Daw 6-18-02 Examine the sensitivity of CDFs of potential bedrock infiltration to changes in SAT and Bedrock K_s

For increased SAT:

Event	File (Base)	File (Perturbed)
58_3995b	TBC17.CDF	SEN17C.CDF
G3_88_1	TBC1.CDF	SEN1C.CDF

Plot files: potential bedrock infil 58_3995b: CDFSEN\SATSEN17.PGW
" " " G3_88-1: CDFSEN\SATSEN1.PGW

For increased bedrock K_s:

Event	File (Base)	File (Perturbed)
58_3995b	TBC17.CDF	SEN17B.CDF
G3_88_1	TBC1.CDF	SEN1B.CDF

plot files: KSSEN17.PGW

Daw 7-8-02

After examining the above plot files, it appeared that there was an excessive amount of "potential bedrock infiltration." Further examination revealed that the SAT of 0.325 for upland elements for the Jan-Apr. period is only slightly below the estimated field capacity, and implies an initial storage of 131.4 mm in a soil of 1000 mm thickness, or an initial storage equal to the mean annual precipitation for a soil of about 1500 mm thickness. The SAT values were estimated from data for shallow soil moisture content and may be appropriate as an initial condition for Hortonian runoff generation. However, the assumption of SAT = 0.325 as a uniform

Daw 7-8-02

relative saturation for deep soils is obviously unrealistic and leads to overestimates of "potential bedrock infiltration." It should also be noted that if SAT is increased by 20% for the sensitivity study the initial relative saturation is greater than the field capacity. Therefore nearly all infiltration becomes "potential bedrock infiltration." Therefore a sensitivity study should require a decrease of SAT so this threshold is not exceeded.

Daw 7-9-02 Rerun the SAT Sensitivity

Initial SAT = 0.325 − 0.2(.325) = 0.260 upland areas
= 0.13 − 0.2(0.13) = 0.104 channels

Create new parameter file: SENJ_AD.PAR ✓

Control files:
SEN1D.FIL ✓ ⇒ SEN1D.OUT
SEN17D.FIL ✓

SEN1D Decrease SAT
Vol = 0.28 mm, ChanF = 0.389 mm Qp = 0.229 mm/h

$$S_V = \frac{0.28 - 0.90}{-0.2 \times 0.90} = 3.44$$

$$S_{CF} = \frac{0.389 - 0.47}{-0.2 \times 0.47} = +0.86$$

$$S_{Qp} = \frac{0.229 - 0.80}{-0.2 \times 0.80} = 3.57$$

Daw 7-9-02

SENI7D

Vol = 16.09 mm   ChanF = 0.540 mm Q_p = 3.14 mm/h

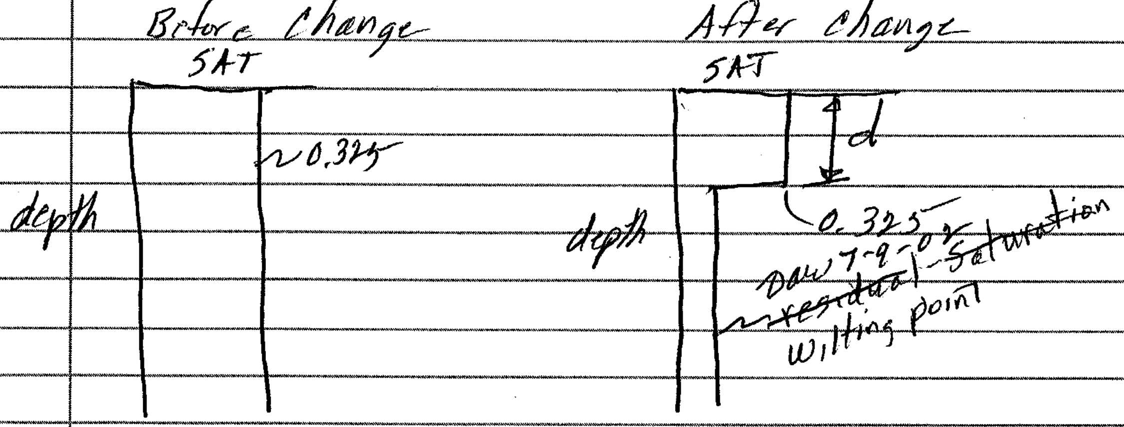
$$S_V = \frac{16.09 - 18.04}{-0.2 \times 18.04} = 0.540$$

$$S_{CF} = \frac{0.540 - 0.560}{-0.2 \times 0.56} = 0.179$$

$$S_{Q_p} = \frac{3.14 - 3.33}{-0.2 \times 3.33} = 0.285$$

Daw 8-28-02 Non-uniform initial water content.

Because of potential overestimates of runoff, bedrock infiltration and potential bedrock infiltration as described on pp 136-137, a change was made in the initial condition for KINEROS2. The moisture profile will be controlled by SAT as before, but and antecedant precipitation depth will be entered as well. This depth might correspond to the previous 7-day precipitation. For winter season, Jan-Apr. the profiles would look like this



The depth of the wetting front depends on API.

Daw 8-28-02

This profile will only be applied to the upper or "soil" layer. If d > thick it is assumed that the difference would have been surface runoff.

Revised program is KIN02-2W in C:\USW_02

Try with rainfall event G3_88_1 depth = 38 mm.
Old parameter file: SWCHJ_AL.PAR
Old control file: SW_TBC1.FIL
Old output file: SW_TBC1.OUT
From File GSWX388.CUM the following was obtained: DAW 8-28-02
Rainfall event G3_88_1 began on day 105
Between 22:42 on day 104 and 16:47 of day 105
there was only 0.01 mm of precipitation. The last rain prior to that date was on day 58-61. with a depth of 20 mm

Create a new directory for output for KIN02-2W with real precip data. C:\USW_02\OUTREAL2

New Control file: SW-TBC1.FIL → TBC1-A.FIL
.OUT file: \OUTREAL2\TBC1-A.OUT Note: An error was noted so R.E. Smith will correct it.

Daw 8-29-02

For precipitation events shown in the table p 93 determine the antecedent precipitations. For the USGS data use the *.CUM files.

Run	Rainfile	Depth	Rain starts (Day hr:min)	API
SWTBC2	G3_91_1	32mm	58 19:36	No rain since day 4 use 2mm
SW_TBC3	G3_92_1	26mm	~~4 10:14~~ 5 12:47 DAW 8-29-02	22 mm since day 363 of 91
SW_TBC4	G3_92_2	29 mm	37 3:5	No rain for 30 days use 2 mm
SW_TBC5	G3_92_3	28mm	40 21:44	29 mm since day 37
SW_TBC6	G3_92_4	31 mm	43 0:41	57 mm " " "
SW_TBC7	G3_92_5	28 mm	62 7:46	No rain for 16 days use 2 mm
SW_TBC8	G3_92_6	27 mm	89 17:18	25 mm since day 80

DAW 9-9-02 Continue estimates of API (Cont)

See table p 93

Run	Rainfile	Depth	Rain Starts (day-hr-min)	API
SW_TBC9	G3_93_1	27.	16-21-11	32 mm since day 10
SW_TBC10	G3_93_2	37.	38-21-12	5 mm since day 20
SW_TBC11	S18_95_1	30.	Mo 1-4 day	25,8 mm since 12/24
DW 9-9-02 ~~SW_TBC11~~				
SW_TBC12	S18_95_2	87	1-21-95	9.6 mm since 1/9
SWTBC13	G3_87_1	26	201-9-58	8 mm since day 170
SWTBC14	G3_87_2	34	309-1-43	20 mm since day 304
SW_TBC15	G3_92_7	59	342-1-58	2 mm since day 301
SW_TBC16	S18_94_1	24	12-24-94	0.4 mm since 12/13
SW_TBC17	S8_3995b	80	3-9-95	40.9 mm since 2/27

DAW 9-10-02

In reviewing the SAIC datafiles I find that gage 18 (the nearest to Upper Split Wash) was not operating from 2/16 through 4/19/95. Data from station 8 were used for the storm of 3/9 – 3/11/95. However, a smaller, but significant event was overlooked for gage 8. This was a storm of 35.2 mm beginning 2/28/95. Add the following rainfile (located in C:\USW_02\REAL_PRE

S8_95_3   35   2/28/95   5.2 mm since 2/14/95

DAW 9-23-02

All KINEROS (KIN02_2W) runs have been completed with the API values listed on p 139 and above. Now get output values from .out files in C:\USW_02\OUTREAL2 and create separate x.SUM files with the summary information in each .OUT file.

Run and output information in table on p 141.

DAW 9/23/02 Upper Split Wash - with API option (Cont)

Upper Split Wash KINEROS runs with tipping bucket rainfall data and API
. File: C:\USW\REALTABLE3

Run Number Note: C was omitted DW 9-23-02	Program & Date	Rain File	API (mm)	.PAR File	.FIL and .OUT File	RO Vol mm Chan. F mm	Qp mm/h Tp, min.
APISW~~C~~_1 ✓	KIN02_2W ✓ 9-20-02	G3_88_1	2	SWCHJ_AL	APISWC_1	0.19 0.43	0.16 1056
APISW~~C~~_2 ✓	KIN02_2W ✓ 9-20-02	G3_91_1	2.	SWCHJ_AL	APISWC_2	0.00 0.21	—
APISW~~C~~_3 ✓	KIN02_2W ✓ 9-20-02	G3_92_1	22.	SWCHJ_AL	APISWC_3	0.11 0.14	0.09 248
APISWC_4 ✓	Etc. ✓ 9-20-02	G3_92_2	2.	SWCHJ_AL	Etc.	0.00 0.19	—
APISWC_5 ✓	✓ 9-20-02	G3_92_3	29.	SWCHJ_AL		0.04 0.14	0.02 422
APISWC_6 ✓	✓ 9-20-02	G3_92_4	57.	SWCHJ_AL		0.09 0.14	0.03 2230
APISWC_7 ✓	✓ 9-20-02	G3_92_5	2.	SWCHJ_AL		0.00 0.20	—
APISWC_8 ✓	✓ 9-20-02	G3_92_6	25.	SWCHJ_AL		0.19 0.17	0.13 1258
APISWC_9 ✓	✓ 9-20-02	G3_93_1	32.	SWCHJ_AL		0.03 0.16	0.03 1178
APISWC_10 ✓	✓ 9-20-02	G3_93_2	5.	SWCHJ_AL		0.09 0.35	0.12 2754
APISWC_11 ✓	✓ 9-20-02	S18_95_1	26.	SWCHJ_AL		0.06 0.15	0.02 2104
APISWC_12 ✓	✓ 9-20-02	S18_95_2	10.	SWCHJ_AL		11.41 0.53	2.82 7240
APISWC_13 ✓	✓ 9-20-02	G3_87_1	8.	SWCHJ_OL		0.00 0.31	—
APISWC_14 ✓ Δt=1.0	✓ 9-20-02	G3_87_2	20.	SWCHNL		0.10 0.18	0.05 1316
APISWC_15 ✓	✓ 9-20-02	G3_92_7	2.	SWCHDL		5.06 0.56	3.06 2064
APISWC_16 ✓	✓ 9-20-02	S18_94_1	1.	SWCHDL		0.00 0.21	—
APISWC_17 ✓	9-23-02	S8_3995B	41.	SWCHJ_AL		14.85 0.34	2.97 2050
APISWC_18	KIN02_2W 9-23-02	S8_95_3	5.2	SWCHJ_AL		0.00 0.31	—

Runoff Vol. = 3.58 mm/y

Channel Infil = 0.49 mm/y

Note. The summary information is stored in a *.SUM file. Same file name but .SUM extension. DAW 9-23-02

If we compare the runoff and channel infiltration in the table above with those on p 93 we see that the mean annual runoff with the API option is 80% of that with the uniform SAT option. Channel infiltration with API is 79% of that without. This is consistent with a reduced volume of water in storage in the upper layer when the API is low.

