# Traffic Control Manipulation

In order to take advantage of this chemical spill, we want to place it in one of three locations that have the desired results on Wooster Square

- Increasing travel time as much as possible
- Reducing incoming traffic as much as possible

To do so, we need to compare the following:

- The situation prior to the spill
- The 3 situations after the spill

**Note: for all plots using FLOW ACCUMULATION, this accompanying visual uses Focal Statistics (Maximum) for better differentiation, but all raster calculations use the original FLOW ACCUMULATION output

# Pre-Spill: Travel Time

First, we want to generate layers indicating the total travel time before the spill had occurred. To do so, we will first create a friction layer, setting roads to have a cost of 1 minute and non-roads to have a cost of 5 minute per pixel. Afterwards, we can find the Cost Distance to Wooster Square.


***Figure 0a. streets***

Description: New Haven streets
Source: provided in sample


***Figure 0g. cost_pre***

Description: cost of travel (1 for roads, 5 for non-roads) before the spill
Source: RECLASSIFY("streets"):

- 1→ 1
- NoData → 5

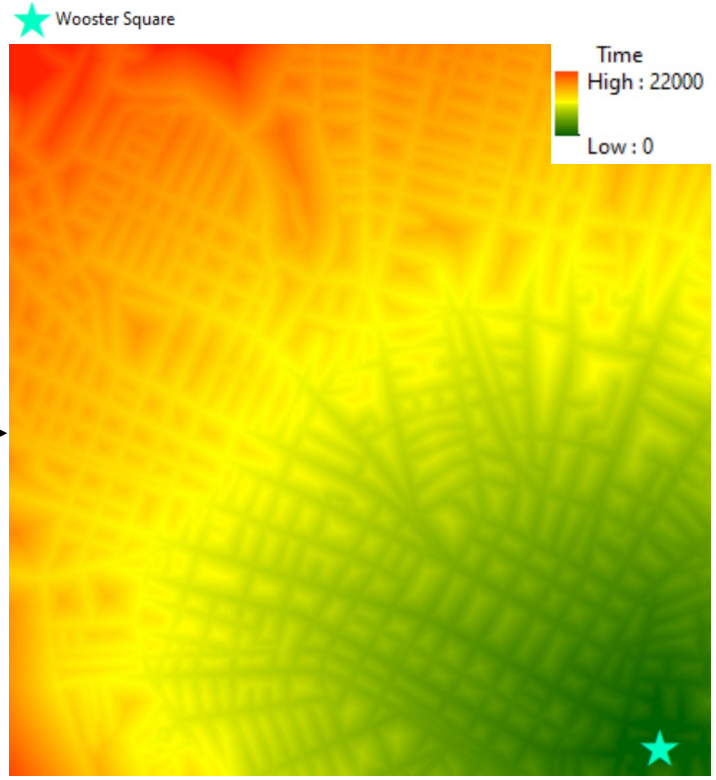



***Figure 0h. time_pre***

Description: time to travel before the spill
Source: COST DISTANCE

- Input Raster: "WoosterSquare"
- Input Cost: "cost_pre"

# Pre-Spill: Incoming Traffic

We also want to generate the incoming traffic towards Wooster Square. We can find incoming traffic by using our time cost as our "elevation". That is, Wooster Square has an elevation of 0, and so all pixels will "flow" towards Wooster Square. To do so, calculate a the flow direction, then flow accumulation of the time costs.

