P2.3

Experiments and Documentation Performed to Predict the Depths of Rivers: Determining the Amount of Time Elapsed for Water to Flow Through the Watershed

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1. INTRODUCTION

*The Burnt Swamp Brook watershed contains 39 soil and subsoil types. Each soil type has its own varying hydraulic conductivities, water capacity, saturation times, and slopes. Soils, along with evapotranspiration, can directly determine how much water can be absorbed by the watershed in a particular amount of time.

Peragallo (1989) and Rector (1981) show the collected data for each soil type in the watershed and the United States Geological Survey (1964) provided topographic data. Since the data for the soil varies depending on the current situation, the results from forecast will also vary greatly without an input of the current soil condition. For extreme situations in the river, extreme situations in the soils are used in which maximum and minimum values in soils help determine maximum and minimum values in the river.

2. GENERAL EQUATION FOR TIME

Starting with the basics, the general equation for time derived from physics as follows:

$$t = \frac{d}{v} \tag{1}$$

The general equation for velocity as follows:

$$v = m * g * \sin\theta \tag{2}$$

$\sin\theta$ can be determined from basic geometry as follows:

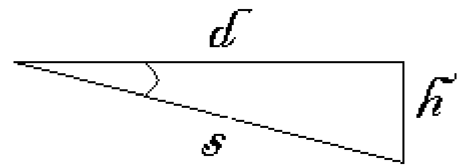

Figure 1. A basic geometric triangle with d, h, and s representing the distance, change in height, and the length of the hypotenuse, respectively.

Therefore,

$$\sin\theta = \frac{h}{\sqrt{d^2 + h^2}} \tag{3}$$

g is the acceleration due to gravity and m is the amount of water, which is found through the use of an integral with respect to time. So, combing this with Eq. 1, Eq. 2, and Eq. 3:

$$t = \frac{d * \sqrt{d^2 + h^2}}{h * g * \int_0^t m * dt} \tag{4}$$

3. THE AMOUNT OF WATER

3.1 DETERMINING EQUATION FOR AMOUNT OF WATER

m can be found using an infinite amount of variables to affect the amount of water at any given point in time in the watershed. It can contain an infinite amount of partial differentials with an infinite amount of degrees expressing how each variable changes in time and how each rate of change changes with time. So, Eq. 4 is, literally, infinitely long.

In this equation, for practical purposes, partial differentials won't go past the second degree. The variables - p is precipitation, A is the area affected, I is Solar Radiation Intensity, T is transpiration from plants, H is hydraulic conductivity of the soil, a is passive absorption into plants, o is osmosis into plants, r is initial runoff

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and D is dew from plants. A and I are used specifically to for the equation for evaporation from Knapp (1985):

$$t=\frac{d*\sqrt{d^2+h^2}}{h*g*\int_0^{\frac{d}{A*\left[r*\frac{\partial r}{\partial t}+D*\frac{\partial D}{\partial t}+P*\frac{\partial p}{\partial t}-\frac{1}{4520}\left(I*\frac{\partial I}{\partial t}\right)-T*\frac{\partial T}{\partial t}-H*\frac{\partial H}{\partial t}-a*\frac{\partial a}{\partial t}-o*\frac{\partial o}{\partial t}\right]*g*\frac{h}{\sqrt{d^2+h^2}}*10^6}} m*dt}$$

$$m=\left(A*\left[r*\left(\frac{\partial r}{\partial t}+t*\frac{\partial^2 r}{\partial t^2}\right)+D*\left(\frac{\partial D}{\partial t}+t*\frac{\partial^2 D}{\partial t^2}\right)+\left(P*\frac{\partial p}{\partial t}+t*\frac{\partial^2 p}{\partial t^2}\right)-\frac{1}{4520}\left(I*\left(\frac{\partial I}{\partial t}+t*\frac{\partial^2 I}{\partial t^2}\right)\right)\right.\right.$$
$$\left.\left.-T*\left(\frac{\partial T}{\partial t}+t*\frac{\partial^2 T}{\partial t^2}\right)-H*\left(\frac{\partial H}{\partial t}+t*\frac{\partial^2 H}{\partial t^2}\right)-a*\left(\frac{\partial a}{\partial t}+t*\frac{\partial^2 a}{\partial t^2}\right)-o*\left(\frac{\partial o}{\partial t}+t*\frac{\partial^2 o}{\partial t^2}\right)\right]\right)*t$$