DAW 9-23-02 Upper Split Wash with API option (Con't)

Create CDFs for annual averages of rainfall excess, bedrock infiltration, potential bedrock infiltration for entire watershed and slope classes.

1. The list file for summary output file names:
   C:\USW_02\APISW.LST ✓

2. The control file is:

   C:\USW_02\APISWAVG.CON ✓

Run Program C:\USW_02\AVGCDF.F95

DAW 9-24-02

First a slight modification in the program is required because the KIN02_2 summary output was changed. There is one compound channel (element number 123) and two rows are now created for this channel section, the first for the channel and the second for the overbank section. Both rows have the same ID number.

After examining the program carefully it appears that the best way to handle it is to call DMODEL4.PRN in the control file. Element number 123 appears twice in this file. Then set NO_ELEMTS to 217 in APISWAVG.CON

3. Prepare Figures:

CDF Files: All in C:\USW_02\CDFREAL2

APIANNUAL.CDF	- mean annual entire watershed
APIA_N.CDF	Apr - Nov " "
APICHANNEL	- mean annual - channel elements
APID_M	Dec - Mar
APIRIDGE	mean annual - ridge
APITOE	" " - Toe of slope
ARIDGEDM	Dec - Mar - ridge
APISLOPE	Mean annual - slope

DAW 9-24-02 CDFs of Infiltration - API option

A portion of a *.SUM file is shown below

```
 ID  Element       Areas            Inflow  Rainfall  Outflow    Peak   Total  Initial   Upper Layer:    Subsoil
      Type    Element Cumulated                                  Flow   Infil   Water  IniAvail Over FC  Infil.
                m^2      m^2         m^3      m^3       m^3      mm/h    m^3   Content    mm      mm       mm
  1    Plane   1787.4   1787.4     0.000  143.307     0.000      0.00  143.31  0.1314   206.99   22.60    0.00
  3    Plane    840.9   2628.3     0.000   67.424    13.885      1.26   53.58  0.1334    94.78   31.69    0.00
  5    Plane   1905.7   4534.0    13.874  152.792    48.230      2.50  118.46  0.1334    56.87   40.48    2.46
  7    Plane   2592.6   7126.6    48.216  207.866    88.749      2.94  167.37  0.1334   151.71   13.31    0.00
  9    Plane   3133.5  10260.1    88.714  251.231    62.458      1.74  277.58  0.1314   206.99   31.01    0.00
 11    Plane   2398.8  12658.9    62.413  192.329    43.429      1.26  211.38  0.1314   330.99    1.75    0.00
  2    Plane   2410.8   2410.8     0.000  193.289    55.611      5.68  137.68  0.1314    28.74   17.30   31.18
  4    Plane   1026.4   3437.2    55.586   82.292    74.751      5.29   63.16  0.1334    47.39   35.18   10.33
  6    Plane   1997.0   5434.2    74.740  160.116   105.684      4.65  129.20  0.1334   132.70   19.85    0.00
  8    Plane   2092.7   7526.9   105.649  167.787   137.900      4.31  135.57  0.1334   199.89    0.72    0.00
 10    Plane   1425.1   8952.0   137.876  114.256   115.537      3.40  136.63  0.1314   405.39    0.00    0.00


106  Channel     41.1   36452.2  270.767     3.295  272.265     1.67    1.80  0.0999   159.07    2.91   26.29
115  Channel     57.2   43774.4  426.850     4.586  428.803     2.08    2.64  0.0999   159.07    4.99   27.05
123 Compound     27.2   47409.2  473.246     2.181  464.557     2.08    1.35  0.0999   159.07    4.25   28.38
123 Overbank    108.8                        8.723                      8.72  0.0999   323.12    0.00    0.23
131  Channel     37.2   52354.3  537.012     2.983  538.076     2.21    1.92  0.0999   159.07    6.86   29.08
137  Channel     36.6   56786.2  588.469     2.934  589.443     2.22    1.96  0.0999   159.07    7.93   29.80
146  Channel    165.0  159795.3 1903.423    13.229 1908.193     2.56    8.45  0.0999    63.63   13.36   30.00
157  Channel    203.7  174025.7 2130.828    16.332 2136.755     2.58   10.40  0.0999    63.63   13.65   29.66
164  Channel     34.9  178686.1 2214.917     2.798 2214.722     2.59    2.98  0.0999    63.63   24.65   41.77
174  Channel     76.0   11698.4  263.842     6.090  266.806     4.62    3.13  0.0999    15.91   13.95   25.19
180  Channel     80.2   20269.0  438.627     6.427  441.639     4.43    3.41  0.0999    15.91   13.92   26.45
190  Channel     41.9  209735.8 2839.555     3.359 2838.808     2.77    4.09  0.0999    63.63   30.24   46.69
199  Channel    132.0  228940.7 3287.164    10.583 3288.772     2.92    8.98  0.0999    63.63   20.06   35.75
209  Channel     89.4  240743.4 3535.356     7.168 3535.068     2.95    7.45  0.0999    63.63   26.77   41.14
216  Channel    229.2  258551.2 3834.436    18.376 3838.714     2.97   14.10  0.0999    95.44   16.53   32.78
```

This information is the same as that on p 92 except that now Col. 12 is the depth of water in the upper layer above field capacity. Thus the potential bedrock infiltration is the sum of Cols 12 and 13.

The form of *.CDF files is identical to that on p 123.

9-27-02 DAW - Run Program STORMCDF.F95 for rainfall events G3-93_2 (APISWC_10) and 518-95_2 (APISWC_12)

Control files: C:\USW_02\APT10CDF.CON + ~~APICD1~~ DAW 9-27-02 APT12CDF.CON

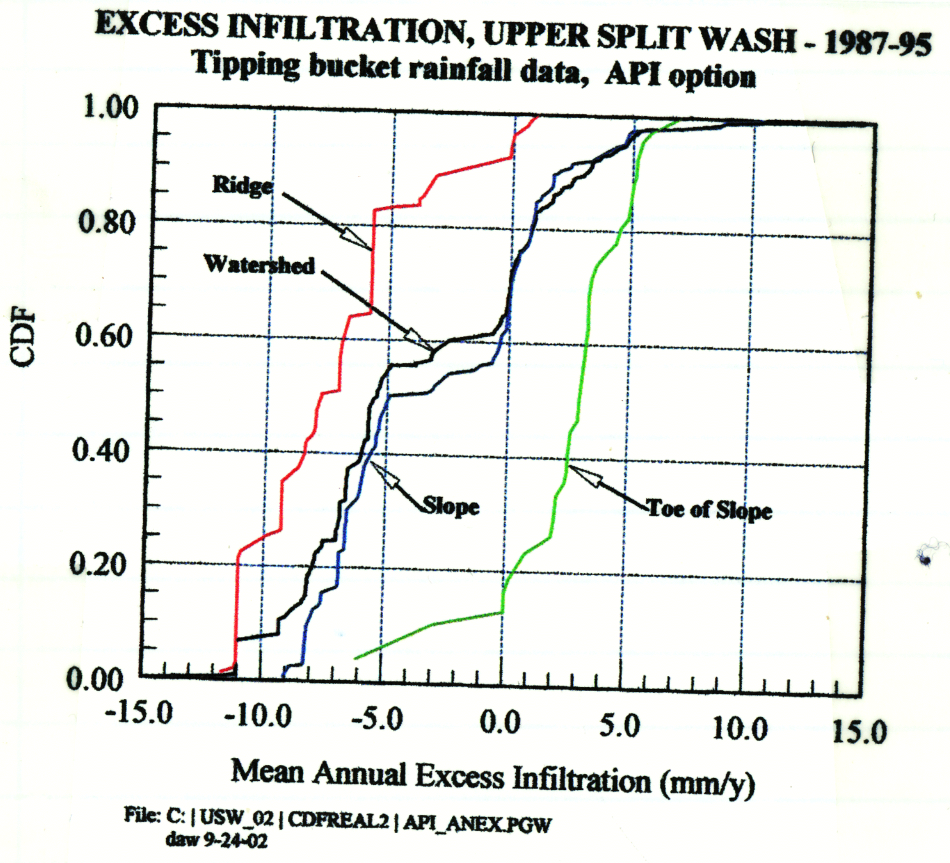
Others APT10CDF.LST, APT12CDF.LST

For APISW_10: Rock Infiltration = 4.15 mm
= 7.56 mm over 55 % of area

For APISW_12: Rock F = 19.46 mm
= 26.69 mm over 73 % of area

DAW 9-25-02 Upper Split Wash – Tipping bucket data
API option 1987-95 (Cont')

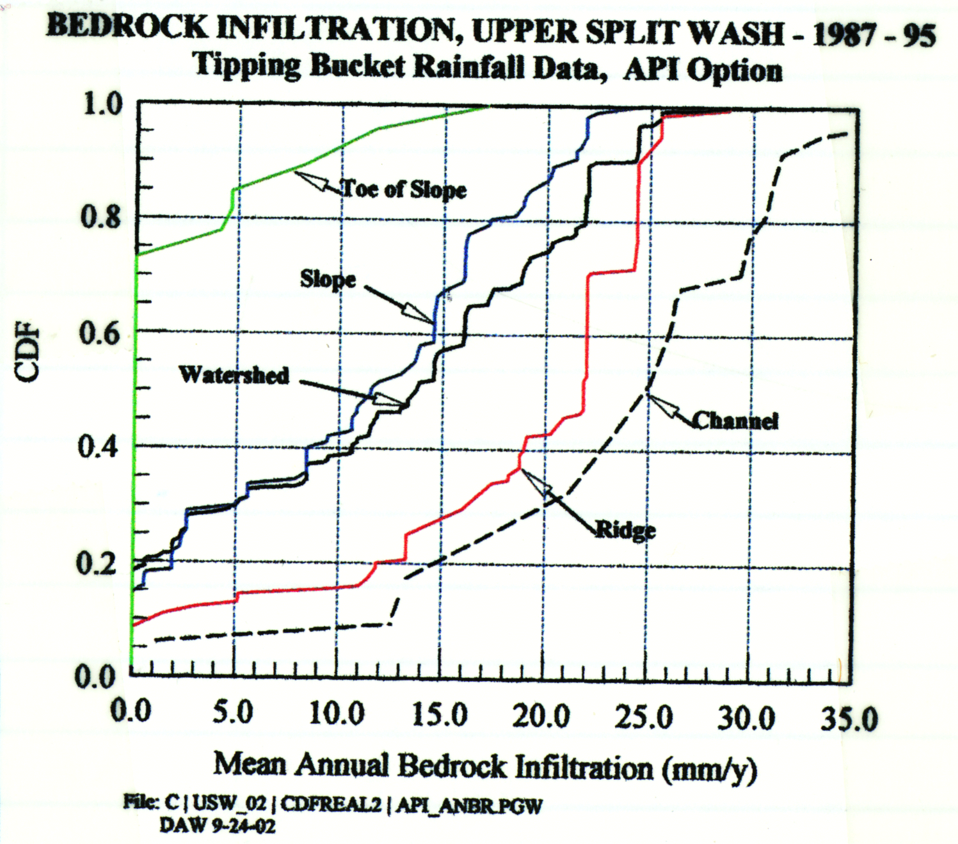
The CDFs of excess infiltration for the watershed and for 3 slope classes are shown in the following figure.


