es5-ws4

August 4, 2025

[15]:
```
# Somewhere USA
import matplotlib.pyplot as plt
time =[0.0,1.0,2.0,3.0,4.0,5.0,6.0,7.0,8.0,9.0,10.0,11.0]
runoff=[0.0,70.0,160.0,110.0,80.0,60.0,45.0,30.0,20.0,12.0,5.0,0.0]
# Excess precip == runoff (in watershed inches)
area = 100 #acres given
excess = 12.0*(sum(runoff)*3600)/(area*43560)  #excess in inches
print(f"Excess precipitation: {excess:.2f} inches")
```

```
Excess precipitation: 5.87 inches
```

Here is the data in the Excel worksheet - we will have to assume the response is to a single hour of precipitation (or experiment a bit, we will need unit weights greater than zero)

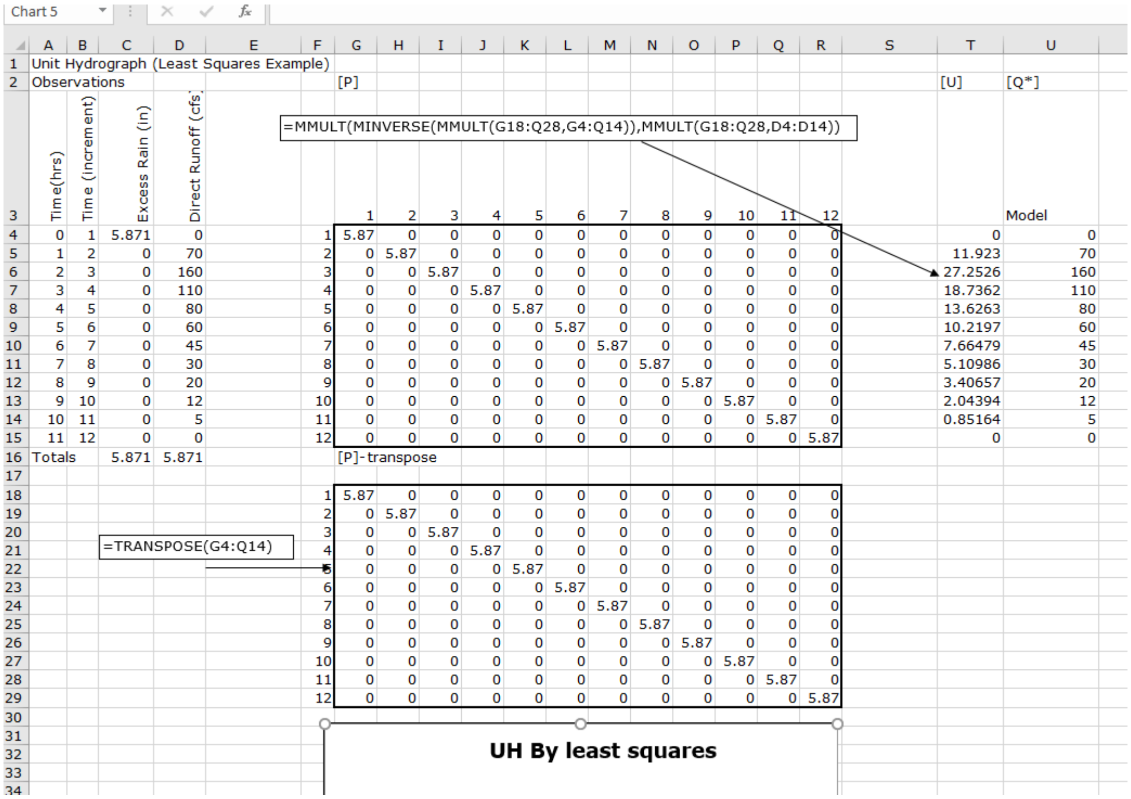


Chart 5

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	Unit Hydrograph (Least Squares Example)																				
2	Observations						[P]													[U]	[Q*]
3	Time(hrs)	Time (increment)	Excess Rain (in)	Direct Runoff (cfs)			1	2	3	4	5	6	7	8	9	10	11	12			Model
4	0	1	5.871	0		1	5.87	0	0	0	0	0	0	0	0	0	0	0		0	0
5	1	2	0	70		2	0	5.87	0	0	0	0	0	0	0	0	0	0		11.923	70
6	2	3	0	160		3	0	0	5.87	0	0	0	0	0	0	0	0	0		27.2526	160
7	3	4	0	110		4	0	0	0	5.87	0	0	0	0	0	0	0	0		18.7362	110
8	4	5	0	80		5	0	0	0	0	5.87	0	0	0	0	0	0	0		13.6263	80
