wide, 2mm long elements
2006 DATFILE$ = filex$ + CHR$(64 + ZZ) + ".dat"
2010 OPEN "o", #1, DATFILE$
2011 PRINT #1, NI, det, restime, flowvel
2020 FOR XI = 1 TO XM - 1 STEP 2: A$ = ""
2021 FOR YI = 0 TO YM
2025 ADDED = Target%(XI, YI) + Target%(XI + 1, YI): MEAN = ADDED / TWO
2030 PCENT = INT(MEAN / TENPCENT)
2040 IF PCENT < 10 THEN B$ = CHR$(48 + PCENT): IF PCENT = 0 THEN B$ = " "
2042 PX = INT(PCENT / 10): IF PX > 0 THEN B$ = CHR$(64 + PX): IF optype < 2
THEN B$ = "*"
2070 A$ = A$ + B$
2080 NEXT: PRINT #1, A$: REM LPRINT LEFT$(SP$,10)LEFT$(A$,65)
2085 NEXT
2090 CLOSE #1
2092 LPRINT "-----"
-----"
2094 NEXT ZZ
2095 CLOSE #2
2100 LPRINT : LPRINT : LPRINT : LPRINT
2200 REM save 1mm by 1mm data
2210 DITFILE$ = filex$ + CHR$(64 + ZZ - 1) + ".dit"
2215 LPRINT "saving "; DITFILE$
2220 OPEN "o", #1, DITFILE$
2221 PRINT #1, NI, det, pup, restime, flowvel
2225 FOR XI = 1 TO XM
2230   FOR YI = 0 TO YM
2235     PRINT #1, Target%(XI, YI): REM PRINT Target%(XI, YI);
2240   NEXT
2245   PRINT #1, "-1000": REM PRINT "-1000"

```