EXCESS INFILTRATION, UPPER SPLIT WASH - 1987-95
Tipping bucket rainfall data, API option

File: C: | USW_02 | CDFREAL2 | API_ANEX.PGW
daw 9-24-02

If we compare these CDFs with those on the top of page 98, we see that the API option results in less runoff (Negative Excess) and consequently there is less runon.

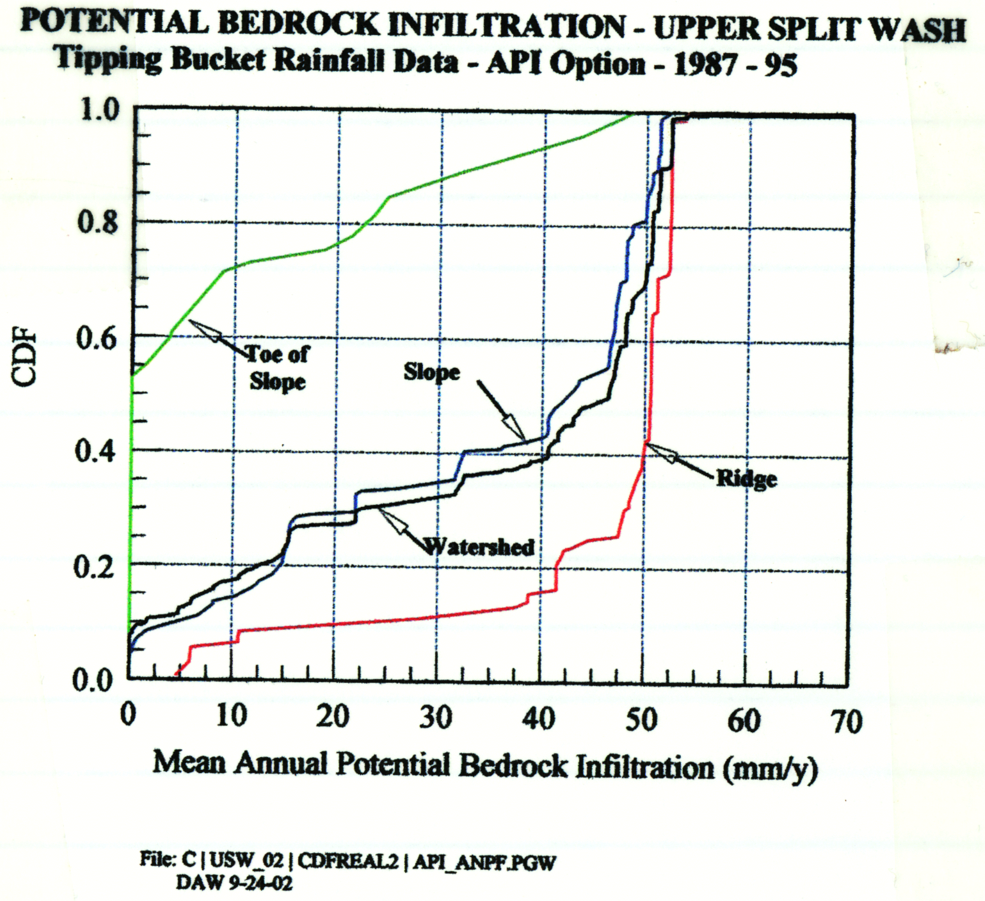
CDFs of bedrock infiltration during the storm are shown below. If we compare this figure with that on p.100 DAW 9-25-02 we see that at a CDF value of 0.8, infiltration with the API option is 2-5 mm greater than with the uniform initial condition. Part of this increase is due to the additional storm (p140) and part is due to the drier initial condition in the bedrock layer for the API option.


BEDROCK INFILTRATION, UPPER SPLIT WASH - 1987 - 95
Tipping Bucket Rainfall Data, API Option

File: C: | USW_02 | CDFREAL2 | API_ANBR.PGW
DAW 9-24-02

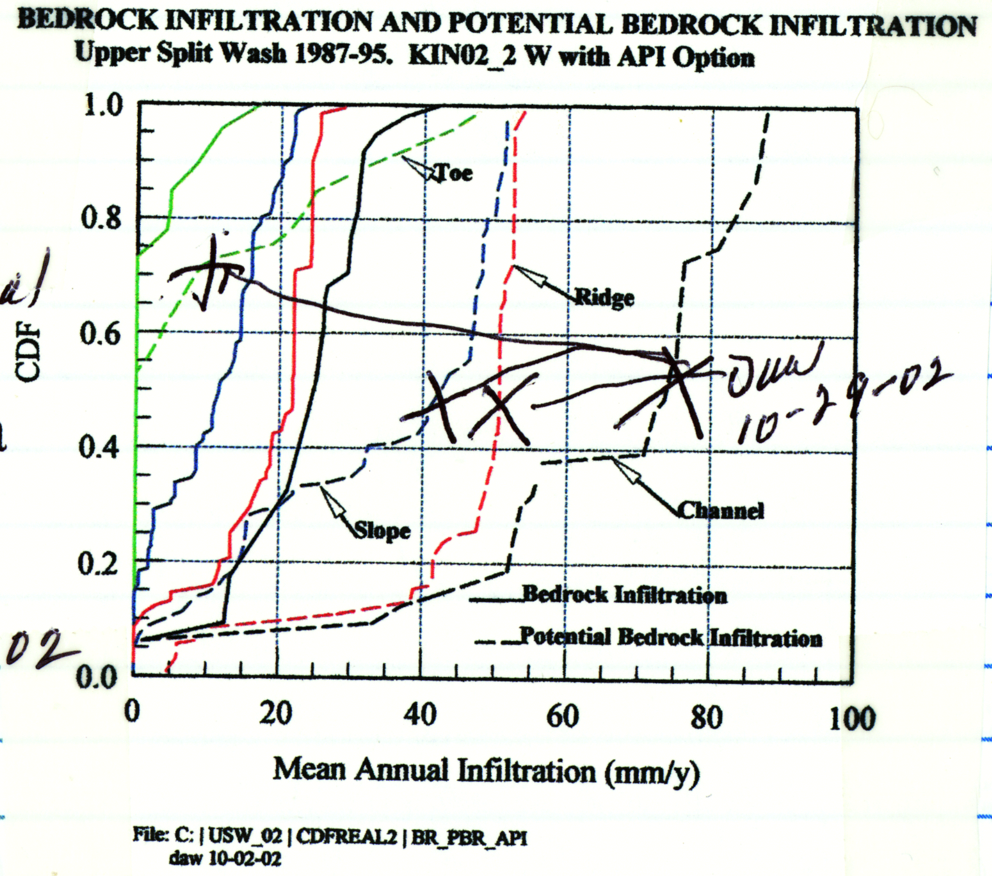
Note:
The potential bedrock infiltration is incorrect.
see p.150
DAW 10-29-02

DAW 10-2-02
CDFs of potential bedrock infiltration are shown below. If this figure is compared with that on the bottom of p 101 we see that the API option leads to considerably more potential bedrock infiltration. This is apparently due to the additional storm, the lower runoff and the drier initial condition for the bedrock layer.


POTENTIAL BEDROCK INFILTRATION - UPPER SPLIT WASH
Tipping Bucket Rainfall Data - API Option - 1987 - 95

File: C | USW_02 | CDFREAL2 | API_ANPF.PGW
DAW 9-24-02

CDFs of bedrock infiltration are compared with CDFs of potential bedrock infiltration in the figure below. At the CDF of 0.80 the horizontal deviation ranges from 17.5 mm for toe-of-slope elements to 54 mm for channels. This is caused by the greater soil depths for toe elements and the infiltration from runoff in the channels, as well as the higher porosity for channel elements.


BEDROCK INFILTRATION AND POTENTIAL BEDROCK INFILTRATION
Upper Split Wash 1987-95. KIN02_2 W with API Option

File: C: | USW_02 | CDFREAL2 | BR_PBR_API
daw 10-02-02

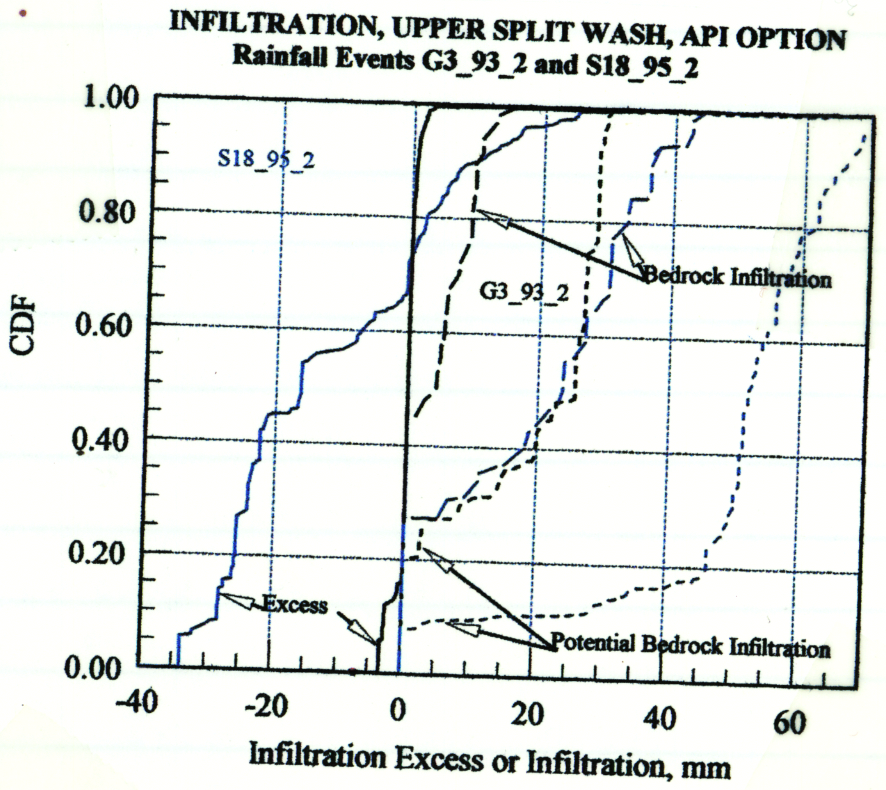
DAW 10-9-02
This figure emphasizes the extreme spatial variability of infiltration and potential deep percolation on Upper Split Wash. The large difference between bedrock infiltration and potential bedrock infiltration for channels indicates that evapotranspiration will play a critical role.

DAW 10-4-02

daw 10-4-02

Prepare graphics for CDFs of individual events, G3_93_2 (API_SW10, API = ~~37~~ 5 mm) and S18_95_2 (API_SW12, API = 9.6 mm). See p 143 for control file names.