9	5	6	0	60		6	0	0	0	0	0	5.87	0	0	0	0	0	0		10.2197	60
10	6	7	0	45		7	0	0	0	0	0	0	5.87	0	0	0	0	0		7.66479	45
11	7	8	0	30		8	0	0	0	0	0	0	0	5.87	0	0	0	0		5.10986	30
12	8	9	0	20		9	0	0	0	0	0	0	0	0	5.87	0	0	0		3.40657	20
13	9	10	0	12		10	0	0	0	0	0	0	0	0	0	5.87	0	0		2.04394	12
14	10	11	0	5		11	0	0	0	0	0	0	0	0	0	0	5.87	0		0.85164	5
15	11	12	0	0		12	0	0	0	0	0	0	0	0	0	0	0	5.87		0	0
16	Totals		5.871	5.871			[P]-transpose														
17																					
18						1	5.87	0	0	0	0	0	0	0	0	0	0	0			
19						2	0	5.87	0	0	0	0	0	0	0	0	0	0			
20						3	0	0	5.87	0	0	0	0	0	0	0	0	0			
21						4	0	0	0	5.87	0	0	0	0	0	0	0	0			
22						5	0	0	0	0	5.87	0	0	0	0	0	0	0			
23						6	0	0	0	0	0	5.87	0	0	0	0	0	0			
24						7	0	0	0	0	0	0	5.87	0	0	0	0	0			
25						8	0	0	0	0	0	0	0	5.87	0	0	0	0			
26						9	0	0	0	0	0	0	0	0	5.87	0	0	0			
27						10	0	0	0	0	0	0	0	0	0	5.87	0	0			
28						11	0	0	0	0	0	0	0	0	0	0	5.87	0			
29						12	0	0	0	0	0	0	0	0	0	0	0	5.87			
30																					
31																					
32																					
33																					
34																					

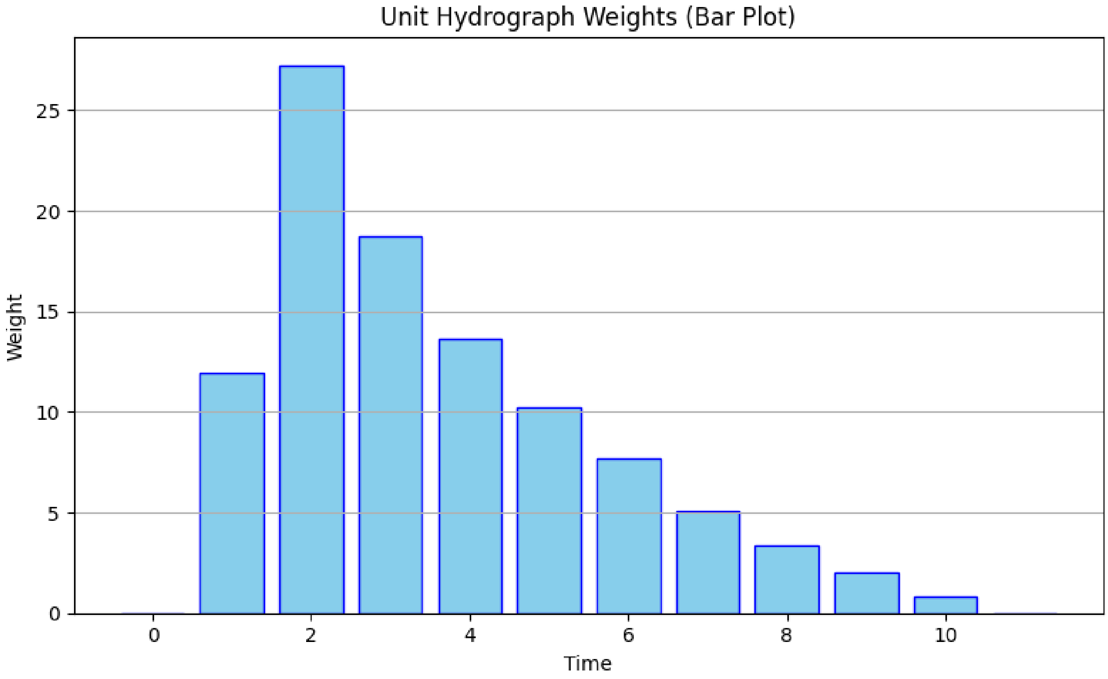
=MMULT(MINVERSE(MMULT(G18:Q28,G4:Q14)),MMULT(G18:Q28,D4:D14))

=TRANSPOSE(G4:Q14)

