

# Procedures

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## 1.0 Set Up

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### 1.1 Rill Slope Changes

The slope of the sand feeders and the rill can be changed.

#### 1.1.1 Rill

The slope of the rill is changed by turning the crank to the jack at the west end of the rill. On the north east side of the rill there is a place on the frame where the digital protractor can be placed when adjusting the channel. The protractor gives the slope in degrees not grade, so it needs to be converted. The slope in degrees can be found by using simple trigonometry. If the desired gradient is 3 percent then the desired slope in degrees is.

$$\text{Tan}^{-1}0.03 = 1.718^{\circ} \quad 1$$

#### 1.1.2 Side Sand Feeders

The Side feeder may have to be lifted so the bottom does not interfere with the rill sides. The nuts must first be loosened on the bottom of the four threaded rods. Don't loosen the top nuts because there is less room for adjustment. The south sand hopper is jacked up with the jack handle; the north hopper's jack is turned around so the jack handle does not fit. Vice grips work well when raising and lowering the north jack, although it's time consuming. It works best if you move the jack up a couple of turn and then loosen the nuts a couple of turns. Keep alternating between loosening the nuts and raising the jack. **If you do one or the other too much by itself the hoppers could lean too much and tip over.** Be sure when you have finished raising the hoppers that the nuts are tight.

### 1.2 Smoothing Sand

Before each run, the sand in the channel needs to be smoothed. The desired sand level will vary from run to run, it is measured on the wooden tool used to smooth the sand surface. The most efficient method to smooth the sand is to turn the end flow on at about 15%. This way, it is easier to push the excess sand down the channel in order to reach the desired sand level. The alignment bar, across the channel, at the east end of the channel is very fragile. When pushing sand down the channel, be sure to watch for the bar. It bends and could break easily. Once the sand to the desired level, the end flow is then turned off. The sand should be somewhat soupy (if the infiltration is left closed). The surface is fairly easy to smooth this way.

### 1.3 Emptying Sand Box

During each run, sediment deposits in the box at the east end of the rill. It becomes full after 3 or 4 runs. To remove the sand, allow the water to drain out first. There are filters at the bottom of the box, which keeps sand from escaping, but permits water to drain. (The sand is generally scooped out in the morning so the water can drain overnight.) Buckets with holes on the bottom are used and a screen (approx. 1mm holes) is placed at the bottom of each bucket. This will allow any excess water to drain without losing sand. When scooping out the sand from the box, be sure not

to damage the filters at the bottom. The filters are slit PVC pipe with Scotch Brite pads tied around them. The ties can be knocked off the pipe if it is hit with a shovel. After the buckets are filled, they are taken outside and spread on the tarps to dry. It takes around 9 to 10 buckets to empty the box when it is full.

#### 1.4 Verifying the Setup

When setting up the simulator for experiments use the checklist provided. Circle the setting on the sheet or write them in before you start the run and then check them off as they are verified during the run. The person taking velocity measurements has ample time during the run to verify the checklist. Figure 1 is a sample sheet.

Run # :	
<input type="checkbox"/> End sand feeder	on / off
<input type="checkbox"/> End flow set	Rate: _____ L/min _____ %
<input type="checkbox"/> Side feeder	on / off
<input type="checkbox"/> Infiltration	on / off      Rate: _____ mm/hr
<input type="checkbox"/> Sensor switch	on
<input type="checkbox"/> Computer setup	(file rillgo)
<input type="checkbox"/> Rainfall	on / off      Rate: _____ mm/hr
<input type="checkbox"/> Side and end hoppers	have sand
<input type="checkbox"/> Water to the rainfall	simulators is on
<input type="checkbox"/> Tank water	is turned on
<input type="checkbox"/> 3 Stopwatches	
<input type="checkbox"/> Bucket set #	_____

Figure 1. Sample check off sheet.

#### 1.5 Computer Setup

The computer must be setup in order to collect data from the sensors during the experiment. Run the *rillgo* program, it is found in *Rillgo* on the home screen. Be sure to disconnect any network connections before this program is executed; it interferes with the data collection. Make sure the water to the sensors is on. This is because the ether net card and the sensor card are not compatible. To setup the computer for a run, select (1) from the menu (*Run Main RILL SIMULATOR Program*). Then enter the desired information on the next screen. The runs are run for 10 minutes. The sample display is about every 10-sec. The LVDT run width value is not considered in data analysis, but a value of 8 is usually entered. After a run, the program must be exited. If it is not, the data taken from the run is erased.