DAW 10-9-02 Infiltration excess, bedrock infiltration, Fb and potential bedrock infiltration (Fpb) are shown below for the above two storms. This figure illustrates that the runoff-runon phenomenon is extremely important for the large storm, but is insignificant for the smaller storm



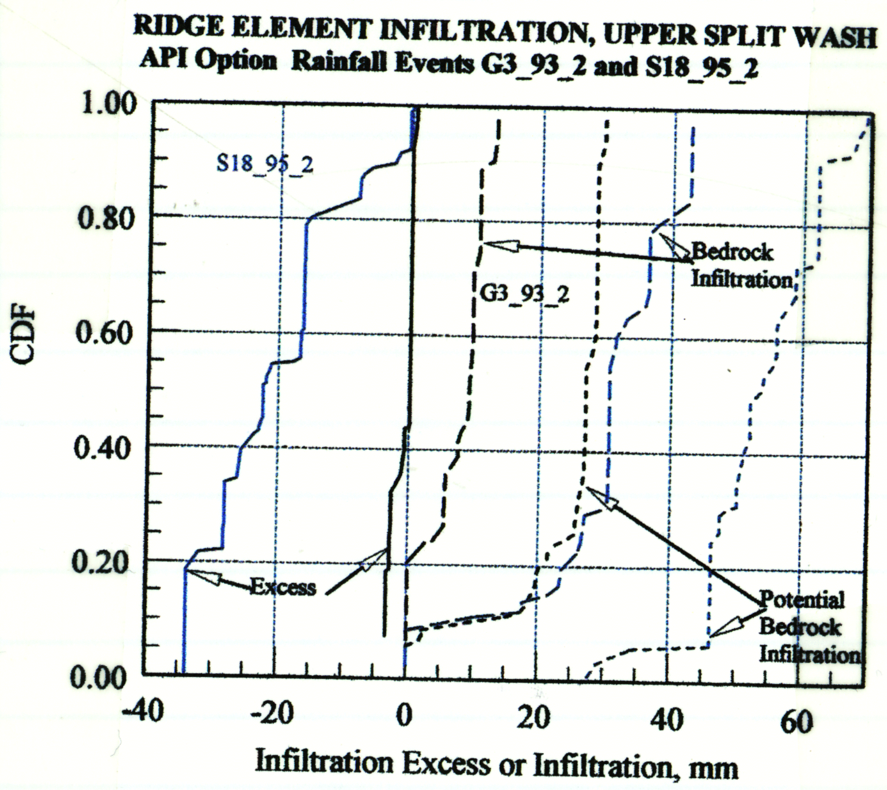
File: C: | USW_02 | CDFREAL2 | 12VS10WSHED.PGW
daw 10-4-02

For S18-95-2 the greatest runoff is for channels on bedrock and the greatest runon is for channels with alluvium depths of 500 mm. They also exhibited the greatest Fpb. Channels 190, 164, 209 and 22 had the greatest Fb. Channel 22 is on bedrock, the other three have alluvium depths of 200 mm, but are located in the lower portion of the watershed and are subject to longer flow durations.

CDFs for ridge elements are shown on p 147

If we compare the potential bedrock infiltration given in files API12.CDF (~~Average Annual~~ Storm S18-95-2) DAW and APIANNUAL.CDF (Average annual) we find that for ridge plane element 99 the single storm contributed 18% of the mean annual. For plane element 167 storm S18-95-2 contributed 12%. with 18 storms, each would contribute 5.5% if contributions were equal.

DAW 10-9-02



File: C: | USW_02 | CDFREAL2 | 12VS10RID.PGW
daw 10-4-02

DAW 10-11-02

In reviewing the detailed output for the runs documented in the table on p 141, a discrepancy was discovered for the channels where the API rainfall was sufficient to wet the profile to the lower layer. This resulted in the channel infiltration to be too low.

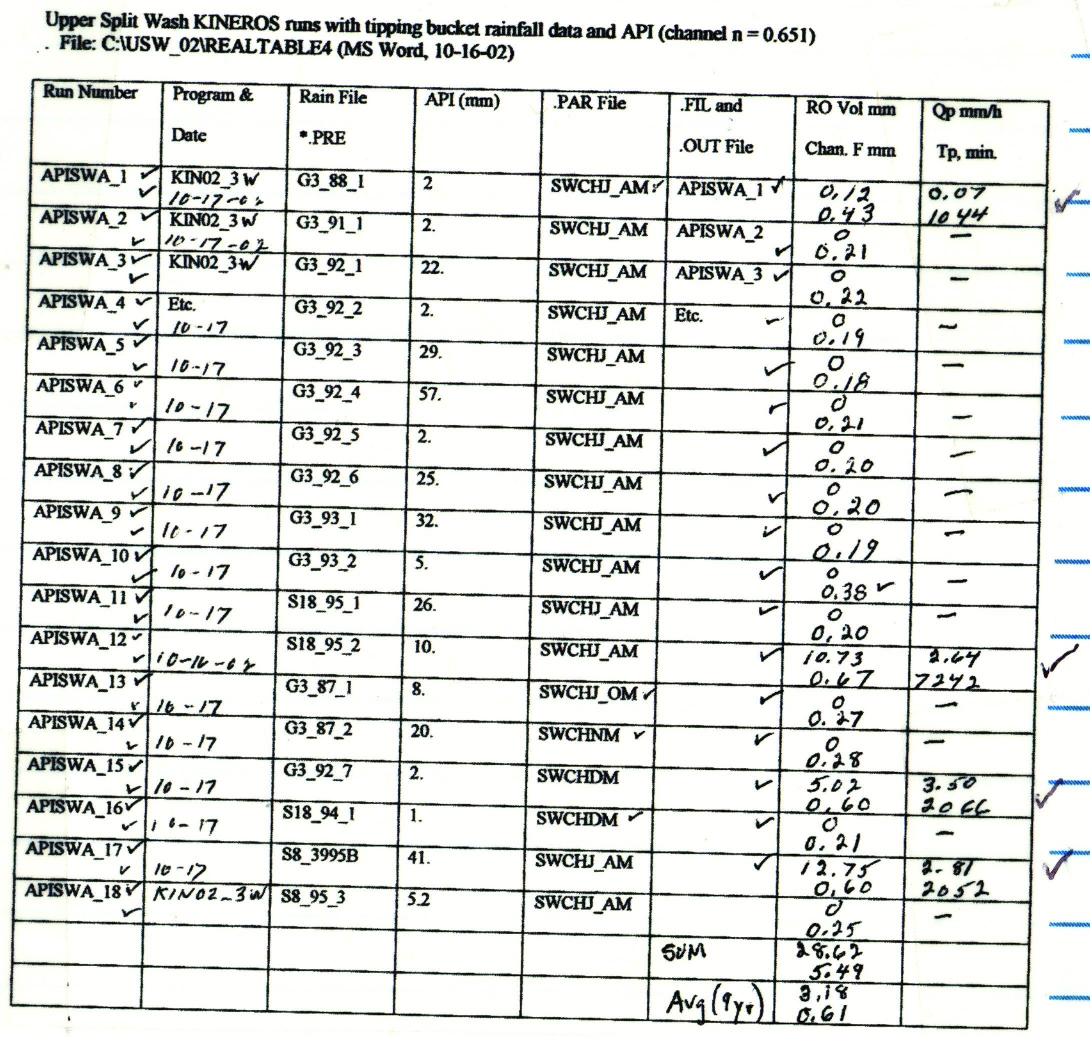
Also an e-mail from Fedors suggested that the Manning's n used in the channels was too low. Accordingly the KINEROS program output was modified by R.E. Smith and new parameter files were prepared with a channel Manning's n of 0.0651. These revised parameter files have the form *M.PAR while the previous files had the form *L.PAR.

Computer runs will be made with the new files.

DAW 10-17-02

Computer runs with KIN02_3.F95 were completed. Results are shown in the table on p 148.

Daw 10-17-02 Tipping Bucket Rainfall - Upper Split Wash
Channel n = 0.0651, API Option



Upper Split Wash KINEROS runs with tipping bucket rainfall data and API (channel n = 0.651)
. File: C:\USW_02\REALTABLE4 (MS Word, 10-16-02)

Run Number	Program & Date	Rain File *.PRE	API (mm)	.PAR File	.FIL and .OUT File	RO Vol mm Chan. F mm	Qp mm/h Tp, min.
APISWA_1 ✓ ✓	KIN02_3W 10-17-02	G3_88_1	2	SWCHJ_AM ✓	APISWA_1 ✓	0.12 0.43	0.07 1044
APISWA_2 ✓ ✓	KIN02_3W 10-17-02	G3_91_1	2.	SWCHJ_AM	APISWA_2 ✓	0 0.21	—
APISWA_3 ✓ ✓	KIN02_3W	G3_92_1	22.	SWCHJ_AM	APISWA_3 ✓	0 0.22	—
APISWA_4 ✓ ✓	Etc. 10-17	G3_92_2	2.	SWCHJ_AM	Etc. ✓	0 0.19	—
APISWA_5 ✓ ✓	10-17	G3_92_3	29.	SWCHJ_AM	✓	0 0.18	—
APISWA_6 ✓ ✓	10-17	G3_92_4	57.	SWCHJ_AM	✓	0 0.21	—
APISWA_7 ✓ ✓	10-17	G3_92_5	2.	SWCHJ_AM	✓	0 0.20	—
APISWA_8 ✓ ✓	10-17	G3_92_6	25.	SWCHJ_AM	✓	0 0.20	—
APISWA_9 ✓ ✓	10-17	G3_93_1	32.	SWCHJ_AM	✓	0 0.19	—
APISWA_10 ✓ ✓	10-17	G3_93_2	5.	SWCHJ_AM	✓	0 0.38 ✓	—
APISWA_11 ✓ ✓	10-17	S18_95_1	26.	SWCHJ_AM	✓	0 0.20	—
APISWA_12 ✓ ✓	10-16-02	S18_95_2	10.	SWCHJ_AM	✓	10.73 0.67	2.64 7242
APISWA_13 ✓ ✓	10-17	G3_87_1	8.	SWCHJ_OM ✓	✓	0 0.27	—
APISWA_14 ✓ ✓	10-17	G3_87_2	20.	SWCHNM ✓	✓	0 0.28	—
APISWA_15 ✓ ✓	10-17	G3_92_7	2.	SWCHDM	✓	5.02 0.60	3.50 2066
APISWA_16 ✓ ✓	10-17	S18_94_1	1.	SWCHDM ✓	✓	0 0.21	—
APISWA_17 ✓ ✓	10-17	S8_3995B	41.	SWCHJ_AM	✓	12.75 0.60	2.81 2052
APISWA_18 ✓ ✓	KIN02_3W	S8_95_3	5.2	SWCHJ_AM		0 0.25	—
					SUM	28.62 5.49	
					Avg (9yr)	3.18 0.61	

This resulted in only 4 surface runoff events for the 9-Yr period. The mean annual runoff was 3.18 mm/y 0.40 mm/y less that show on the table p 41. The mean annual channel infiltration increased to 0.61 mm/y, consistent with reduced runoff from the watershed and a higher Mannings n which leads to slower channel response.