UH By least squares

[16]:
```
import matplotlib.pyplot as plt
```

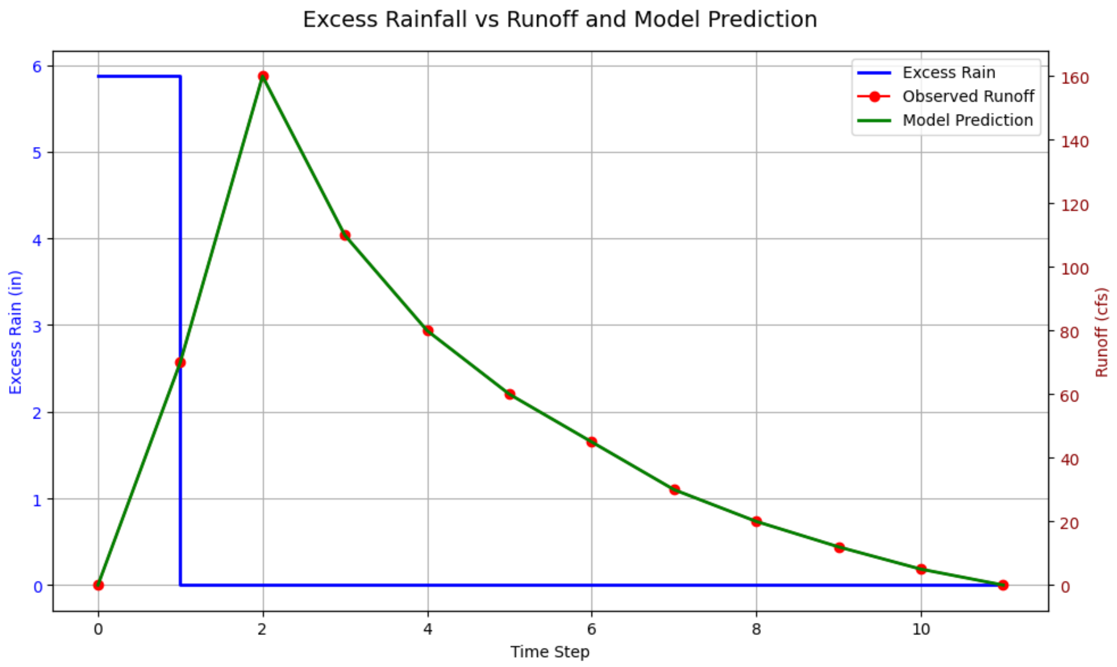
```
uh_weights = [0.0, 11.923, 27.2526, 18.7362, 13.6263, 10.2197, 7.66479,
              5.10986, 3.40657, 2.04394, 0.85164, 0.0]
time = list(range(len(uh_weights)))

plt.figure(figsize=(8, 5))
plt.bar(time, uh_weights, color='skyblue', edgecolor='blue')

plt.title("Unit Hydrograph Weights (Bar Plot)")
plt.xlabel("Time")
plt.ylabel("Weight")
plt.grid(True, axis='y')
plt.tight_layout()
plt.show()
```



[17]:

```
# After Modeling using the Excel sheet - rendering results
import matplotlib.pyplot as plt

# === Data Lists ===
excess_rain = [5.871, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
direct_runoff = [0, 70, 160, 110, 80, 60, 45, 30, 20, 12, 5, 0]
model_runoff =   [0, 70, 160, 110, 80, 60, 45, 30, 20, 12, 5, 0]
time = list(range(len(excess_rain)))

# === Create figure and axes ===
fig, ax1 = plt.subplots(figsize=(10, 6))
```

```

# --- Left Y-axis: Rainfall ---
ax1.set_xlabel("Time Step")
ax1.set_ylabel("Excess Rain (in)", color='blue')
rain_line = ax1.step(time, excess_rain, where='post', color='blue',␣
 ↪linewidth=2, label="Excess Rain")[0]
ax1.tick_params(axis='y', labelcolor='blue')

# --- Right Y-axis: Runoff and Model ---
ax2 = ax1.twinx()
ax2.set_ylabel("Runoff (cfs)", color='darkred')
runoff_line, = ax2.plot(time, direct_runoff, 'ro-', label="Observed Runoff",␣
 ↪linewidth=1.5)
model_line, = ax2.plot(time, model_runoff, 'g-', label="Model Prediction",␣
 ↪linewidth=2)
ax2.tick_params(axis='y', labelcolor='darkred')

# --- Title and Grid ---
fig.suptitle("Excess Rainfall vs Runoff and Model Prediction", fontsize=14)
fig.tight_layout()
ax1.grid(True)

# --- Combined Legend ---
lines = [rain_line, runoff_line, model_line]
labels = [line.get_label() for line in lines]
ax1.legend(lines, labels, loc='upper right')

plt.show()
```



Excess Rainfall vs Runoff and Model Prediction
Excess Rain (in)
0
1
2
3
4
5
6
Runoff (cfs)
0
20
40
60
80
100
120
140
160
Time Step
0
2
4
6
8
10
Excess Rain
Observed Runoff
Model Prediction

```
[ ]:
```