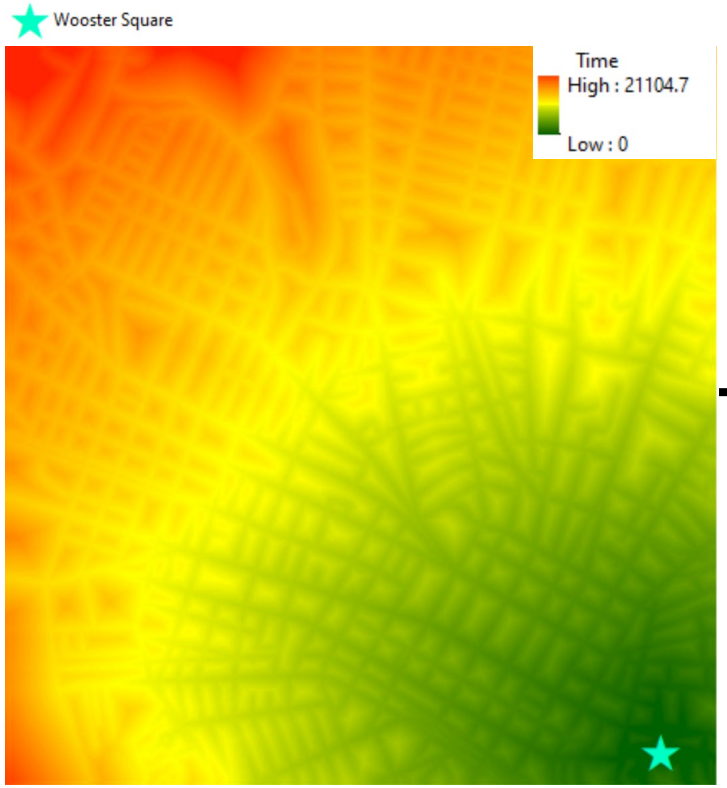



***Figure 0h. time_pre***

Description: time to travel before the spill
Source: COST DISTANCE
- Input Raster: "WoosterSquare"
- Input Cost: "cost_pre"

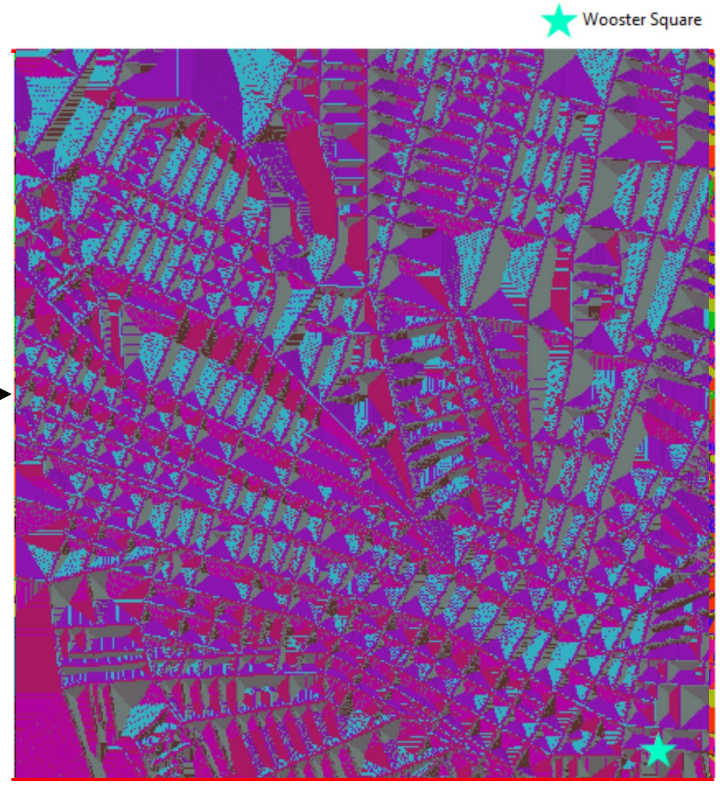



***Figure 0i. trafdir_pre***

Description: flow direction of traffic before the spill
Source: FLOW DIRECTION
- Input Surface Raster: "time_pre"