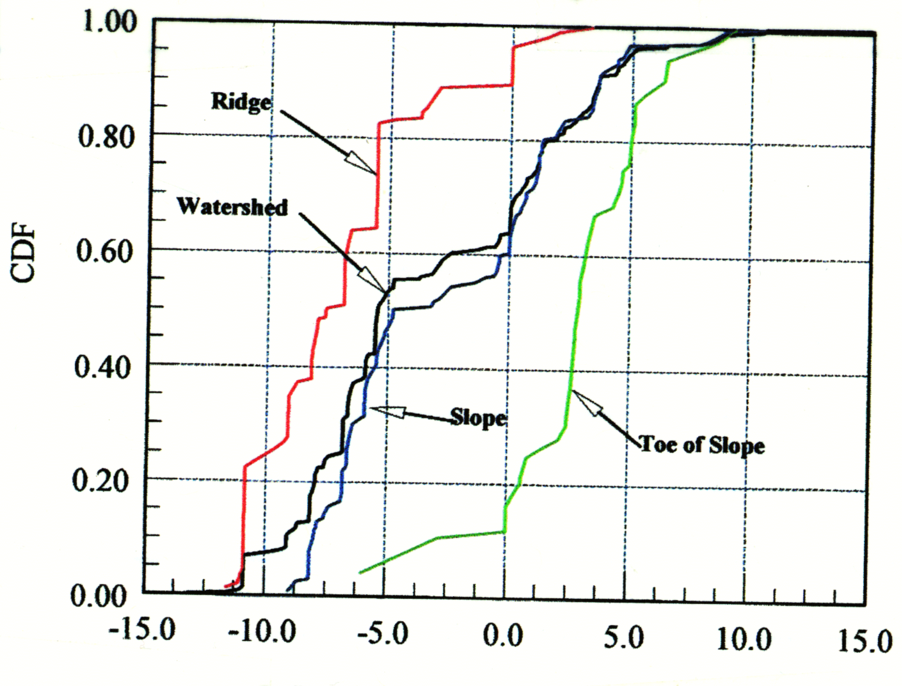
Run program C:\USW_02\AVGCDF.F95
Control file: APISWAVGA.CON } in C:\USW_02
List " : APISWA.LST }
output showed mean bedrock infiltration of 12.3 mm/y
or 15.0 mm/y over 80% of watershed

Daw 10-28-02

The CDFs of Excess Infiltration for the entire watershed and for each slope class are shown below

There is a minor difference between these CDFs and those on p 144, reflecting the correction in the API option and Mannings n.

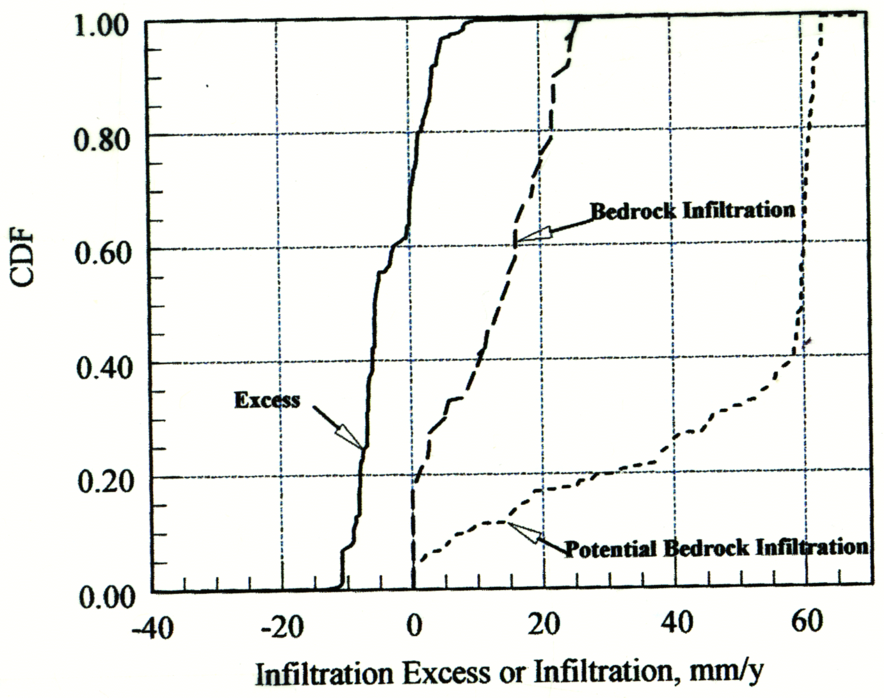
EXCESS INFILTRATION, UPPER SPLIT WASH, 1987-95
API Option, Channel Manning's n = 0.0651



File: C: | USW_02 | CDFREAL2 | APIA_ANEX.PGW
daw 10-21-02

CDF's of mean annual bedrock infiltration, potential bedrock infiltration and infiltration excess for Upper Split Wash are shown below.

WATERSHED INFILTRATION, UPPER SPLIT WASH, 1987-95
API Option, Channel Manning's n = 0.065



File: C: | USW_02 | CDFREAL2 | APIAANNUAL.PGW
daw 10-21-02

Potential bedrock infiltration is greater than that shown on p 145 (API_ANPE.PGW). This reflects the correction of the API option. The watershed excess CDF and bedrock infiltration are only slightly different from CDFs shown on p 144 & p 145.

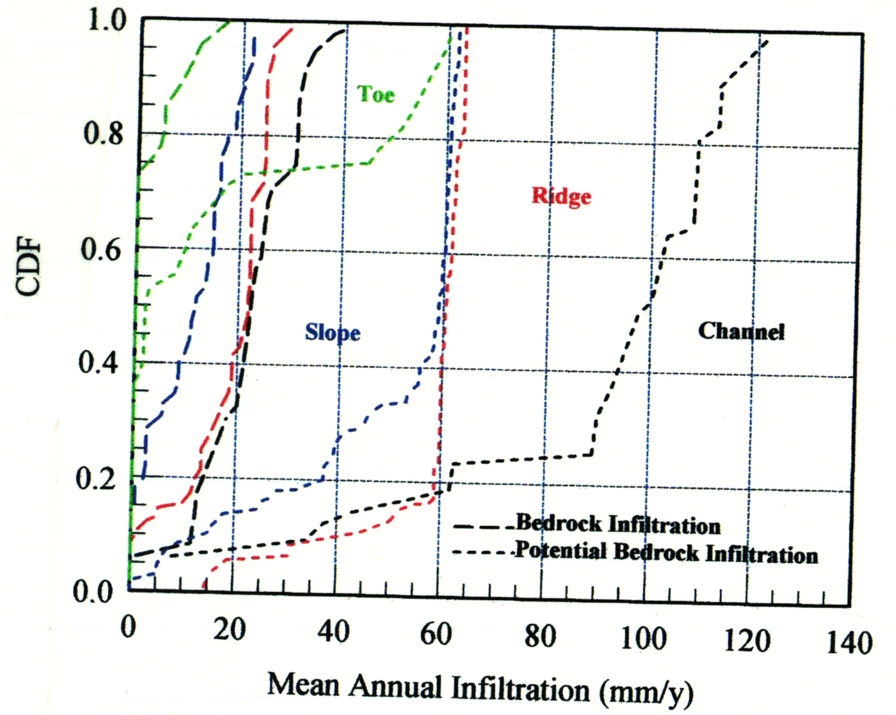
The mean annual potential runoff-producing rainfall for the 9-yr period was 75.4 mm and there were 2 events per year on average.

~~steep betwe~~ Daw 10-28-02 Note that the CDF is very steep between 55 and 65 mm/y, reflecting 60% of soils with a depth < 200 mm. See soil depth CDF on p 107. The elements with no potential bedrock infiltration had soil depths > 2000 mm

DAW 10-28-02

CDFs of bedrock and potential bedrock infiltration (Annual averages for 9-yrs) are shown below. If we compare these CDFs with those on the bottom of p145 we see that the potential bedrock infiltration Fbp is now much greater. This is due to the correction in the API infiltration option and to the higher Mannings n for the channels. Soil depths of 120mm had the greatest Fbp. For channels the greatest Fbp was in element 146 with a depth of alluvium = 200 mm, next was element 137 with 500mm

BEDROCK INFILTRATION AND POTENTIAL BEDROCK INFILTRATION
UPPER SPLIT WASH, 1987-95. KIN02_3, API Option, Channel Manning's n = 0.065



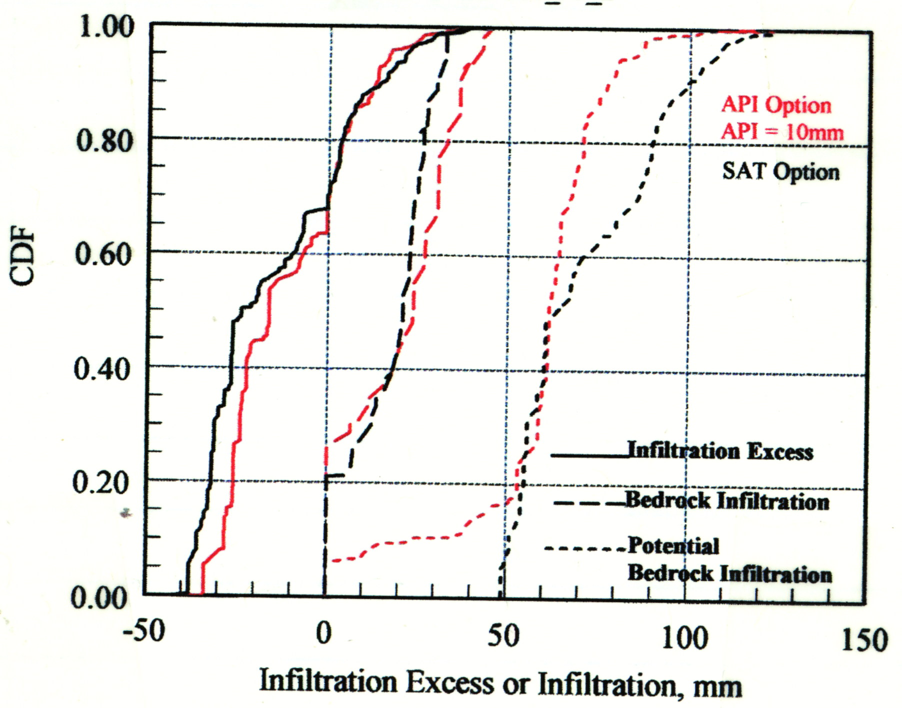
File: C : | USW_02 | CDFREAL2 | FP&PB_API.PGW
daw 10-28-02

The effect of the API option versus the SAT option was examined for a single storm as well.
Run APISW12A had an API of 10 mm.
Run APISW12B had the SAT option The effect is shown in the following figure. The API option results in about 25% of the watershed having no bedrock infiltration and about 6% of the watershed having no potential bedrock infiltration. This is much more realistic. The API option also has less runoff (and runon).

Conclusion:

The API option is preferred.

COMPARISON OF API OPTION WITH SAT OPTION
Rainfall Event S18_95_2



File: C: | USW_02 | CDFREAL2 | 12AVS12B.PGW
daw 10-29-02

DAW 10-29-02

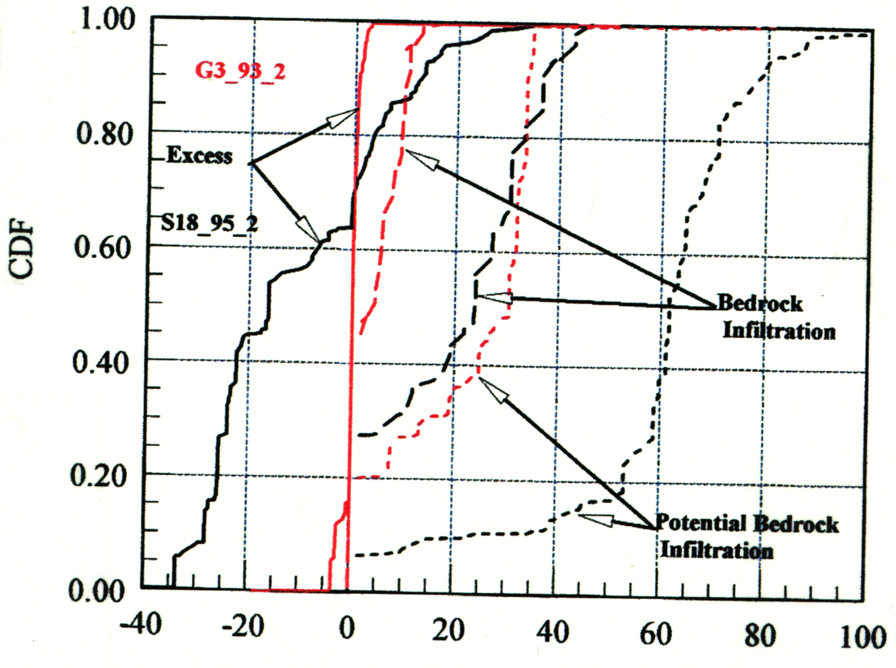
Check effect of an increase in channel Mannings n.
Create APISW12C.FIL with SWCHJ_AL.PAR and APISW#2C.OUT

This resulted in a slight increase in runoff 10.74 mm versus 10.73mm with n in channels = 0.0165. The peak flow rate increased to 2.70 mm/h @ 7240 min vs 2.64 mm/h @ 7242 min. The channel infiltration was reduced slightly 0.65 mm vs 0.67 mm. It appears that while a Mannings n of 0.0651 is more realistic, channel infiltration and runoff are not very sensitive to channel Mannings n for this small, steep watershed.