```

2250 NEXT
2255 CLOSE #1
2260 LPRINT "Program ended at", TIME$, DATE$
2270 LPRINT "-----"
-----"
2275 LPRINT : LPRINT : LPRINT
3998 END
4000 REM
4001 REM
4999 REM -----
5010 INPUT "Name of 'DIT' file to load (return only = none) "; DIT$
5011 IF DIT$ = "" THEN 5500
5015 OPEN "i", #1, DIT$ + ".DIT"
5016 INPUT #1, NI, det, pup, restime, flowvel
5017 pupfactor = MASS / pup: pup = MASS: drnum = NI
5018 LPRINT : LPRINT "using "; DIT$; ".DIT for data in input": LPRINT
5020 FOR XI = 1 TO XM: PRINT "loading row "; XI
5030   FOR YI = 0 TO YM
5040     INPUT #1, N%: IF N% >= 0 THEN Target%(XI, YI) = N% * pupfactor
5050   NEXT
5060   INPUT #1, A%: IF A% >= 0 THEN LPRINT "error in reading data input file":
STOP
5065 NEXT: PRINT
5070 CLOSE #1
5200 GOTO 5530
5500 INPUT "enter detached/non-detached ratio "; det
5510 INPUT "enter particle residence time (secs) "; restime
5520 INPUT "enter flow velocity (mm/s) "; flowvel
5530 TRAVEL = restime * flowvel
5340 LPRINT "detached/non-detached ratio "; det
5350 LPRINT "particle residence time (secs) "; restime
5360 LPRINT "flow velocity (mm/s) "; flowvel
5998 LPRINT "-----"
-----"
5999 LPRINT
6000 RETURN

```

APPENDIX II

TECHNICAL MEMORANDUM 43/1988

CSIRO Division of Soils

NOT FOR PUBLICATION

The material contained here has not been refereed. It may be quoted as a personal communication following written consent of the authors.

AN INJECTION BARREL FOR THE TOP ENTRY SEDIMENTATION TUBE

by P.I.A.Kinrell and C.McLachlan

ABSTRACT

A modification to the top of Griffith sedimentation tube is described. The modification involved redesigning the injection barrel in order to inject soil material into the tube more reliably.

INTRODUCTION

The Griffith Tube (Hairsine and McTanish 1986) is an apparatus for obtaining data on the settling velocity of soil particles. It is an adaptation of the technique developed by Puri (1934) to the measurement of the fall velocity distribution of sediment outside the size range covered by Stoke's law.

The apparatus consists of a vertical tube above a turntable of sample trays. When sealed at the top, the tube contains a static column of water when the open bottom end is immersed in a circular tank of water containing the turntable. Particles injected into the water at the top of the tube fall through the column of water and are collected in the sample trays at the bottom. The turntable is used to change the sample trays at pre-determined intervals.

The system can only operate when the top of the tube is sealed. Two mechanisms for inserting soil material and sediment were described by Hairsine and McTanish. One, a tipping bucket, was used to insert dry material into the top of the water column. The other, an injection barrel, was used for wet material. The modifications described here apply to this second mechanism.

THE MODIFICATION

The sample injection barrel used by Hairsine and McTanish was based on a hypodermic syringe. The bottom of the syringe was cut off to provide a straight tube. This tube was inserted into a perspex barrel which, when fitted to the top of the tube of water, formed an air-tight seal.

During the time when the sample was being introduced into the injection barrel, the bottom of the tube of water was sealed by contact with a foam pad on the rotary table. Once the sample was introduced into the injection barrel, the bottom of the barrel was sealed using an aluminium foil flap and vacuum grease or petroleum jelly. The tube of water was then sealed at the top by the injection barrel and the sample introduced into the column

when the plunger was automatically drawn into the tube by the weight of the water applied to the aluminium flap when the tube was lifted from the foam pad.

In general, the injection barrel system described by Hairsine and McTanish works reasonably well. However, there are two problems that can be experienced with their system. The first results from the need to use a grease to seal the aluminium flap. As the soil or sediment materials pass over the flap, some may adhere to the grease and not be injected into the column of water. The second can result from the frailty of the plungers used in many disposable hypodermic syringes. The force by which the top end of the plunger hits the end-stop can cause the end to break off and cause the system to fail. The modifications described below overcome both of these problems.

The operation of the new injection barrel is shown in Figs. 1 and 2. Instead of the aluminium foil flap, a cone connected to the piston by a rod is used to retain the sample within the cylinder prior to the injection phase. A pin inserted through the handle of the plunger prevents the piston from moving until the injection procedure is initiated. Once inserted into the collar of the tube filled with water, the pin is removed and the tube lifted off the pad on the turntable to initiate the injection process. As with the earlier design, the force of the weight of water acting on the cone and the piston acts to pull them down and inject the soil or sediment materials into the water column. The rush of water over the surfaces of the cone helps clean the material off the cone. The downward movement of the piston is halted when the rubber bung which forms part of the handle reaches the barrel. This bung not only stops the downward motion of the piston but also provides an air-tight seal at the top of the barrel.

The cone can be screwed on and off the rod to the piston. It is removed from the rod when the sample is being introduced into the barrel when it is inverted (Fig.3). The barrel is then filled with water and the cone screwed back onto the rod so as to seal the sample into the barrel before it is placed onto the collar of the tube. The adjoining surfaces between the collar and the barrel are liberally covered with vacuum grease or petroleum jelly to ensure an air-tight seal.

The cone, rod, piston and handle of the new system were machined from brass. The handle screwed into the body of the piston through a hole in the centre of the bung. The body of the injection barrel was machined from perspex. Care is required to obtain a smooth surface within the barrel to facilitate the movement of the piston without any additional lubricants. However, any difficulty in the initiating the injection process automatically when the tube is lifted off the pad can be overcome by forcing the piston down manually.

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APPENDIX III

Computer model demonstrating principles that can be used to model the effect
of the dynamic depositional layer over large areas

OVERVIEW

In the computer model, flow over a plane is represented by major elements in which flow depth and velocity remain uniform in space and time. The model calculates erosion, deposition, and re-detachment of deposited particles resulting from raindrop impacting flows in small elements lying within these major elements. Erosion and deposition are considered in separate steps. The model commences by calculating the mass of material eroded from the most upstream element. This material then enters the next downstream element, and is deposited to the dynamic depositional layer (DDL) in a manner that depends on flow depth, flow velocity and particle fall velocity. The degree of protection (H) provided by the DDL depends on the ratio of the mass of the deposited material lying within the element and the capacity of RIFT to transport the deposited material across the downstream boundary of the element. In the model, the data from the experiments in Chapter 3 is used to provide the estimates of this transport capacity. Once H has been determined, it is used to calculate the masses of the particles transported from both the DDL and the soil matrix within the element, and this material then becomes the input to the next downstream element. Because the model works progressively downstream from the most upstream element, it operates as a "steady-state" model.