#### 1.6 Setting Rainfall Simulators

Before each run, the rainfall simulators must be set to the desired rainfall intensity. The settings are programmed already. The reset knob must be turned if the settings need to be changed (i.e. from M1 to H2). Once this is done, the simulators are ready

for a run. The pumps, drives, and processor are turned on before the actual run, so when it is time to start the rain, only one knob needs to be turned – the *processor program knob* needs to be set on *run*. Table 1 shows the settings for the rainfall simulator as of 8/6/97.

Table1. Simulator Settings

Simulator Setting	≈ Rainfall in mm / hr
L1	90
L2	--
L3	--
M1	80
M2	95
M3	100
H1	--
H2	160
H3	170

### 1.7 Lowering Wooden Frame

The wooden frame is used to help lift and lower the plastic to keep the sediment feeders from getting wet during a run with rainfall. This frame is lowered before the feeders are pushed into position, if the experiment is running with rainfall. If the frame is lowered after the sediment feeders are pushed in then the plastic tarp does not form proper channels for diverting the water to the end of the tarp. If rainfall is not required, the frame does not need to be lowered. The tarp is lowered so it is about one foot above the metal bar. The tarp should be at the position where the end drains are at the bottom of the channel in the plastic. If it is lowered too far, the sediment feeders will crush the tentacle-like tubes, which are used to divert water into the grates.

### 1.8 Setting Up the End Flow Rate

To get the correct motor setting for a given flow rate interpolate between the data in table 2. The sand flow rate, from the sediment feeder at the top, is not adjusted, just turned on at 5 grams / second and off.

Table 2. Flow out of simulator.\*

% of top motor speed	Side flow (L/min)	End flow (L/min)	Total flow (L/min)
50	9.164	23.072	32.236
55	10.966	30.942	41.907
60	10.553	33.586	44.139
65	11.493	36.701	48.194
70	12.413	40.711	53.124
80	13.233	44.656	57.889
90	14.200	48.157	62.357

\* These numbers are only valid when the following criteria are met. The filter must be on the side flow pipes. The filter must contain 2 Scotch Brite pads held in place by the metal plate. The filter must also be clean. The valves must also be in their proper positions. The valve controlling side flow is opened all the way and the valve to the

end flow is marked with magic marker. The tank return valve is closed and the valve controlling total flow is opened all the way.

## 2.0 Rill Experiments

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### 2.1 File Nomenclature

There are essentially two types of files – laser scanner and flow files. All of the file names begin with “r.” The second letter of the file name signifies the percent slope the run was executed at. “a” would be at 1%, “b” at 2%, “c” at 3%, and so on. The third character indicates the different runs performed at a particular slope. (i.e. If “rac” is a run done at 1% slope, with a rainfall intensity of 170 mm/hr, “rad” would be a run performed with a 1% slope, with a rainfall intensity of 100 mm/hr) Repeated runs are indicated by a number following the first three characters. (i.e. rac1 and rac2 are repetitions of the same experiment) All files are *.dat* files.

Flow files are the files containing data taken from the sensors during the run (see 1.0 *Setup*). The flow file names involve only the above described. (i.e. *rac2.dat*)

The laser scanner filenames are a little different. The channel is scanned twice for each run – once after the sand is smoothed in the channel (before a run) and another after a run. These files are categorized by an additional “a” (for the initial scan) or “b” (for the final scan) in the filename. (i.e. *rac1a.dat* is the filename for the initial scan and *rac1b.dat* for the final scan)

### 2.2 Starting A Run

After everything is set for a run (see *Checklist*), a run can be done.

1. First the pump is turned on at the power strip. This also turns on the end sand feeder if its switch is on.
2. Then the water to the tank is turned on, not too hard or the tank will overflow.
3. The person who just did those steps walks to the front to let the person standing at the computer know when the water comes to the very end of the rill, just before it starts to pour over.
4. At that point he signals to the other person to turn on the rain, start the rain and primary stopwatch. Generally, one stopwatch is used to keep track of the total time. This stopwatch is started simultaneously with the flow file on the computer.
5. Then each takes their measurements once per minute.
6. During the run, the settings are verified on the checklist. The experiment should also be observed for: sand build up on the side, the tank overflowing, the channel in the plastic is not overflowing into the experiment, the sand is not falling on the floor and leaks in the equipment.