DAW 10-30-02

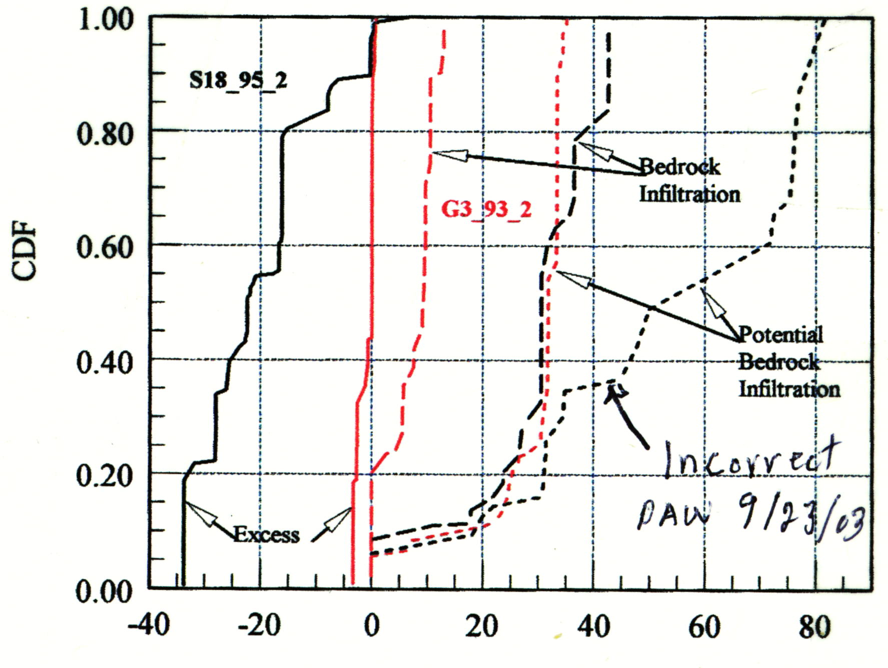
Computer runs with KIN02_3 were made DAW ~~run~~ for storms G3-93-2 and S18-95-2 as discussed on p 146 Infiltration excess, bedrock infiltration and potential bedrock infiltration CDFs for the watershed and for ridge elements are shown below. The infiltration excess and bedrock infiltration are nearly identical to the curves on pp 146+147 but potential bedrock infiltration is greater.

INFILTRATION, UPPER SPLIT WASH, API OPTION
Rainfall Events G3_93_2 and S18_95_2



File: C: | USW_02 | CDFREAL2 | 12AVS10AWSHED.PGW
daw 10-29-02

RIDGE ELEMENT INFILTRATION, UPPER SPLIT WASH
API Option Rainfall Events G3_93_2 and S18_95_2



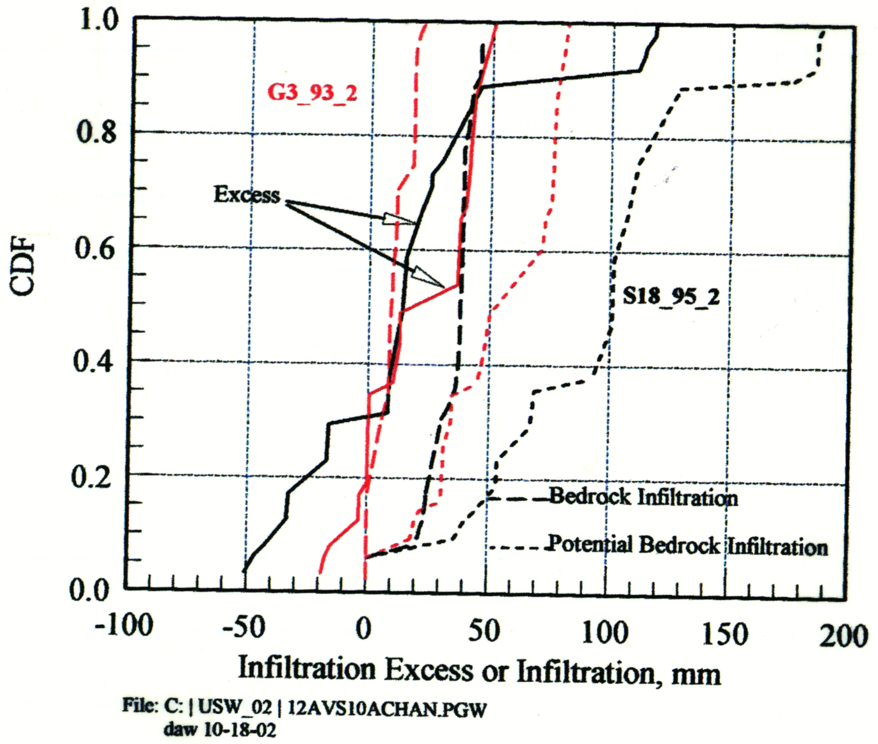
Incorrect
DAW 9/23/03

File: C: | USW_02 | CDFREAL2 | 12AVS10ARID.PGW
daw 10-18-02

Daw 10-30-02

Infiltration excess, bedrock infiltration and potential bedrock infiltration for the two storms for channel elements are shown below.

CHANNEL ELEMENT INFILTRATION, UPPER SPLIT WASH
API Option, Events G3_93_2 and S18_95_2

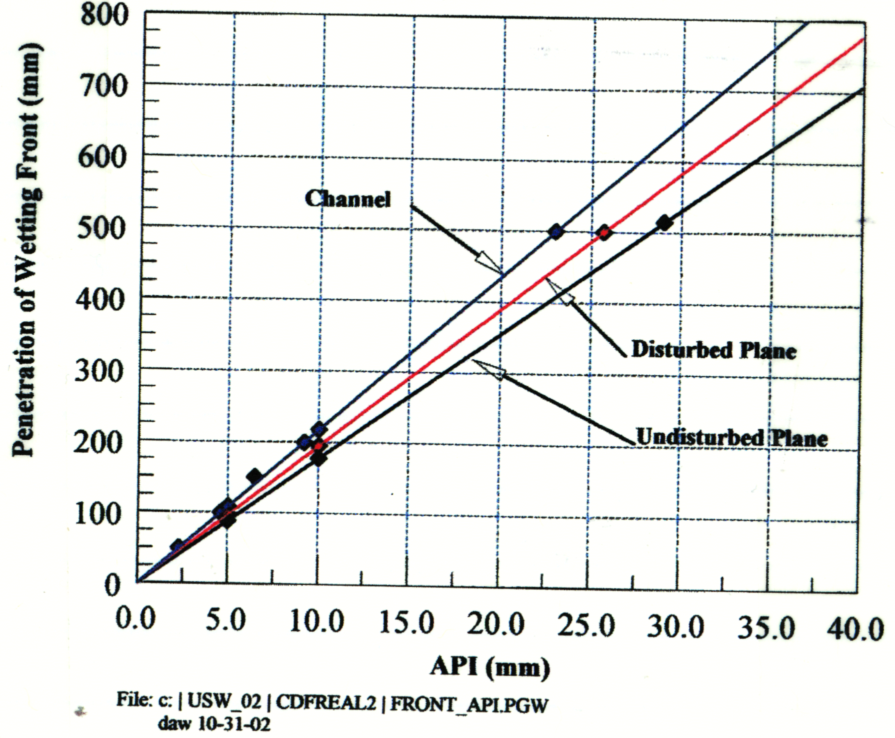


File: C: | USW_02 | 12AVS10ACHAN.PGW
daw 10-18-02

Note Daw 11-6-02

Given the textural characteristics of the "soils" in upper Split Wash, the value of API has little effect for the shallowest soils. (See computations on pp 154-155

PENETRATION OF WETTING FRONT FOR JAN. - APR.
Plane SAT = 0.325; Channel SAT = 0.13



File: c: | USW_02 | CDFREAL2 | FRONT_API.PGW
daw 10-31-02

For a soil depth of 120 mm an API of 6.1 mm will result in the same initial condition as without the API option. (See relationships on the left. This holds for the Jan-Apr period. Thus the API option affects the shallowest soils for 7 of the 18 events in the Table on p 148.

Daw 10-30-02

Prepare a figure similar to that on p 104. - Mean annual potential bedrock infiltration versus soil and channel alluvium depth

Procedure

1) Copy file REALCDF\THICK_F.DAT
to REALCDF2\THICK_FA.DAT ✓

2) Enter data from files \CDFZEAL2\APIANNUALA.CDF and \APICHANNLA.CDF into Cols 3 and 6 of THICK_FA.DAT ✓

3) Fit regression equations with PROSTAT

Daw 10-31-02

Planes:

$y = 68.83 - 0.0499X$ $R^2 = 0.817$

x = depth of soil or alluvium in mm

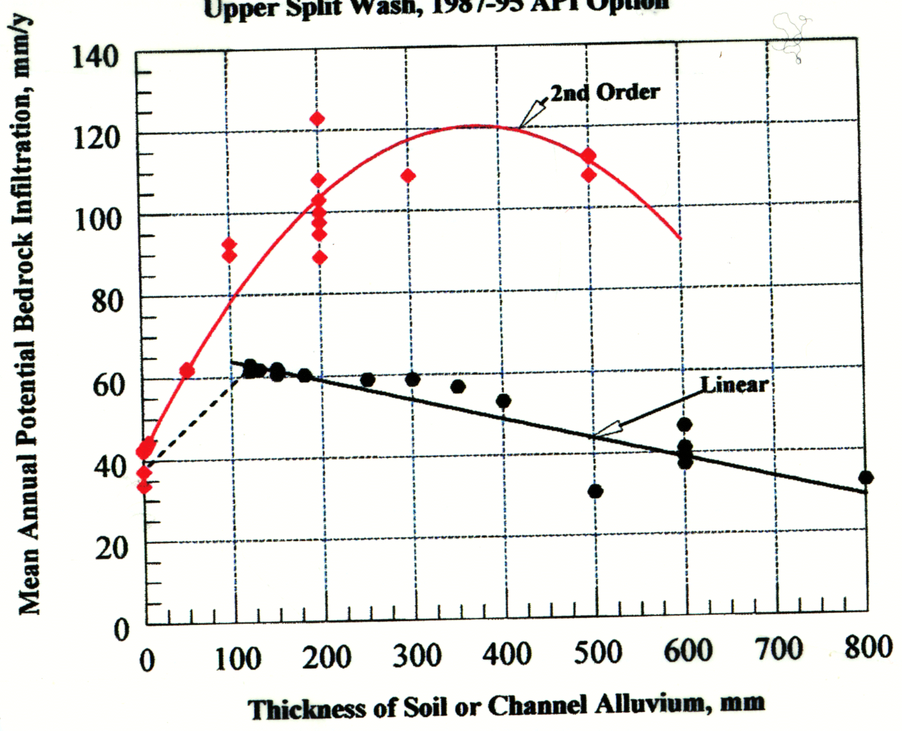
y = mean annual potential bedrock infiltration