In the model, particles lifted into the flow are considered to be distributed uniformly through the flow although this may not necessarily be so under natural conditions. The model uses Rubey's (1933) formula to calculate particle fall velocity. Other formulae may be more accurate but this formula is sufficiently accurate to demonstrate the interactions between flow velocity and particle velocity in distributing particles over the surface of an element. Also, no account of turbulence and the time of particle uplift are taken into account in determining particle travel distances.

The size distribution of particles in the DDL is assumed to be uniform throughout an element. Element length is a function of the length of the major element being considered and is not associated with flow and particle characteristics. Consequently this assumption is not strictly correct but provided the element length is small at the upstream end of the eroding area where most of the differentiation takes place, it is reasonable. For this reason, the size of the major elements varies along the length of the plane.

DEPOSITION TO THE DDL

The mass of sediment entering an element is represented by q_{si} . Assuming that the material is uniformly distributed through the depth of flow, the mass of particles of a particular size (p) deposited over an area of the bed that is directly related to hu/v . Given N sizes of particle, M_x , the mass per unit area of the bed deposited over the distance $hu/v_p[N]$ (assuming N is associated with the largest particle) is given by

$$M_x = \sum_{n=1}^N (P_i[n] q_{si} v_p[n]) / (huW) \quad (1)$$

where $P_i[n]$ is the proportion of the n th sized particle being transported by the flow and W is the width of the flow. The proportion of the n th sized particle in the material deposited is given by

$$P_d[n] = P_i[n] q_{si} v_p[n] / (huWM_x) \quad (2)$$

While the largest particle deposited is not deposited over the same distance from the beginning of the element as the smallest particle, raindrop induced saltation moves the largest particle downstream along the element. Currently, as an approximation, it is assumed that the composition within the distance $hu/v_p[N]$ is maintained over the whole length of the element. Strictly, for this to be the case, the element length should be restricted to $hu/v_p[N]$.

THE PROTECTIVE EFFECT OF THE DDL

The protective effect of the DDL is absolute ($H=1$) when the mass of

material in the DDL within the active zones associated with any boundary is greater or equal to the maximum mass (Q_{sox}) the drops can transport across that boundary. When the DDL contains only the particles of the n th size, this mass is given by

$$Q_{sox}[n] = k_p[n] f[h,r] I u W \quad (3)$$

where $f[h,r]$ is the function that accounts for the interactions between raindrop size and flow depth and $k_p[n]$ is the susceptibility of particles of the n th size to transport by rain-impacted flow. k_p and $f[h,r]$ values can be estimated from the equations developed in Chapter 3. Given that the mass of material per unit area comprising n th sized particles in the active zone associated with those particles is equal to the product of $P_d[n]$ and M_x when no previous DDL existed, the ratio of this product to the product of $P_d[n]$ and $Q_{sox}[n]v_p[n]/hu$ provides an indication of the value of H provided by these particles in the DDL. If this ratio is greater than 1, $H=1$. If not then H is equal to this ratio. Currently, values of H for the DDL are calculated by comparing the sums of the product of $P_d[n]$ and M_x and the product of $P_d[n]$ and $Q_{sox}[n]v_p[n]/hu$ rather than summing the values of H for individual particle sizes. Provision is also made to keep account of material the remains in the DDL when the $H=1$ condition occurs. No provision is made for any differential utilization of energy in removing particles from the DDL.

DISCHARGE OF SEDIMENT FROM AN ELEMENT

The mass of sediment exiting an element is represented by q_{so} . It comprises material that passes through the element with being deposited (because the travel distance of this material exceeds the length of the element), material from the DDL and, if $H<1$, material detached from the underlying soil matrix. The mass (q_{sos}) of sediment passing through without being deposited is provided for during the calculation of the mass being deposited to the DDL in an element. The mass of sediment from the DDL (q_{sod}) is calculated from

$$q_{sod}[n] = H P_d[n] k_p[n] f[h,r] I u W \quad (4)$$

The mass of sediment from the soil matrix (q_{som}) is calculated from

$$q_{\text{SOM}}[n] = (1-H) f[M] P_d[n] k_p[n] f[h,r] I u W \quad (5)$$

where $f[M]$ is the ratio of the susceptibility of the n th sized particles in the soil matrix to detachment by raindrop impact and $k_p[n]$. $f[M]$ is assumed not to vary with particle size.

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PROG$ = "DDLAYERJ.BAS"      'updated 28/7/92
```

```
MDF = .01                  'RATIO OF DETACMENT RTE MATRIX TO DEPOSIT =1%
```

```
R = 50                     'RAIN RATE = 50MM/HR
```

```
RR = R / 1000! / 3600      'RAIN RATE TO M/S
```

```
' SED DROP SIZE DISTRIBUTION OF THE RAIN TO THAT OF
' VEEJET 80100 NOZZLE
```

```
DIM DSIZE(20), DPROP(20)
```

```
DATA 0.35,0.45,0.55,0.65,0.75,0.9,1.1,1.3,1.5,1.7
```

```
DATA 1.95,2.25,2.55,2.85,3.15,3.5,3.9,4.3,4.75,5.25
```

```
DATA 0,0.011,0.681,0.403,0.966,3.36,9.47,11.424,11.56,11.686
```

```
DATA 26.37,13.365,5.765,3.168,1.519,.62,.217,.058,-1,0
```

```
FOR I = 1 TO 20
```

```
  READ DSIZE(I)
```

```
  NEXT
```

```
    FOR I = 1 TO 20
```

```
      READ X
```

```
      IF X < 0 THEN 10
```

```
      NSIZES = I
```

```

      DPROP(I) = X / 100
10 NEXT
PRINT " drop size      fan"
FOR I = 1 TO 20
PRINT DSIZE(I), DPROP(I) * 100
NEXT
PRINT : PRINT
'
'  PARTICLE SIZE (MM)
DATA 0.02,0.04,0.06,0.08,0.1,0.2,0.4,0.8,1.0,2.0
'  PROP OF SED
DATA 0.05,0.02,0.02,0.05,0.07,0.5,0.2,0.07,0.019,0.001

LABA$ = "SIZE(mm)      ORIGINAL      DDL"
OUTA$ = "  ###        #.###        #.#####"
```



```

DIM P(10), PP(10), VP(10)
'
GRAV = 980                                'GRAVITY ACCN (CM/S**2)
VISC = .01002                             'WATER VISCOSITY (POISE)
RHOP = 2.6                                'SG SAND
RHOW = 1!                                 'SG WATER
VF1 = 9 * VISC * VISC
VF2 = 3 * VISC
RHOIM = RHOP - RHOW
MMf = 1 / 1000!
'
SEDS = 10
FOR I = 1 TO SEDS
  READ P(I)
NEXT
FOR I = 1 TO SEDS
  READ PP(I)
  PX = P(I) / 10 / 2
  VP(I) = (SQR(VF1 + 1.3333 * GRAV * RHOIM * PX ^ 3) - VF2) / PX / RHOW
  VP(I) = VP(I) / 100
NEXT
```