### 2.3 Sediment measurements

Samples of the sediment deposition are taken during each run. These samples are collected in small plastic buckets of fairly uniform size. There are a number of sets of buckets available from previous work on the rill simulator experiment. Each set contains nine buckets (one set is used per run), which are numbered from one to nine. Each set is also differentiated with a different letter (A, B, C, etc.). The set of buckets used for a particular run must be recorded. It is suggested to write it directly on the

*Sediment Measurement* form before the run and on the checklist, to avoid forgetting later.

During a run, samples are collected at increments of one minute. A total of nine samples are taken. The first is collected after 30 seconds into the run. The following samples are taken every minute thereafter.

Samples are collected by placing a bucket directly under the opening where both sediment and water exit the channel. A stopwatch is used to measure the time the bucket is actually held under the opening. Approximately three seconds should be sufficient. This time should be recorded on the *Sediment Measurement* forms, along with the total weight of the bucket, directly after it is measured.

The mass of the sand must be determined; hence, the sand must be completely dried. To do this, the water must be carefully poured out after the total weight is measured. There is sufficient time during the run to pour the water out, but this can also be done after the run. Just be sure that the total weight is measured. After as much of the water is poured out, the buckets can be taken outdoors to dry if the weather permits. The buckets of sand dry at different rates, depending on the amount of sediment in them. It generally takes about one day for the sand to dry completely. The sand dries more quickly if the buckets are periodically shaken throughout the day to break up the clumps. When the sand is completely dry, the weight of the sediment and buckets are measured. After this is done, the sand is placed in the large sifting barrels to be used again for later experiments (see 6.0 *Drying Sand*). If the sand in the buckets do not dry before the end of the day, the buckets must be taken inside, and taken outside again the following day if it is still wet. DO NOT try to dry these buckets of sand in the ovens. The buckets will melt in a matter of minutes. However, if there is a shortage of buckets, a heat gun can be used to dry the sand. It may take some time for the sand to dry. In addition, the buckets can become very hot quickly, and can even melt. Use with caution. Another option is to acquire more buckets. They can be found in a number of labs in the building. It is not suggested to get too many buckets.

The actual masses of the buckets do not need to be weighed each time. Table 2 displays the weight of the buckets available.

Table 2. Weight of Buckets

	A	B	C	D	E	F	G	H	K	M
1	275.2	275.7	261.4	275.2	275.1	275.8	275.5	275.2	260.4	275.6
2	276.1	274.8	275.3	254.6	274.7	275.3	274.7	261.8	275.3	276.0
3	275.5	274.0	275.6	270.9	275.0	276.1	275.2	275.8	276.0	275.0
4	274.7	276.2	275.2	276.1	262.2	272.7	275.7	276.0	275.2	275.2
5	275.4	265.6	275.3	275.3	275.8	274.9	275.2	276.3	275.5	276.4
6	275.6	258.2	275.9	276.0	275.4	275.4	275.7	276.3	276.1	276.2
7	268.5	276.0	274.9	275.0	276.1	275.3	256.0	275.2	275.3	276.9
8	275.6	276.0	276.2	275.5	275.6	275.8	272.2	275.0	276.2	275.6
9	275.9	275.2	275.5	275.1	275.1	275.6	259.1	276.2	275.8	274.9

#### 2.4 Velocity Measurements

Velocity measurements are made by squirting die into the ramp just before the water enters the box. At the same time a stopwatch is started. The person taking measurements then walks to the other end of the simulator and stops the stopwatch just as the leading edge of the die exits the channel. If you are short you may need to stand on a crate. This is done 9 times throughout the run, about every minute.



### 3.0 Data Entry

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The data from the experiment forms are entered into Microsoft Access. This can be done from the lab computer and be stored directly into Tom's computer.

On the home screen, select the *Network Neighborhood* icon. The computers in the building are listed on the screen. If there is no list (only an option of *Entire Network*), shut down the computer and try again. Otherwise, select the *Tom's pc* icon. This will provide connection to Tom's computer. Next, click on *My Document*, then *rillsim.mbd*. Data is entered in the forms as desired.