Channels:

$y = 42.2 + 0.419X - 0.00056X^2$ $R^2 = 0.91$

The data for selected plane and channel elements and the above curves are shown in this figure. Channel elements in red. Although the potential bedrock infiltration is greater for these elements than that shown on p 104 it appears that there is an optimum channel alluvium depth around 350 mm. A dotted line for plane elements suggests that for bare rock Fbp is similar to that for bedrock channels

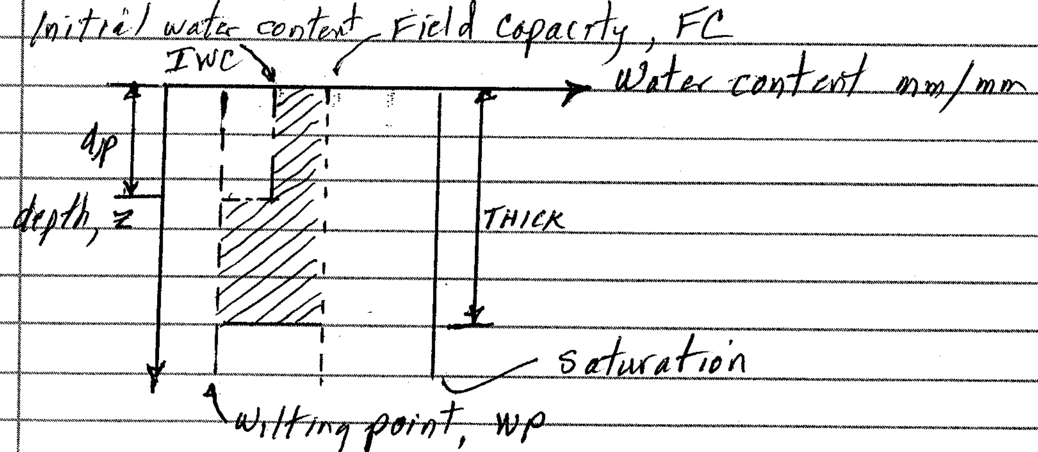
MEAN ANNUAL POTENTIAL BEDROCK INFILTRATION VS SOIL DEPTH
Upper Split Wash, 1987-95 API Option



File: C: | USW_02 | CDFREAL2 | THICK_FA.PGW
daw 10-31-02

DAW 11-2-02 API Option - Further Analysis

1. Penetration of API front



Note: IWC, WP and FC values from *.OUT files
Given the above initial water content profile

$$(IWC - WP)\,d_p = API \qquad d_p \leq THICK \text{ (soil depth)}$$

$$d_p = API/(IWC - WP)$$

The cross hatched area in the figure represents the volume of infiltration that can be retained if the final profile is at field capacity.

$$R_{fc} = (FC - WP)\,THICK - (IWC - WP)\,d_p; \quad d_p < THICK$$

$$= (FC - WP)\,THICK - API$$

where R_{fc} is retention at field capacity

For undisturbed soils during the Jan - Apr period

$$R_{fc} = (0.1326 - 0.075)\,THICK - API$$

$$= 0.0576\,THICK - API \qquad R_{fc} \geq 0.0012\,THICK$$

$$d_p = API/(0.1314 - 0.075) = 17.73\,API$$

DAW 11-2-02

For disturbed soils Jan - Apr

$$R_{fc} = (0.1462 - 0.0821)\,THICK - API$$

$$= 0.0641\,THICK - API \qquad R_{fc} \geq 0.0148\,THICK$$

$$d_p = API/(0.1334 - 0.0821) = 19.49\,API$$

For Channel Alluvium Jan - Apr

$$R_{fc} = (0.0751 - 0.0539)\,THICK - API$$

$$= 0.0212\,THICK - API \qquad R_{fc} \geq 0.0248$$

$$d_p = API/(0.0999 - 0.0539) = 21.73\,API$$

Thus with this initial water content and a sufficiently large API, some of the water present as an initial condition would become potential bedrock infiltration

DAW 11-5-02 Maximum retention.

If API = 0 there is a maximum amount that can be retained if the initial profile is at wilting point

Undisturbed Soils

Jan - ~~Apr~~ Dec $R_{max} = 0.0576$ THICK

~~Jul - Oct~~ ~~$R_{max} =$~~
~~Nov~~ ~~$R_{max} =$~~
~~Dec~~ ~~R~~

DAW 11-5-02 The maximum retention does not vary seasonally

Disturbed Soils: $R_{max} = 0.0641$ THICK

Channels: $R_{max} = 0.0212$ THICK

DAW 11-5-02 Run 2 storms from the Solitario Canyon Study with the API option. The storms (simulated) 11SEP5A and PAUG4 which led to 10yr and 100yr peak flow rates for Solitario Canyon were selected by Woolhiser et al 2000, "Channel Infiltration in Solitario Canyon, Yucca Mountain, Nevada" ASCE Journ of Hydrologic Engr. Vol 5 No 3. p240-249 for sensitivity analysis for Hortonian Runoff generation.

1. Find API values:

11SEP5A - from file THIRD50.DUR API = 9.1 mm
Depth = 37.34 mm
PAUG4 - from file 50150-2.DAY
Depth = 26.67 mm - No rain for 15 days use API = 0.1 mm
Dur = 36 min

2. Parameter File: SWCHJ-OM.PAR
PLANE SAT = 0.155
CHANNEL SAT = 0.13

3 Control files
11SEP5A → API-SEP5.FIL
OUTREAL2\API-SEP5.OUT
RO = 6.74 mm, Q_p = 9.1 mm/h at 56 min Chan F = 0.616 mm
PAUG4 → API-AUG4.FIL
OUTREAL2\API-AUG4.OUT
RO = 11.55 mm, Q_p = 36.9 mm/h @ 12 min Chan F = 1.08 mm

DAW 11-6-02 Sensitivity with API Option and Rain-on-channel. Channel Mannings' n = 0.0651

See p 130 for sensitivity studies with rain on channel but without API option.

1. Create new folder C:\USW-02\SENSITIV2 ✓

All control and parameter files will be in this directory.

As before I will use 4 rainfall events, S18-95-2, S8-3995b, G3-88-1 and G3-92-7. These events all caused surface runoff and had a range of APIs.

If we examine the figure on p 154 we see that the volume of water that can be retained above field capacity is a function of the soil thickness and the API. However it is also related ~~th~~ DAW 11-6-02 to the parameter G and the porosity. through WP and FC. If we differentiate the expression for water retained at field capacity

$$dR_{FC} = (FC - WP)\,d\,Thick - d\,API$$

This quantity will be an important factor determining potential bedrock infiltration.

Sensitivity coefficients will be determined for perturbations of soil thickness, THICK, API, bedrock K_S, G and DIST

The objective functions (outputs) to be considered are: runoff volume, Total Channel F, peak rate of runoff, median bedrock infiltration and median potential bedrock infiltration.

DAW 11-6-02 Sensitivity (Con't)

File naming convention in directory C:\USW-02\SENSITIVZ

Perturbed Value	STORM S8-3995b	GS_88_1	S18_95_2	G3_97_7
• THICK	SENI7AA ✓✓	SEN_IAA ✓✓		
" Ks bedrock	SENI7AB ✓✓	SEN_IAB ✓✓		
✗ API	SENI7AC ✓	SEN_IAC ✓		
° DIST	SENI7AD ✓	SEN_IAD ✓		
G	SENI7AE ✓	SEN_IAE ✓		

DAW 11-7-02

The parameters DIST and G are included in the sensitivity study because they are used in the KINEROS program to calculate residual water content, wilting point and field capacity and therefore have an effect on the soil storage above field capacity.

New (modified) parameter files must be created to perturb the above parameters. The events shown above occur in the Jan-Apr period and the Dec period.

Copy SWCHJAM.PAR to SENSITIVZ ✓
" SWCHDM.PAR " " ✓

DAW 11-7-02

Jan-Apr ~~DIST~~ perturbed → SWCHJ_AM.PAR saved as SENJ_A~~E~~D.PAR ✓
Replace DIST for soils 0.25 → 0.20 ✓

Create control file: SENI7AD.FIL ✓ and run
$Q = 13.92$ mm $Q_p = 3.04$ mm/h @ 2052
Chan. F = 0.605 mm

DAW 11-8-02 Continue sensitivity study

Create control file SEN_IAD.FIL to run event GS_88-1 with perturbation of DIST for plane elements. ✓
Output ~\SENSITIVZ\SEN_IAD.OUT
$Q = 0.24$ mm $Q_p = 0.16$ @ 1220 Chan F = 0.44 mm

To continue the exploratory sensitivity analysis, create Jan-Apr- parameter file with G perturbed (Only G for planes)

Jan-Apr G perturbed → SWCHJ_AM.PAR saved as SENJ_AE.PAR
Change G for planes by +10%. 50. → 55. ; 80. → 88. ✓

Create control file SENI7AE.FIL and Run
Output \SENI7AE.OUT
$Q = 12.71$ mm $Q_p = 2.80$ at 2052. Chan F = 0.601 ✓

Create control file SEN_IAE.FIL ✓ + Run
output SEN_IAE.OUT
$Q = 0.11$ mm $Q_p = 0.074$ mm/h @ 1218 ChanF = 0.436 mm

DAW 11-11-02

DAW 11-11-02

Create control file SEN_IA~~E~~C.FIL ✓ API sensitivity
There will be a change in the API in the control file. Original API was 2.0 mm. Increase 20% to 2.4mm
Output: SEN_IAC.OUT
$Q = 0.14$ mm $Q_p = 0.0813$ @ 1238 Chan F = 0.435

DAW 11-11-02 Sensitivity (Cont)

Create control file SEN17AC.FIL ✓ API perturbation
Original API = 41 mm increase 20% → API = 49.2 mm
output: SEN17AC.OUT
Q = 12.66 mm Qp = 2.77 mm/h @ 2052 min ChanF = 0.597 mm

Create control file SEN17AA.FIL sensitivity to THICK
Parameter file: 1) recover DETJ_AI.PAR from Colorado backup files. ✓ This had THICK increased by 20% for all plane and channel element.
2) Update Manning's n for channels, save as SENJ-AA.PAR. ✓ Input widths for rain-on-channel ✓
output: SEN17AA.OUT

DAW 11-12-02 Corrected error in *.par file →
~~Q = 8.83 mm Qp = 2.47 mm/h @ 2052 ChanF = 1.02 mm~~
Q = ~~8.93 mm~~ 9.00 mm Qp = ~~2.49~~ 2.51 mm/h @ 2052 ChanF = ~~1.03 mm~~ 0.662 mm

Create control file SEN_1AA.FIL. Sensitivity to thick
Output: SEN-1AA.OUT PARAMETER: SENJ_A~~B~~A.PAR DAW 11-11-02
Q = 0.00 Qp = 0 ChanF = ~~0.575~~ 0.453 mm
DAW 11-12-02

Create control file SEN17AB.FIL sensitivity to bedrock Ks
Output: SEN17AB.OUT
DAW 11-12-02
~~Q = 11.47 mm Qp = 2.68 mm/h @ 2052 ChanF = 0.619 mm~~
Q = 11.48 mm Qp = 2.69 mm/h @ 2052 ChanF = 0.619 mm

Create control file SEN_1AB.FIL: Sensitivity to bedrock Ks
Output: SEN_1AB.OUT
Q = 0.083 mm Qp = 0.068 @ 1216 min ChanF = 0.440

DAW 11-11-02 Sensitivity (Cont)

Create Spreadsheet (Quattro Pro 10)
SENSITIV2\Sensitivity.qpw ✓

Dimensionless sensitivity coefficients are calculated as on p 131, i.e.

$$S = \frac{\Delta F}{F} \div \frac{\Delta p}{p}$$

where F is objective function or output and p is a parameter or watershed descriptor.