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'          PARTICLE FALL VEL (M/S) CALCD ABOVE VIA
'          RUBEY'S (1933) FORMULA

DIM H(10), U(10), IND(10), PPN(10, 100, 10), QSI(10, 100, 10), QSO(10, 100,
10)
DIM DDLMX(10, 100, 10)
'
'   FLOW DEPTH(MM)
DATA 0.01,0.5,1,1.5,2,2.5,3,3.5
'   FLOW VELOCITY (MM/S)
DATA 5,10,20,40,70,110,160,240
'   INTER NODE DIST(M)
DATA 0.5,1,2,3.5,5,7,9,12
'
NODES = 8
ELEMENTS = 100
SEDS = 10

FOR I = 1 TO NODES
  READ X: H(I) = X / 1000
NEXT
FOR I = 1 TO NODES
  READ X: U(I) = X / 1000
NEXT
FOR I = 1 TO NODES
  READ X: IND(I) = X
  FOR II = 1 TO ELEMENTS
    FOR III = 1 TO SEDS: QSI(I, II, III) = 0!: NEXT
  NEXT
NEXT
NEXT

'
XWIDTH = 1!
'
' FLOW DEPTH IN M, FLOW VEL IN M/S, WIDTH IN M, INTER NODE DIST IN M

```

```

OPEN "O", #1, "QSOOUTJ2.DAT"
PRINT #1, "Running "; PROG$, DATE$, TIME$
PRINT #1,
PRINT "Running "; PROG$, DATE$, TIME$

DIST = 0
FOR NODE = 1 TO NODES
  DIST = DIST + IND(NODE)
  PRINT #1, : PRINT #1, "NODE"; NODE; " AT "; DIST; " METRES"
  PRINT #1, "F.DEPTH="; H(NODE); "M,    F.VEL="; U(NODE); " M/S "
  PRINT #1,
  PRINT #1, LABA$
  FOR ELE = 1 TO ELEMENTS