(5)

For starting the FORTRAN program, vegetation and evapotranspiration are ignored from the equation:

$$t=\frac{d*\sqrt{d^2+h^2}}{h*g*\int_0^{\frac{d}{A*\left[r*\frac{\partial r}{\partial t}+P*\frac{\partial p}{\partial t}-H*\frac{\partial H}{\partial t}\right]*g*\frac{h}{\sqrt{d^2+h^2}}*10^6}} m*dt}$$

$$m=\left(A*\left[r*\left(\frac{\partial r}{\partial t}+t*\frac{\partial^2 r}{\partial t^2}\right)+\left(P*\frac{\partial p}{\partial t}+t*\frac{\partial^2 p}{\partial t^2}\right)-H*\left(\frac{\partial H}{\partial t}+t*\frac{\partial^2 H}{\partial t^2}\right)\right]\right)*t$$

(6)

3.2 DETERMINING THE REMAINING RUNOFF

Runoff can come from a number of sources including precipitation, overflowing streams, and dams. Eq. 6 can help determine how much time it will take for the runoff to reach the river, however, a separate formula is needed to determine how much of that runoff will reach the river. Consider the following situation:

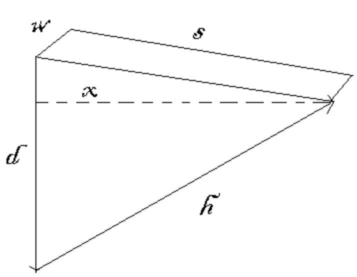

*Figure 2. A parcel of water, covering the area of w*s, flows into a river.*

Above is a simple geometric visual of a common hydrologic situation. The parcel of water takes an amount of time t to reach the river. The amount of runoff can be found by finding the volume of the triangle based on the amount of time it takes for the runoff to reach the river:

$$r_f = r_i - \frac{1}{2} * w * (d * t) * \sqrt{s^2 - S^2} \qquad (7)$$

Where r_f is the final runoff, r_i is the initial runoff, d is the hydraulic conductivity of the soil, w is the width of the area affected by the runoff, s is the distance traveled by the runoff, t is the amount of time elapsed by the traveling runoff, and S is the slope of the soil.

3.3 DETERMINING VELOCITY OF THE RUNOFF

Factoring in more variables to determine frictional forces against runoff will make an infinite long equation infinitely longer. Therefore, frictional forces are neglected and only the absorption forces from the soil are applied for the first series of trial runs with the program. An average velocity is determined by assuming constant acceleration on a sloped plane.

3.4 CHANGES THAT CAN BE MADE

Eq. 7 can change based on given situations. For example, d*t may change if $r_i - r_f$ is greater than the water capacity of the soil. If that happens, d*t is substituted with c, for capacity. The runoff may also travel over several different soils. If that happens, s is the distance traveled over one particular type of soil and another addition is made to the equation to cope with the runoff traveling over a different of soil, but it is still the same general equation.

Eq. 7 can be substituted into Eq. 6 for r. However, H would changed similarly if the runoff travels over more than one soil type and then Eq. 6 would be for the amount of time elapsed by the runoff traveling over one soil type and a new integral would be used for the new variable of H. If the soil becomes saturated will the runoff is entering the watershed, Eq. 6 would have to change again because H becomes 0.

Time t will also change if there is an initial velocity accompanying the runoff such as a dam burst and stream flooding. This change in velocity is added into v after the first set of data is solved.

The change in v changes t and that will also change r.

There are an infinite amount of changes that can be made based on what type of soils and what type of path the runoff takes. Therefore, Eq. 6 is infinitely long with an infinite amount of frictional forces being applied to the runoff with an infinite amount of possible paths that can be taken in the watershed.