There are three different forms – *Experiment*, *Sediment*, and *Velocity*. The *Experiment* forms are used to show the settings of each run (i.e. rain intensity, infiltration rate, etc.). The *Sediment* forms are used to record the data samples taken from the run with respect to sediment output (i.e. total, sediment + bucket, and bucket weights, and time). Only the data entries for Total Weight should be rounded to 4 significant digits. Lastly, the *Velocity* forms are used to record to the velocity measurements of the water taken during the run. Data should not be rounded when entered.

## 4.0 Scanning

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A scan must be done both before (but after smoothing the sand) and after each run. Scanning the surface before provides a baseline to compare the surface after the run. Most importantly, the laser scanner must be positioned parallel for each scan.

To scan the simulator, use the following instructions:

- 1) Roll the scanner over the simulator. **Be sure that no cables become hung up on the simulator when moving the scanner.** Make sure the inside edge of the frame is one inch beyond the edge of the ramp transporting the water. If this is not done there may not be enough room for the scanner to scan the entire rill, and the scanning mechanism will hit the automatic shutoff switch.
- 2) Lock the north west wheel on the scanner
- 3) Plug in the computer, and turn on the computer. Next turn on the laser.
- 4) Cd into the rillsim directory, then type rill. Now the file can be created and the scanner can be lined up.
- 5) To create the file hit F1(setup menu).
- 6) Next hit F7 (change file name)
- 7) Hit 1 to change the file rill.dat to the proper file name. Type in the proper file name and hit enter. See section 2.0 titled *Rill Experiments* for Tom's nomenclature for naming rill experiment files.
- 8) To line up the laser, move the laser so it is half on the edge at the west end just before the east bar. The program must be running rillsim in order for the laser to be able to move .
- 9) When the laser is in this position move the laser in the  $-x$  direction to just before the bar.
- 10) Now rotate the laser scanner about the northwest wheel, the locked one, so the laser is half on the north east edge of the side just before the east bar. Now lock the northeast wheel.
- 11) Move the laser in the  $+x$  direction to just before the west bar and repeat steps 3,4, and 5. Do this until the laser starts on the west side of the north edge and ends up on the east side of the north edge; when the laser is moved down the north edge. The north edge is not exactly straight so it will not follow the edge very well. The laser just has to start on the northwest edge and end up on the northeast edge near each bar. Do not use the south edge of the rill simulator because it is even less straight than the north, and experiments have been completed in the past using the north alignment method.
- 12) Now return to the main screen using F-10 from the file changing screen.
- 13) Move the laser around the circumference of the area to be scanned. This is to check the range of motion. It insures the scanner will not get hung up or hit any interrupt switches.
- 14) Start the scan, when the laser is in position, using F-6.
- 15) Exit the program when done scanning. This insures the file is saved.

## 5.0 Transferring Files From Laser Scanner

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To transfer data from the laser scanner, the files are first copied onto a 5 ¼" disk. The DOS command on the scanner is `<copy filename a: >` note that only two files can be copied onto one disk, this is because of the size of the files.

Example:

```
C:\RILLSIM> copy reg2*.dat a:      (copies reg2a.dat and reg2b.dat onto disk a)
```

The files are then transferred to Tom's f: drive. This is done from Tom's lab computer. On the home screen, click the *My Computer* icon, then the *Cochrane on 'Soils' (F:)* icon. This gives you access to Tom's directory. (If access is denied, reboot the computer.) The disk files are transferred into the *Rillsimulator* file folder. In this folder, the disk files are saved into the corresponding set of experiment. For example, the *reg2a.dat* file is transferred into the *reg* folder.

To transfer the files from the 5 ¼" disk to the f: drive, simply select the *5 ¼ Floppy (B:)* icon under *My Computer*. The files on the disk is shown on the screen. The two files are highlighted with the mouse and dragged to the corresponding file folder (after the folder has been opened). Once the disk files have been transferred into the f: drive, they are deleted.

To delete, drag the two highlighted files to the *Recycle Bin* icon on the home screen. It is suggested to delete files from the computer, since it is quicker. However, it can be done on the laser scanner with the *del* command.