    IF NODE > 1 OR ELE > 1 THEN

'    CALC MASS PER UNIT AREA OF DETACHED MATERIAL TO DDL
'    AND MASS PASSING STRAIGHT THROUGH ELEMENT
    SUMDDLX = 0
    FOR SED = 1 TO SEDS
      IF ELE = 1 THEN
        QSI(NODE, ELE, SED) = QSO(NODE - 1, ELEMENTS, SED)
      ELSE
        QSI(NODE, ELE, SED) = QSO(NODE, ELE - 1, SED)
      END IF
      XSED = H(NODE) * U(NODE) / VP(SED)
      DDLX(NODE, ELE, SED) = DDLX(NODE, ELE, SED) + QSI(NODE, ELE, SED) /
XSED / XWIDTH
      SUMDDLX = SUMDDLX + DDLX(NODE, ELE, SED)
      QSO(NODE, ELE, SED) = 0
      IF XSED > IND(NODE) / ELEMENTS THEN
        QSO(NODE, ELE, SED) = QSI(NODE, ELE, SED) - QSI(NODE, ELE, SED) *
IND(NODE) / ELEMENTS / XSED
      END IF
    NEXT

'    CALC MAX MASS PER UNIT AREA RIFT CAN REMOVE FROM DDL
    SUMDDLQSOM = 0

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```

FOR SED = 1 TO SEDS
  PPN(NODE, ELE, SED) = DDLMX(NODE, ELE, SED) / SUMDDLX
  XSED = H(NODE) * U(NODE) / VP(SED)
  GOSUB 2000          'KS * F[H,D] *RR * U * W
  QSOM = QSOMSED * PPN(NODE, ELE, SED) / XSED / XWIDTH
  IF ELE = ELEMENTS THEN
    PRINT #1, USING OUTAS; P(SED); PP(SED); PPN(NODE, ELE, SED)
  END IF
REM   DDLMX(NODE, ELE, SED) = DDLMX(NODE, ELE, SED) - QSOM
REM   IF DDLMX(NODE, ELE, SED) < 0 THEN DDLMX(NODE, ELE, SED) = 0
  SUMDDLQSOM = SUMDDLQSOM + QSOM
NEXT
REM LPRINT : LPRINT "SUMDDLX "; SUMDDLX, "SUMDDLQSOM "; SUMDDLQSOM

'   CALC PROTECTIVE EFFECT OF DDL

HDDL = SUMDDLX / SUMDDLQSOM
IF HDDL > 1 THEN HDDL = 1

ELSE
  HDDL = 0
END IF

'   CALC SED DISCHARGE

QSONODE = 0
FOR SED = 1 TO SEDS
  XSEDXX = 1
  XSED = H(NODE) * U(NODE) / VP(SED)
  IF XSED > IND(NODE) / ELEMENTS THEN XSEDXX = IND(NODE) / ELEMENTS / XSED
  GOSUB 2000          'KS * F[H,D] *RR * U * W
  ONEMH = 1 - HDDL
  QSOMAT = QSOMSED * PP(SED) * XSEDXX * ONEMH * MDF
  QSODDL = QSOMSED * PPN(NODE, ELE, SED) * XSEDXX * HDDL

  IF HDDL < 1 THEN
    DDLMX(NODE, ELE, SED) = 0
  ELSE

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        QSODDLA = QSODDL / XSED / XSEDXX / XWIDTH
        DDLMX(NODE, ELE, SED) = DDLMX(NODE, ELE, SED) - QSODDLA
    END IF

    QSO(NODE, ELE, SED) = QSO(NODE, ELE, SED) + QSOMAT + QSODDL
    QSONODE = QSONODE + QSO(NODE, ELE, SED)
NEXT
NEXT          ' END ELE LOOP

PRINT #1,
PRINT #1, "f[h,r]="; Fhr, "H="; HDDL, "QSO="; QSONODE; " kg/m/s"
PRINT #1,
PRINT #1,

NEXT          ' END NODE LOOP

PRINT #1,
PRINT #1, "Execution completed "; DATE$, TIME$
PRINT "Execution completed "; DATE$, TIME$

END

' SUBROUTINES

2000    SUMKSFhd = 0
        DEPTHMM = H(NODE) * 1000!

    FOR DROP = 1 TO NSIZES
        HC = 1.74768 + 2.88237 * LOG(DSIZE(DROP))
        IF DEPTHMM <= HC THEN
            XLX = 5.7975 - .1881 * DEPTHMM
        ELSE
            B = EXP(.76649 - .48251 * DSIZE(DROP))
            XLX = 5.7975 - .1881 * HC - B * (DEPTHMM - HC)

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END IF
KSFhd = EXP (XLX) * DEPTHMM
SUMKSFhd = SUMKSFhd + KSFhd * DPROP (DROP)
NEXT