Freeze and Cherry (1979) show that there are infinite amount of forces being applied to percolating runoff through the soil. However, only the maximum and minimum values from Peragallo (1989) and Rector (1981) will be used in this part of the experiment. Although the rates of changes in elevation in the watershed are much more complicated, which directly affects the acceleration of the runoff, the general changes in elevation gathered by the USGS (1964) are going to be used through the experiment until a more thorough survey of the Burnt Swamp Brook Watershed can be made.

4 PHYSICAL PROPERTIES OF THE RIVER

The changes in the properties of the river are derived from observations made in the summer of 2004 during the beginning of the project. The program uses proportional changes to make predictions on how the river will react. For example, at a depth of 0.23 m, a width of 2.4 m, and a slope of 5 degrees, the river will have a velocity of 0.14 m/s. The flow capacity of the river will be at 0.38 m deep and 3.0 m wide with a velocity of 0.97 m/s. The maximum values of the depth, width, and velocity are the first things to be inputted into the program along with an input file with soil data values.

5 FORTRAN PROGRAM

In the trial watershed, there is no vegetation. There is only soil and water, pavement is included as a soil type. In this program, frictional force applied by the soil is neglected. The only force that acts against the soil is the absorption force applied by the soil. Evaporation is also neglected.

As a result, runoff may move with a slightly increased velocity due to the assumption of constant velocity. Also, due to the assumption of no evaporation, the remaining amount of runoff will also be slightly greater.

5.1 SOIL INPUT DATA

The program starts by inputting the soil data as follows:

```
39
CaB       3         8         0.0000140
0.0000420           0.0904    0.1737  20052    62388
CaC       8         15        0.0000140
0.0000420           0.0904    0.1737  20052    62388
CaD       15        35        0.0000140
0.0000420           0.0904    0.1737  20052    62388
CbB       3         8         0.0000140
0.0000420           0.0919    0.1745  20052    62388
CbC       8         15        0.0000140
0.0000420           0.0919    0.1745  20052    62388
CbD       15        25        0.0000140
0.0000420           0.0919    0.1745  20052    62388
CeC       3         15        0.0000140
0.0000420           0.1112    0.1890  20040    62400
ChB       3         8         0.0000040
0.0000420           0.0960    0.2850  36000    360000
ChC       8         15        0.0000040
0.0000420           0.0960    0.2850  36000    360000
ChD       15        25        0.0000040
0.0000420           0.0960    0.2850  36000    360000
Co        0         2         0.0000010
0.0000420           0.4890    0.6287  33000    990000
Fm        0         3         0.0000040
0.0000420           0.5374    0.6858  36000    360000
HrC       3         15        0.0000040
0.0000420           0.0244    0.0640  8400     84000
HrD       15        35        0.0000040
0.0000420           0.0244    0.0640  8400     84000
MmB       3         8         0.0000140
0.0000420           0.0800    0.1603  20460    63600
MoB       3         8         0.0000040
0.0000420           0.0894    0.1763  203400 360000
MoC       8         15        0.0000040
0.0000420           0.0894    0.1763  203400 360000
PaA       0         3         0.0000040
0.0000420           0.0846    0.2334  714853 13458000
PaB       3         8         0.0000040
0.0000140           0.1008    0.2139  639568 11334000
PaC       8         15        0.0000040
0.0000140           0.1008    0.2139  639568 11334000
Ra        0         3         0.0000014
0.0000040           0.2672    0.8994  360000 1080000
RdA       0         5         0.0000040
0.0000014           0.0348    0.0884  749400 14874000
Rf        0         3         0.0000040
0.0000420           0.0223    0.1057  12000    120000
RgB       2         8         0.0000040
0.0000014           0.0348    0.0884  749400 14874000
RoD       3         25        0.0000040
0.0000420           0.0229    0.0632  8400     84000
Sb        0         3         0.0000430
```

```
0.0001400   0.0358 0.2210 10800  35410
SeB    3    8      0.0000040
0.0000140   0.0666 0.1679 691200 2304000
StB    3    8      0.0000040
0.0000140   0.0640 0.1641 691200 2304000
SuB    2    8      0.0000140
0.0000420   0.0126 0.1046 23400  72000
Sw     0    3      0.0000040
0.0000420   0.3089 0.4415 23520  208451
Ud     0    25     0
0           0      0      0      0
Wa     0    2      0.0000140
0.0000420   0.0495 0.2311 18780  58397
WaA    0    5      0.0000140
0.0000420   0.0495 0.1821 18360  57187
WhA    0    5      0.0000040
0.0000420   0.0635 0.1062 971716 18414000
WoB    0    8      0.0000040
0.0000420   0.0879 0.2532 549726 10272000
WrA    0    3      0.0000040
0.0000140   0.1001 0.2266 691011 12396000
WrB    3    8      0.0000040
0.0000140   0.1001 0.2266 691011 12396000
WsB    3    8      0.0000040
0.0000140   0.0960 0.2225 691011 12396000
```