Example:

```
C:\RILLSIM> del reg2*.dat      (deletes reg2a.dat and reg2b.dat)
```

For efficiency, more than one disk is used at a time. While one is being used to copy the files from the laser scanner, another disk is used to transfer the data on the disk to the f: drive.

## 6.0 Drying sand

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Wet sand is spread out on plastic tarps at every opportunity possible. During the summer, with dry weather, it takes one to three days to dry the sand. It is best to use the sand outside before sand in the building is used. This is because one day of rain may make it impossible to get dry sand from the tarps for three days. If you have reserved dry sand inside, experiments can continue to be performed throughout the period of rain and immediately preceding it.

Wet sand is spread thinly on the tarps. This enables the sand to dry faster. The sand is stirred periodically, allowing the wetter sand on the bottom to dry. The sand on the top dries fairly quickly. If there is an immediate need for sand, this top layer can be skimmed (it is suggested to use hands to do this). Be sure the sand collected is **completely** dry; wet sand cannot be placed in the sediment feeders. If wet sand is placed in the feeders, it must be completely removed from the feeders, which is very time consuming. This wet sand blocks sand from going through the feeders.

When sand is being collected from the tarps, it must first be sifted. This separates most of the wet sand from the dry sand. It also eliminates larger particles of debris. To sift the sand, use a sieve that just fits over the mouth of the buckets. Cut and place a 1 mm (approx.) screen – circular in shape -- in the sieve. When the sand is being sifted, the wet sand remains in the sieve. Do not force the sand through, or wet sand will end up in the bucket. Simply dump this wet sand back on the tarps and continue sifting. If too much of the sand is wet, discontinue collecting sand. Generally sand is collected at the end of the day when it is completely dry.

The dry sand collected is sifted twice – once in the sieves and another when it is dumped in the brown plastic garbage cans. A screen is placed on the barrel using a large piece of 1mm screen. It can be held in place by tying wire or string around the screen on the barrel. Using a cable and vice grips also works. It is essentially a large sifter. This twice sifted sand can then be used to fill the sediment feeder hoppers.

During the evenings, the sand outside must be covered. Sand may blow away or it may rain.

In the future, when it becomes too cold to dry sand outside, the possibility of drying sand inside on shelves should be considered. If sand is to be purchased, it is obtained from Von Tobel Lumber and Hardware. The address and phone number are 319 N Earl Av. Lafayette, and 448-1525. The sand being used as of 7/30/97 is fine white sandblasting sand.

## 7.0 Calibration

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### 7.1 Laser Scanner Calibration

The laser scanner must be calibrated periodically, usually once every two weeks. A tool with steps of exactly 5mm is necessary to calibrate; it is called a calibration triangle. This tool is placed in the channel, deep enough in the sand so that the bottom step is below the level of the lowest point to scan. It is necessary to dig about 10 inches into the sand.

The camera is aligned in order for the photoelectric sensor to detect the full range of altitude on the surface. The camera is aligned by moving loosening one of the three four-pointed star knobs. Move each one individually. A small knob on the right at the base of where the lens attaches, lets the user switch between viewing the alignment position and exposing the photoelectric sensor to the image.