Fhr = SUMKSFhd / 644
KSSSED = 644 * EXP (-.9229 - .6324 * LOG (P (SED)))
QSOMSED = KSSSED * RR * U (NODE) * XWIDTH * Fhr
RETURN
```

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NODE 1 AT .5 METRES

F.DEPTH= .00001 M, F.VEL= .005 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000023
0.04	0.020	0.000026
0.06	0.020	0.000049
0.08	0.050	0.000199
0.10	0.070	0.000418
0.20	0.500	0.012977
0.40	0.200	0.062504
0.80	0.070	0.795278
1.00	0.019	0.128246
2.00	0.001	0.000278

$f[h,r] = 5.138963E-03$ $H = .4909803$ $QSO = 5.510634E-08$ kg/m/s

NODE 2 AT 1.5 METRES

F.DEPTH= .0005 M, F.VEL= .01 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000023
0.04	0.020	0.000026
0.06	0.020	0.000048
0.08	0.050	0.000197
0.10	0.070	0.000413
0.20	0.500	0.012808
0.40	0.200	0.056868
0.80	0.070	0.817091
1.00	0.019	0.112270
2.00	0.001	0.000256

$f[h,r] = .2335238$ $H = .4938292$ $QSO = 5.029915E-06$ kg/m/s

NODE 3 AT 3.5 METRES

F.DEPTH= .001 M, F.VEL= .02 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000018
0.04	0.020	0.000020
0.06	0.020	0.000037
0.08	0.050	0.000150
0.10	0.070	0.000315
0.20	0.500	0.009713
0.40	0.200	0.036339
0.80	0.070	0.872860
1.00	0.019	0.080382
2.00	0.001	0.000167

f[h,r]= .4231111 H= .5604797 QSO= 2.032363E-05 kg/m/s

NODE 4 AT 7 METRES

F.DEPTH= .0015 M, F.VEL= .04 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000016
0.04	0.020	0.000017
0.06	0.020	0.000032
0.08	0.050	0.000129
0.10	0.070	0.000271
0.20	0.500	0.008352
0.40	0.200	0.030218
0.80	0.070	0.901476
1.00	0.019	0.059349
2.00	0.001	0.000140

f[h,r]= .5729301 H= .5964491 QSO= 5.825154E-05 kg/m/s

NODE 5 AT 12 METRES

F.DEPTH= .002 M, F.VEL= .07 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000013
0.04	0.020	0.000014
0.06	0.020	0.000027
0.08	0.050	0.000109
0.10	0.070	0.000229
0.20	0.500	0.007027
0.40	0.200	0.024798
0.80	0.070	0.922573
1.00	0.019	0.045095
2.00	0.001	0.000115

$f[h,r] = .6831794$ $H = .6365605$ $QSO = 1.289691E-04$ kg/m/s

NODE 6 AT 19 METRES

F.DEPTH= .0025 M, F.VEL= .11 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000011
0.04	0.020	0.000012
0.06	0.020	0.000022
0.08	0.050	0.000089
0.10	0.070	0.000187
0.20	0.500	0.005734
0.40	0.200	0.019822
0.80	0.070	0.939363
1.00	0.019	0.034667
2.00	0.001	0.000092

$f[h,r] = .73939$ $H = .6815671$ $QSO = 2.334204E-04$ kg/m/s

NODE 7 AT 28 METRES

F.DEPTH= .003 M, F.VEL= .16 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000009
0.04	0.020	0.000009
0.06	0.020	0.000017
0.08	0.050	0.000071
0.10	0.070	0.000148
0.20	0.500	0.004527
0.40	0.200	0.015384
0.80	0.070	0.953140
1.00	0.019	0.026624
2.00	0.001	0.000072

f[h,r]= .7378291 H= .7300548 QSO= 3.607851E-04 kg/m/s

NODE 8 AT 40 METRES

F.DEPTH= .0035 M, F.VEL= .24 M/S

SIZE (mm)	ORIGINAL	DDL
0.02	0.050	0.000008
0.04	0.020	0.000008
0.06	0.020	0.000015
0.08	0.050	0.000062
0.10	0.070	0.000129
0.20	0.500	0.003961
0.40	0.200	0.013348
0.80	0.070	0.961215
1.00	0.019	0.021191
2.00	0.001	0.000062

f[h,r]= .6915619 H= .755344 QSO= 5.235027E-04 kg/m/s

Execution completed 07-28-1992

16:32:39