The first number of the input file is indicating that there are a total of 39 subsoil types in the Burnt Swamp Brook Watershed. The first 3 letter sequences are the abbreviations for all the soil subtypes. The next 2 numbers are the minimum and maximum slopes followed by the minimum and maximum hydraulic conductivity values, the minimum and maximum water capacity values, and the minimum and maximum saturation times.

At this point, the program reads as follows:

```
      program river depth
      integer slpmin,slpmax,numsoil
      real
hydmin,hydmax,capmin,capmax,run,dist,chgmin,c
hgmaxs,depa,depb,runa,runb,precip
      real
prearea,volprecip,nora,wesa,a,b,c,d,soilmin,soilma
x,depi,wid,veli,volriv,o,maxdep,maxvel,x,y
      real
nor,wes,depr,j,k,l,vela,velb,vavga,vavg,timea,time
b,max,min,runvin,depra,deprb,
      real
vola,volb,maxwid,maxvola,maxvolb,floodriva,floodr
ivb,timeflooda,timefloodb,maxvol
      character moreprecip*3,soil*3
      data volprecip,moreprecip/0.0,'yes'/
      open(1,file='soildata.in',status='old')
      open(2,file='riverdepth.out',status='new')
```

5.2 MAXIMUMS OF THE RIVER

During the observational stage of the project, the maximums of the river had been predetermined. The maximum depth, width, and velocity of the river had been determined to be 0.38 m, 3.0 m, and 0.974 m/s, respectively. The maximums were inputted in the program:

5.3 INPUTTING INITIAL VALUES

The program asks the user to input the initial runoff, average depth of the runoff, initial velocity of the runoff, amount of precipitation (when the rate was constant). After asking if there is more precipitation, it asks for the initial location of the runoff and the precipitation. The program responds by inputting the correct soil data depending on the location that was inputted.

At this point, the program continues as follows:

```
      maxdep=0.38
      maxwid=3.0
      maxvel=0.974
      maxvol=maxdep*maxwid*maxvel
      read(1,1) numsoil
 1    format(i2)
      print*,'Enter amount of runoff, if any, in
cubic meters.'
      read*,run
      if (run.gt.0) then
       print*,'Enter the average depth of the
runoff, in meters.'
       read*,depr
       print*,'Enter the initial velocity of the
runoff, if any, in meters per second.'
       read*,runvin
      end if
      do while (moreprecip.eq.'yes')
       print*,'Enter amount of precipitation, in
meters, when the rate was constant.'
       read*,precip
       if (precip.gt.0) then
        print*,'Where the precipitation entered
the watershed…'
        print*,'Enter the Northern latitude, first in
whole degrees, followed by feet.'
        read*,north,nora
        print*,'Enter the Western longitude, first
in whole degrees, followed by feet.'
        read*,west,wes
        if
(north.e.42.and.nor.eq.1.84.and.west.eq.71.and.w
es.eq.23.85) then
```

```
            numsoil=numsoil-10
            dist=302.172
           end if
           do 2 i=1,numsoil
            read (1,3)
soil,slpmin,slpmax,hydmin,hydmax,capmin,capma
x,satmin,satmax
 3
format(a3,1x,i2,1x,i2,1x,f9.7,1x,f9.7,1x,f6.4,1x,f6.4,
1x,i6,1x,i8)
 2         continue
           print*,'Enter amount of time that
precipitation fell and the area affected, in square
meters.'
           read*,timep,prearea
           volprecip=volprecip+precip*prearea
          else
           volprecip=0
           prearea=0
          end if
          print*,'Is there more precipitation to enter?
yes or no.'
          read*,moreprecip
         end do
         if (run.gt.0) then
          print*,'Where the runoff entered the
watershed…'
          print*,'Enter the Northern latitude, first in
whole degrees, followed by feet.'
          read*,northa,nora
          print*,'Enter the Western longitude, first in
whole degrees, followed by feet.'
          read*,westa,wesa
          if
(northa.e.42.and.nora.eq.1.84.and.westa.eq.71.an
d.wesa.eq.23.85) then
           numsoil=numsoil-10
           dist=302.172
          end if
          do 13 i=1,numsoil
           read (1,14)
soil,slpmin,slpmax,hydmin,hydmax,capmin,capma
x,satmin,satmax
 14
format(a3,1x,i2,1x,i2,1x,f9.7,1x,f9.7,1x,f6.4,1x,f6.4,
1x,i6,1x,i8)
 13       continue
         end if
```