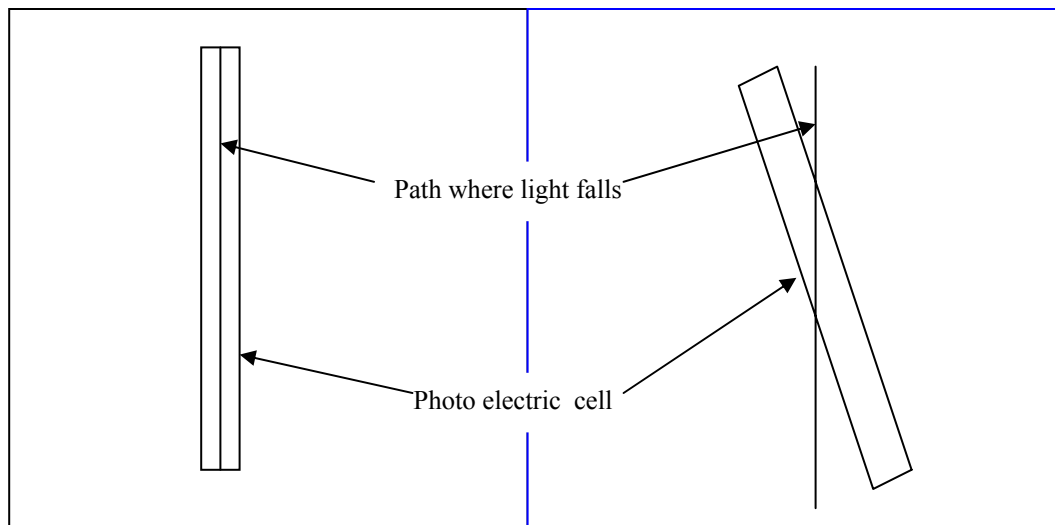


Figure 1. Aligned camera

Figure 2 Misaligned camera

The light path is where the light is reflected. Depending on elevation the light will be somewhere on this path.

The photoelectric cell must be able to detect the full range of altitude from the calibration triangle. If the camera is misaligned as in Figure 2 the high and low data will be clipped from the scan and there will only be a small range of usable data. The camera is aligned if the camera can detect the light from the top of the calibration triangle to the bottom. To check this move the laser up and down the triangle while looking at the read LED on the box above the power supplies. If the light comes on, this means the laser is not being detected.

Once the camera is aligned, position the laser so that it is at the bottom step. Be sure the step tool is lined so the laser shines on each step when moved in the east-west direction. The laser output (bit numbers) is recorded on paper for each step of the

calibration triangle. To do this, enter the laser scanner program used to scan (type *cd rillsim* at the c prompt, then *rill*). Hit F9 (Move Carriage). On the screen, there is a *laser output* heading, with the value beneath it. This is the number that should be recorded, along with the step on the tool. The bottom step is the 0mm mark. The next step is 5mm, the next 10mm, and so on. Record the values until the last step is reached, or until the end of the range (the screen would read 999). This information is entered into the laser scanner in the rillsim directory. The filename is called *<caldate.dat>*. (i.e. a calibration done on 7/24/97 should be named *cal0724.dat*)

To enter this data into the scanner, type *cd rillsim*, if you are not in the directory already, then *<edit filename>*.

Example:

```
C:\RILLSIM: edit cal0724.dat
```

There is a specific format used to enter in the data. Look in old calibration files and determine what this is. On the first line, type the number of steps that had readings. On the second line, enter the height of the first step, which is 0. Push tab, then enter the value of the laser output at that height. On the third line, enter the height of the second step, which is five, then tab, then the laser output. Continue this format for the remaining data entries.

Example:

```
20
0      786
5      765
10     742
15     721
.
.
105    322
```

## 7.2 Water Calibration

### 7.2.1 Infiltration Calibration

The infiltration is a function of the height of the valve. To calibrate the infiltration turn on the water so it just trickles over the edge of the rill. This means the rill is thoroughly saturated. Open the valve to allow maximum infiltration and maintain a trickle over the edge of the rill, just to insure total saturation. Measure the flow rate with the computer to obtain a gross measurement of what the infiltration is. Unclamp and move the infiltration valve up and down the bar to adjust the amount of infiltration. Check on the computer to see if the infiltration is where it is desired. When the computer infiltration flow rate is close, adjust the clamp as needed. Then take a flow measurement with a 5-gallon bucket and a stopwatch. Take the sample for about 1 to 2 minutes. There is less error in a longer reading than in a short reading. Weigh the water and divide the mass of the water by the time for the reading to get the mass flow rate in grams per second. Then readjust the height of the valve and take

another measurement. Move the valve up if you want a lower flow rate and down if you want a higher flow rate.

The mass flow rate can be converted into mm per hour by the following conversions.