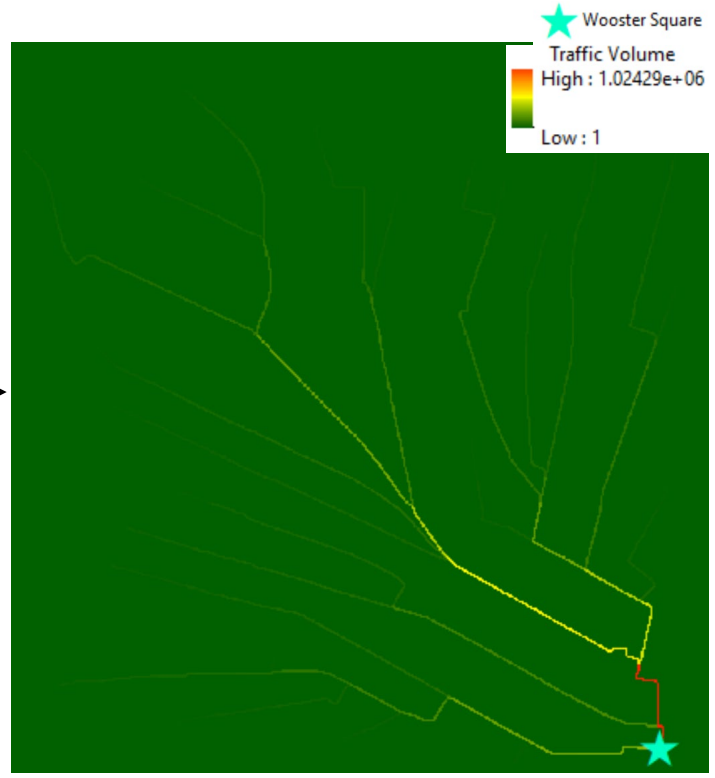



***Figure 0k. trafacc_pre***

Description: flow accumulation of traffic before the spill
Source: FLOW ACCUMULATION
- Input Flow Direction: "trafdir_pre"

# Step b: Split Sites

Split the three sites into three separate raster data.