5.4 DETERMINING THE AMOUNT OF TIME

The program takes Eq. 6 to determine the amount of runoff and the amount of time elapsed when it reaches the river. However, it solves it in pieces in order to make writing the program more simple:

```
          chgmin=(slpmin*dist*.0254)/100
          chgmax=(slpmax*dist*.0254)/100
          j=prearea+(run/depr)
          k=precip+depr-hydmin
          o=precip*depr-hydmax
          l=volprecip+run
          a=dist/(j*k*9.8*(chgmin/sqrt(dist**2+chgmi
n**2))*10**6)
          b=dist/(j*o*9.8*(chgmax/sqrt(dist**2+chgm
ax**2))*10**6)
          c=dist*sqrt(dist**2+chgmin**2)
          d=dist*sqrt(dist**2+chgmin**2)
          soilmin=sqrt(j)*dist*capmin
          soilmax=sqrt(j)*dist*capmax
          runa=(j*k*a)-((j*hydmin*a**2)/2)
          timea=c/(chgmin*9.8*runa)
          timeb=d/(chgmax*9.8*runb)
          vavga=(dist/timea)
          vavgb=(dist/timeb)
          if (runvin.gt.0) then
           vavga=vavga+runvin
           vavgb=vavgb+runvin
           timea=dist/vavga
           timeb=dist/vavgb
          end if
          if (l.gt.soilmin) then
           runa=run-(0.5*sqrt(dist**2-
chgmin**2)*capmin*sqrt(j))
          else
           runa=run-(0.5*sqrt(dist**2-
chgmin**2)*(sqrt(j)/vavga)*hydmin*sqrt(j))
          end if
          if (l.gt.soilmax) then
           runb=run-(0.5*sqrt(dist**2-
chgmax**2)*capmax*sqrt(j))
          else
           runb=run-(0.5*sqrt(dist**2-
chgmax**2)*sqrt(j)/vavgb)*hydmax*sqrt(j))
          end if
```

5.5 INPUTTING INITIAL RIVER DATA

The user must now input the initial river data. The user must input the initial depth, width, and streamflow of the river. Afterwards, the program finishes the computations for the changes made in the river based on the inputted initial conditions.

```
          print*,'Enter the initial depth, width, and
streamflow of the river, in meters and seconds,
respectively.
          read*,depi,wid,veli
          volriv=depi*wid*veli
          max=sqrt(run/depr)/vavga
```

```
min=sqrt(run/depr)/vavgb
maxvola=maxwid*maxdep*maxvel*min
maxvolb=maxwid*maxdep*maxvel*max
depra=runa/sqrt(run/depr)
deprb=runb/sqrt(run/depr)
vola=vavga*depra*sqrt(run/depr)
volb=vavgb*deprb*sqrt(run/depr)
volriva=(vola*min)-(depra*wid*veli*min)
volrivb=(volb*max)-(deprb*wid*veli*max)
depa=volriva/(wid*veli*min)
depb=volrivb/(wid*veli*max)
vela=(volriva*0.0871560)/20
velb=(volrivb*0.0871560)/20
```