From GPM to mm / hr

Part of the wood frame hangs over the end of the rill,  
so the area getting rain is only 140 3/8 in X 14 in

$$(\# \text{gal} / \text{min})(3.785 \text{ l} / \text{gal})(60 \text{ min} / \text{hr})(1000 \text{ mm}^3 / 1 \text{ cm}^3)(1/1965.25 \text{ in}^2)(1 \text{ in}^2 / 6.4516 \text{ cm}^2)(1 \text{ cm}^2 / 100 \text{ mm}^2) = \text{mm} / \text{hr}$$

it simplifies to

$$(\# \text{ of GPM})(179.11 \text{ min mm} / \text{ gal hr}) = \# \text{ of mm} / \text{ hr} \quad 2$$

From grams / second to mm / hr

$$(\# \text{ grams} / \# \text{ seconds})(1 \text{ cm} / \text{ gram})(1000 \text{ mm}^3 / \text{ cm}^3)(3600 \text{ sec} / 1 \text{ hr})(1/1965.25 \text{ in}^2)(1 \text{ in}^2 / 6.4516 \text{ cm}^2)(1 \text{ cm}^2 / 100 \text{ mm}^2)$$

this simplifies to

$$(\# \text{ grams} / \text{ sec})(2.8393 \text{ sec mm} / \text{ gram hr}) = \# \text{ mm} / \text{ hr} \quad 3$$

## 7.2.2 Rainfall Calibration

### 7.2.2.1 Total Flow

Lower the plastic tarp and close the infiltration valve. The total rainfall that falls through the wood frame and lands in the trough is gathered. The total rainfall in grams per second is converted to mm / hr from equation 3. Tom can adjust the settings on the simulator if needed.

### 7.2.2.2 Rainfall Distribution

The sand is first smoothed out, and then metal frames are inserted in the channel. Numbered square plastic containers are inserted in the frames in numerical order. The plastic is lowered. Then the simulator is turned to the appropriate setting and turned on for 1 minute. The simulator is then turned off and the containers are weighed. The information is put into a spreadsheet and the data is looked at graphically. The flow to each nozzle can not be individually adjusted but leaks and drips can be fixed. There are two types of nozzles, 80/100 and 80/150, they can be switched to obtain the desired effect. Also moving the simulators in the x and y-direction can change the distribution.

## 7.2.3 End Flow Calibration

The end flow is measured by diverting the water from the end feeder ramp to a bucket while timing the process. The side flow should be running during the process. The bucket is then weighed and the mass is divided by the time to get the end mass flow rate. Do not use a bucket with a hose attached to the bottom of the bucket to get a flow rate. It may seem easier to get a measurement from a setup like this but it is not. A

flow rate measurement has been attempted from the hose of a setup like this. While the water enters the bucket at a constant rate, the water leaves the 2-inch hose as some sinusoidal function. Since the measurement is only taken for a few second you will get a high or a low reading and not the average. Flow rates for given motor setting should not change significantly from the data in table 2 as long as the conditions listed below table 2 are in place.

#### **7.2.4 Side Flow Calibration**

The original hole size was chosen by taking several one foot one inch sections with 12 holes drilled down the length. Each section used different size holes. The flow rates were measured for each at various pressures. A hole diameter of 0.02 inches spaced every inch was chosen for the desired flow rate. If a new section needs to be made there are several 0.02-inch bits in a plastic bag in one of the drill bit cases. There is not a chuck that fits this small size so the bit must be wrapped in paper before it is placed in the chuck.

##### **7.2.4.1 Total flow**

The water coming from the end should be diverted from the channel for this process. A bucket with a hose attached to the bottom works well for this. The hose should have at least a 2-inch diameter. The infiltration valve is turned off and the holes are inspected to make sure they are not clogged. Side flow calibrations are then done by measuring the grams of water that flow out the end of the channel. Wait for the channel out flow to reach steady state when doing this. This can be checked by taking several measurements.

##### **7.2.4.2 Flow Distribution**

The uniformity of flow is checked by placing enough buckets in a line to catch all of the water. The pipe is placed with the holes pointed down and the flow is timed. The buckets are then weighed. The mass flow per section is then put in a spreadsheet.

#### **7.3 Sand Flow Calibration**

##### **7.3.1 Total Flow**

The total flow is measured by placing a tarp under the sand feeders and the run time taken. The sand is then weighed and the grams per second are calculated.

##### **7.3.2 Flow Distribution**

Metal frames are inserted into the channel. Then plastic containers are put in the metal frame in numerical order. The side feeders are put in position and run for about a minute. The containers are weighed and the data is put into a spreadsheet. After viewing the feed distribution the directional fins are adjusted make the distribution more uniform. The process is repeated until the desired uniform flow of sand is met.