DAW 11-12-02

Now create *.sum (Summary files) for 10 runs on p 158.

Make new directory for CDF files for the sensitivity study.

C:\USW_02\CDFSEN2 ✓

From the spreadsheet Sensitivity.qpw we see that the greatest sensitivities are for THICK, K_s bedrock and DIST. Because obtaining CDFs for all events is quite time-consuming, obtain sensitivity of median F_b and F_{bp} for these parameters only.
Prepare control files for STORMCDF.F95
Files will be in directory C:\USW_02\SENSITIV2

Daw 11-12-02

Event GS_88_1

Control Files *.LST

SEN_1AA.CON ✓ SEN_1AA.LST ✓ 2.60 mm; 5.06 over 51%

SEN_1AB.CON ✓ SEN_1AB.LST ✓ 3.94 mm; 7.17 over 55%

SEN_1AD.CON ✓ SEN_1AD.LST 4.28 mm; 7.68 over 56%

Event S8_3995b

Control files *.LST

SEN17AA.CON ✓ SEN17AA.LST 18.18 mm; 23.03 mm on 79%

SEN17AB.CON ✓ SEN17AB.LST 19.81 mm; 24.98 79%

SEN17AD.CON ✓ SEN17AD.LST 15.76 mm; 19.56 80.9%

Note: Differences in runoff volume for API perturbation appear to be within numerical error.

USW_02\API_1ACDF.CON ✓ API_1ACDF.LST

Fb= 3.69 mm ; 6.72 mm over 55%

Daw 11-23-02

A copy of C:\USW_02\SENSITIV2\SENSITIVITY.gpw is shown on p164.

Daw 11-21-02 Update TPA adjustment analysis with API option.

Use PSIPLOT

copy file C:\USW_02\OUTREAL\EXCESSAVG.PDF

to \OUTREAL2\EXCESSAVAPI.PDF

Refer to pages 116-122

Copy infiltration excess amounts from file

~~OUTREAL~~ Daw 11-21-02 C:\USW_02\CDFREAL2\APIANNUALA.CDF

to EXCESSAVAPI.PDF

Use PROSTAT For Regression Analysis of form on p121

See regression report below.

$AvgdF = 4.936 + 0.314 A_r - 0.0145 \bar{d}$ COD= 0.642

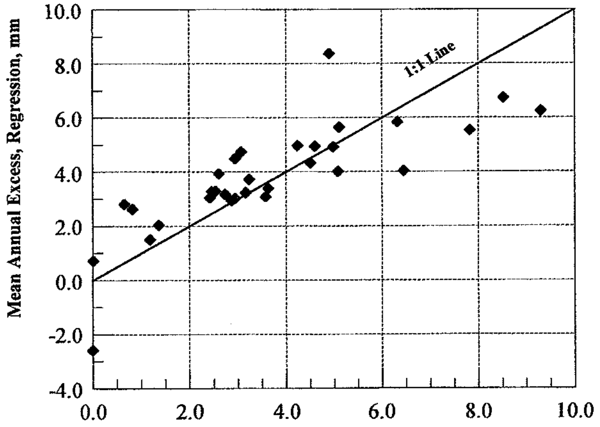
r= 0.801

n = 33

A plot of computed vs observed infiltration excess

```
===========================================================
     Multiple Regression Report

     Data File Name: C:\USW_02\OUTREAL2\EXCESSAVAPI.PDW

===========================================================
 Equation: AVGDF=P0+P1*Ar+P2*aveH

Number of used data points:         33
 Save Options:
          Save Data


 Number of Function Calls:          8

 Fitted Parameters:
                P0=    4.93576206
                P1=    0.31412271
                P2=   -0.014513286

             Chi-Sq:   71.21091685
             SumSqr:    71.21091685
             StdDev:    1.54068077


 Goodness of Fit Statistics ...

              __C O D:    0.64191469
              __Corrl:    0.80119579
              __M S C:    0.84516584

 Parameter Statistics...


 Parameter: P0= 4.93576206

              StdDev:    0.71235359
       Coeff. of Variance:   14.43249461

__95 % Confidence Interval

  __Uninvariant ...
                   LOW:    3.48094194
                   HIGH:   6.39058218
  __Supporting Plane ...
                   LOW:    2.82656600
                   HIGH:   7.04495812

Parameter: P1= 0.31412271

              StdDev:    0.053342112
       Coeff. of Variance:   16.98129735

__95 % Confidence Interval

  __Uninvariant ...
                   LOW:    0.20518359
                   HIGH:   0.42306184
  __Supporting Plane ...

                   HIGH:    0.47206250


 Parameter: P2= -0.014513286

              StdDev:    0.0028980250
       Coeff. of Variance:    -19.96808214

__95 % Confidence Interval

  __Uninvariant ...
                   LOW:   -0.020431843
                   HIGH:  -0.0085947299
  __Supporting Plane ...
                   LOW:   -0.023094001
                   HIGH:  -0.0059325719



===========================================================

  ---Created with ProStat
  ---Thu Nov 21 15:04:33 2002

===========================================================
```

Computed vs "Observed" Mean Annual Excess Infiltration
Upper Split Wash (1987-95) KINEROS2, API Option



Mean Annual Excess Infiltration, KINEROS2, mm

File: C:|USW_02|OUTREAL2.~~PGW~~\ EXCESSAPI.PGW
daw 11-21-02
Daw 11/21/02

DAW 11-23-02 Sensitivity (Con't.)

Copy of file C:\USW_02\SENSITIV2\SENSITIVITY.gpw

S_V S_{QP} S_{CF} S_{FB}

S8_3995b

PARAMETER	Base Q, mm	Pert Q, mm	Sensitivity	Base Qp mm/h	Pert Qp mm/h	Sensitivity	Base Fc mm	Pert Fc mm	Sensitivity	Base Med Fb	Pert Med Fb	Sensitivity	Base Med Fbp
THICK	12.75	9	-1.4706	2.81	2.51	-0.5338 *	0.6	0.662	0.5167 *	21.08	20.71	-0.0878	56.4
BEDROCK Ks	12.75	11.48	-0.4980	2.81	2.69	-0.2135	0.6	0.619	0.1583	21.08	23.54	0.5835 *	56.4
API	12.75	12.66	-0.0353	2.81	2.77	-0.0712	0.6	0.597	-0.0250	21.08			56.4
DIST	12.75	13.92	-0.4588	2.81	3.04	-0.4093	0.6	0.605	-0.0417	21.08	19.29	0.4246	56.4
G	12.75	12.71	-0.0314	2.81	2.8	-0.0356	0.6	0.601	0.0167	21.08			56.4

GS_88_1

PARAMETER	Base Q, mm	Pert Q, mm	Sensitivity	Base Qp mm/h	Pert Qp mm/h	Sensitivity	Base Fc mm	Pert Fc mm	Sensitivity	Base Med Fb	Pert Med Fb	Sensitivity	Base Med Fbp
THICK	0.12	0	-5.0000	0.07	0	-5.0000	0.43	0.453	0.2674 *	2.98	0.502	-4.1577	28.48
BEDROCK Ks	0.12	0.08	-1.6667	0.07	0.068	-0.1429	0.43	0.44	0.1163	2.98	3.2	0.3691	28.48
API	0.12	0.14	0.8333	0.07	0.0813	0.8071	0.43	0.435	0.0581	2.98			28.48
DIST	0.12	0.24	-5.0000	0.07	0.16	-6.4286	0.43	0.44	-0.1163	2.98	3.78	-1.3423	28.48
G	0.12	0.11	-0.8333	0.07	0.074	0.5714	0.43	0.438	0.1395	2.98			28.48

S_{FBP}

	Pert Med Fbp	Sensitivity
THICK	59.5	0.2748
BEDROCK Ks	58.5	0.1862
DIST	50.65	* 0.5098

	Pert Med Fbp	Sensitivity
THICK	26.18	* -0.4038
BEDROCK KS	28.49	0.0018
DIST	27.62	0.1510

Sensitivity coefficients are:

1. S_V - sensitivity of runoff volume
2. S_{QP} = sensitivity of peak runoff rate
3. S_{CF} = " " channel infiltration
4. S_{FB} = " " median bedrock infiltration
5 S_{FBP} = " median potential "

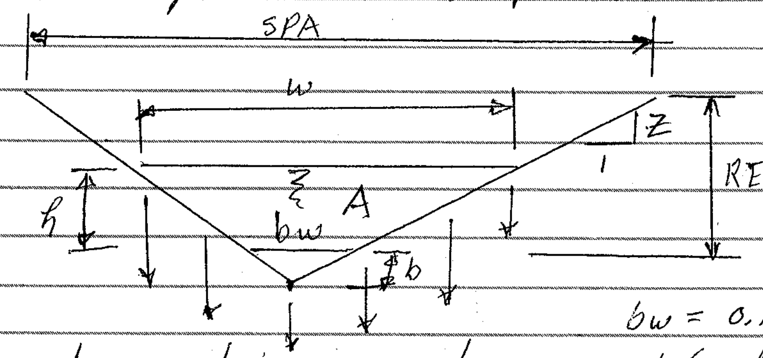
All coefficients greater than 1 are circled on the figure. It is clear that the depth of soil and channel alluvium is very important, especially for the smaller event GS_88-1.

DAW 11-25-02

The channel infiltration is most sensitive to the soil and alluvium thickness. This is consistent. Although increasing soil depths on the plane elements reduces runoff, this reduction of runoff is more than compensated by the greater capacity of the channel alluvium.

DAW 11-26-02 Validation Test for Microtopography of KINEROS2.

In KINEROS2 the surface of "plane" elements is represented as parallel vee-shaped channels.



bw = 0.10 SPA

The channel x-section properties are defined above. Infiltration at the soil infiltrability occurs over a width, w.

The side slopes are symmetrical with slope $Z = \frac{2RE}{(SPA-BW)}$

From the KINEROS Manual (Woolhiser et al, 1990) we have for channels

$$\frac{\partial A}{\partial t} + \frac{dQ}{dA}\frac{\partial A}{\partial x} = q_e(x,t)$$

where Q is the discharge and $q_e(x,t)$ is the lateral inflow rate per unit length of channel.

Consider a steady state case with a discharge, Q_o at the upper boundary, and with infiltration at the saturated hydraulic conductivity. Then

$$\frac{dQ}{dA}\frac{dA}{dx} = -K_s w \quad \text{or} \quad \frac{dQ}{dx} = -K_s w \quad \text{where } w = w(Q)$$

and rainfall rate = 0

now w is a function of Q.

$Q = \cancel{\alpha h^m}$ DAW 11-26-02 $Q = \alpha R^{m-1} A$

For the Manning eq. $\alpha = \frac{1}{n} S^{1/2}$ where S is the slope

$m = 5/3$

$$\frac{dQ}{w(Q)} = -K_s dx$$

however w(Q) is a complicated expression so an analytic solution for the steady-state Q(x) is not possible. Could do a Runge-Kutta numerical solution.