The numbers used in vela and velb are constants of proportionality for determining the streamflow of the river based on the amount of water in the river. This was found by observing how the streamflow of the river changed from the changes of the amount of water flowing through the river.

```
if (vela.gt.maxvel) then
 vela=maxvel
end if
if (velb.gt.maxvel) then
 velb=maxvel
end if
if (volriva.gt.maxvola) then
 floodriva=volriva-maxvol
 timeflooda=floodriva/maxvol
end if
if (volrivb.gt.maxvola) then
 floodrivb=volrivb-maxvol
 timefloodb=floodrivb/maxvol
end if
if (runa.le.0.or.volriva.le.0.or.depa.le.0)
then
 runa=0
 timea=0
 depa=depi
 vela=veli
 volriva=volriv
end if
if (runb.le.0.or.volrivb.le.0.or.depb.le.0)
then
 runb=0
 timeb=0
 depb=depi
 velb=veli
 volrivb=volriv
end if
```

5.6 OUTPUTTING THE RESULTS

The program finishes by outputting its final results into an output file:

```
        write(2,4)
 4      format('Burnt Swamp Brook')
        write(2,5)
 5      format()
        write(2,17) soil
 17     format('The water travels through the soil
type(s) ',a3,'.')
        write(2,18)
 18     format()
        write(2,6) depi,wid,veli
 6      format('Initially, the river has: a depth of
',f4.2,' meters, a width of ',f3.1,' meters, and a
velocity of ',f4.2,' meters per second.')
        write(2,7) precip,prearea,run,runvin
 7      format('Additionally, there was ',f5.3,'
meters of precipitation over an area of ',f10.2,'
square meters along with ',f8.2,' cubic meters of
runoff with an initial velocity of ',f6.2,' meters per
second.')
        if (run.gt.0) then
         write(2,8) northa,nora,westa,wes
 8       format('Runoff entered the watershed at
',i2,' degrees and ',f4.2,' feet N and ',i2,' degrees
and ',f5.2,' feet W.')
        end if
        write(2,9)
 9      format()
        write(2,10) timea,timeb
 10     format('It will take between ',f10.2,' and
',f10.2,' seconds for the additional water to reach
the river.')
        write(2,11) depa,depb
 11     format('After the water enters the river, the
depth will be between ',f14.4,' and ',f14.4,'
meters.')
        if (depa.gt.maxdep.or.depb.gt.maxdep)
then
         write(2,20) vela,velb
 20      format('The river will reach its flood
velocity between ',f6.4,' and ',f6.4,' meters per
second.')
        else
         write(2,15) vela,velb
 15      format('The velocity will be between
',f6.4,' and ',f6.4,' meters per second.')
        end if
        write(2,21)
 21     format()
        if (depa.gt.maxdep) then
         write(2,16) depa,timeflooda
 16      format('With a theoretical depth of ',f12.4,'
meters, the river will flood for ',f10.0,' seconds
before returning below its flood stage.')
```

```
      end if
      if (depb.gt.maxdep) then
       write(2,19) depb,timefloodb
 19    format('With a theoretical depth of ',f12.4,'
meters, the river will flood for ',f10.0,' seconds
before returning below its flood stage.')
      end if
      if (timea.eq.0.or.timeb.eq.0) then
       write(2,22)
 22    format('With a theoretical time of 0
seconds, all of the runoff is absorbed into the
soil.')
      end if
      if (depa.eq.depi.or.depb.eq.depi) then
       write(2,24) depi
 24    format('With a theoretical depth of ',f4.2,'
meters, the water in the river is flowing out faster
than the runoff is flowing in.')
      end if
      rewind 1
      close(1)
      close(2)
      end
```

6.0 RUNNING THE PROGRAM

After writing the program, two trial runs were formed to check the performance of the program. Both runs use the same data and both runs only have runoff with no precipitation. However, the second run deals with an initial velocity with the runoff whereas the first run has the runoff with an initial velocity of zero.

6.1 FIRST TRIAL RUN

Using a basic linux terminal, the program will do the following:

```
macielj@annex01:~/flood> a.out
 Enter the amount of runoff, if any, in cubic
meters.
995.27
 Enter the average depth of the runoff, in
meters.
0.3048
 Enter the initial velocity of the runoff, if
any, in meters per second.
0
 Enter amount of precipitation, in meters,
when the rate was constant.
no
 Is there more precipitation to enter? yes
or no.
no
 Where the runoff entered the
watershed…
 Enter the Northern latitude, first in whole
degrees, followed by feet.
42
1.84
 Enter the Western longitude, first in whole
degrees, followed by feet.
71
23.85
 Enter the initial depth, width, and
streamflow of the river, in meters and seconds,
respectively.
0.23
2.4
0.14
```

The results are outputted to the file riverdepth.out as follows:

```
Burnt Swamp Brook

The water travels through the soil type(s) SuB.

Initially, the river has: a depth of 0.23 meters, a
width of 2.4 meters, and a velocity of 0.14 meters
per second.
Additionally, there was 0.000 meters of
precipitation over an area of 0.00 square meters
along with 995.27 cubic meters of runoff with an
initial velocity of 0.00 meters per second.
Runoff entered the watershed at 42 degrees and
1.84 feet N and 71 degrees and 23.85 feet W.

It will take between 0.00 and 0.00 seconds for the
additional water to reach the river.
After the water enters the river, the depth will be
between 0.2300 and 0.2300 meters.
The velocity will be between 0.1400 and 0.1400
meters per second.

With a theoretical time of 0 seconds, all of the
runoff is absorbed into the soil.
With a theoretical depth of 0.23 meters, the water
in the river is flowing out faster than the runoff is
flowing in.
```

6.2 SECOND TRIAL RUN

The initial velocity is changed from 0 to 10 meters per second:

```
macielj@annex01:~/flood> a.out
 Enter the amount of runoff, if any, in cubic
meters.
995.27
```

Enter the average depth of the runoff, in meters.
0.3048
Enter the initial velocity of the runoff, if any, in meters per second.
10
Enter amount of precipitation, in meters, when the rate was constant.
no
Is there more precipitation to enter? yes or no.
no
Where the runoff entered the watershed…
Enter the Northern latitude, first in whole degrees, followed by feet.
42
1.84
Enter the Western longitude, first in whole degrees, followed by feet.
71
23.85
Enter the initial depth, width, and streamflow of the river, in meters and seconds, respectively.
0.23
2.4
0.14

By changing the initial velocity of the runoff, the results changed drastically:

Burnt Swamp Brook

The water travels through the soil type(s) SuB.

Initially, the river has: a depth of 0.23 meters, a width of 2.4 meters, and a velocity of 0.14 meters per second.
Additionally, there was 0.000 meters of precipitation over an area of 0.00 square meters along with 995.27 cubic meters of runoff with an initial velocity of 10.00 meters per second.
Runoff entered the watershed at 42 degrees and 1.84 feet N and 71 degrees and 23.85 feet W.

It will take between 30.22 and 30.22 seconds for the additional water to reach the river.
After the water enters the river, the depth will be between 26368.8496 and 29542.9258 meters.
The river will reach its flood velocity between 0.9740 and 0.9740 meters per second.

With a theoretical depth of 26368.8496 meters, the river will flood for 45594. seconds before returning below its flood stage.

With a theoretical depth of 29542.9258 meters, the river will flood for 51082. seconds before returning below its flood stage.

7 CONCLUSIONS

Even though the forces applied in the program were minimal, it has great potential. Each additional force will be applied one at a time and the affects on the results will be noted.

The theoretical depths for the flood scenarios are the depths of the river if the water did not exceed the width of the river. From this, the amount of water that will flood out of the river can be determined.

The program shows clearly what happens when water faster through a watershed than it should. However, the runoff did flow faster than it would and more water entered the river than would actually enter if all the possible forces were applied. The program also shows how key the soil in the watershed is in absorbing runoff and precipitation that enters the watershed.

8 REFERENCES

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