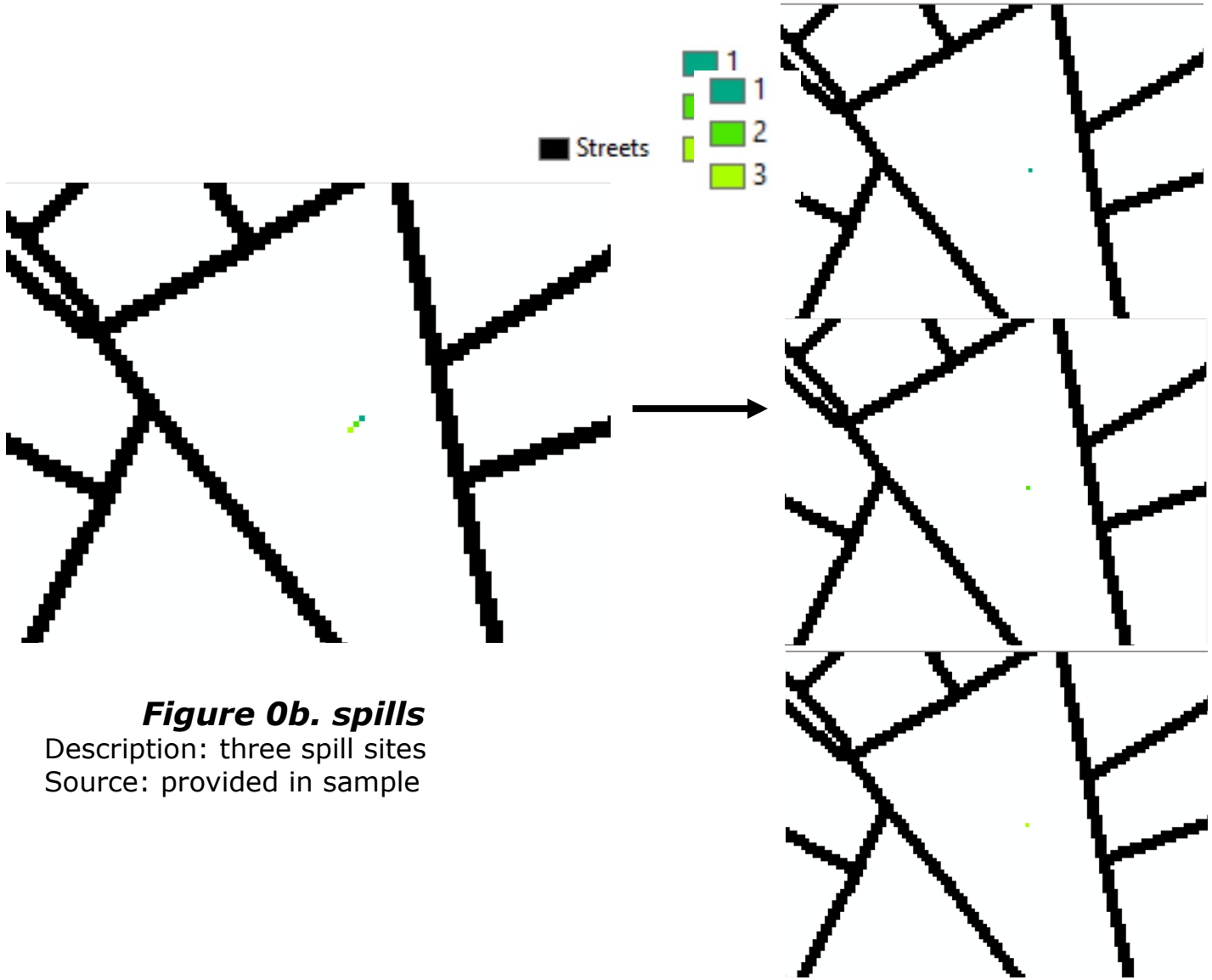



***Figure 0b. spills***
Description: three spill sites
Source: provided in sample

***Figure 1b. pt1***
Description: point 1
Source: RECLASSIFY("spills")
- 1 → 1
- 2 → NoData
- 3 → NoData
- NoData → NoData

***Figure 2b. pt2***
Description: point 2
Source: RECLASSIFY("spills")
- 1 → NoData
- 2 → 1
- 3 → NoData
- NoData → NoData

***Figure 3b. pt3***
Description: point 3
Source: RECLASSIFY("spills")
- 1 → NoData
- 2 → NoData
- 3 → 3
- NoData → NoData

# Step c-f: Flow Accumulation

Find where the chemical is spilled onto based on starting point.

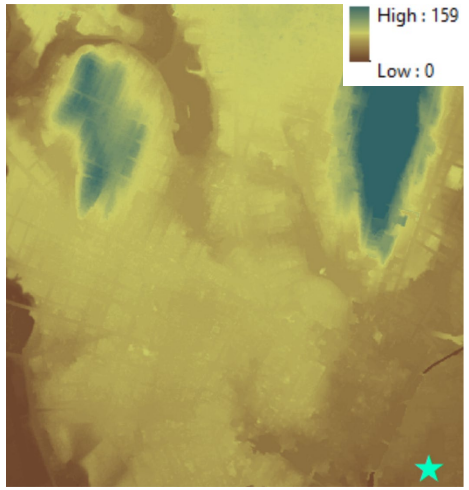



***Figure 0c. elevation***

Description: elevation
Source: provided in sample

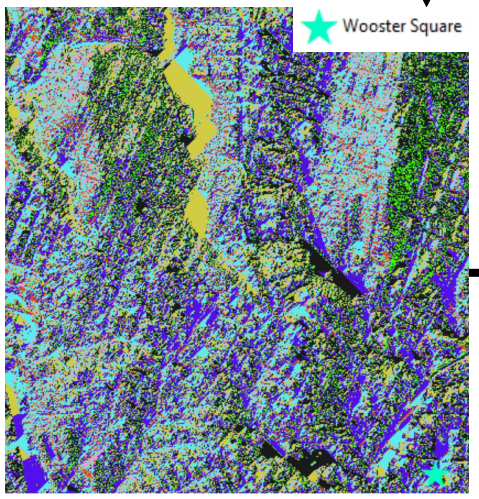



***Figure 0d. flow_dir***

Description: flow direction of elevation
Source: FLOW_DIRECTION("elevation")

***Figure 1e/2e/3e: flowacc_1, flowacc_2, flowacc_3***

Description: Flow accumulation starting at pixel 1 (left), pixel 2 (center), pixel 3 (right)
Source: FLOW ACCUMULATION

- Input Flow Direction: "flor_dir"
- Input Weight Raster: "pt1" (left), "pt2" (center), "pt3" (right)

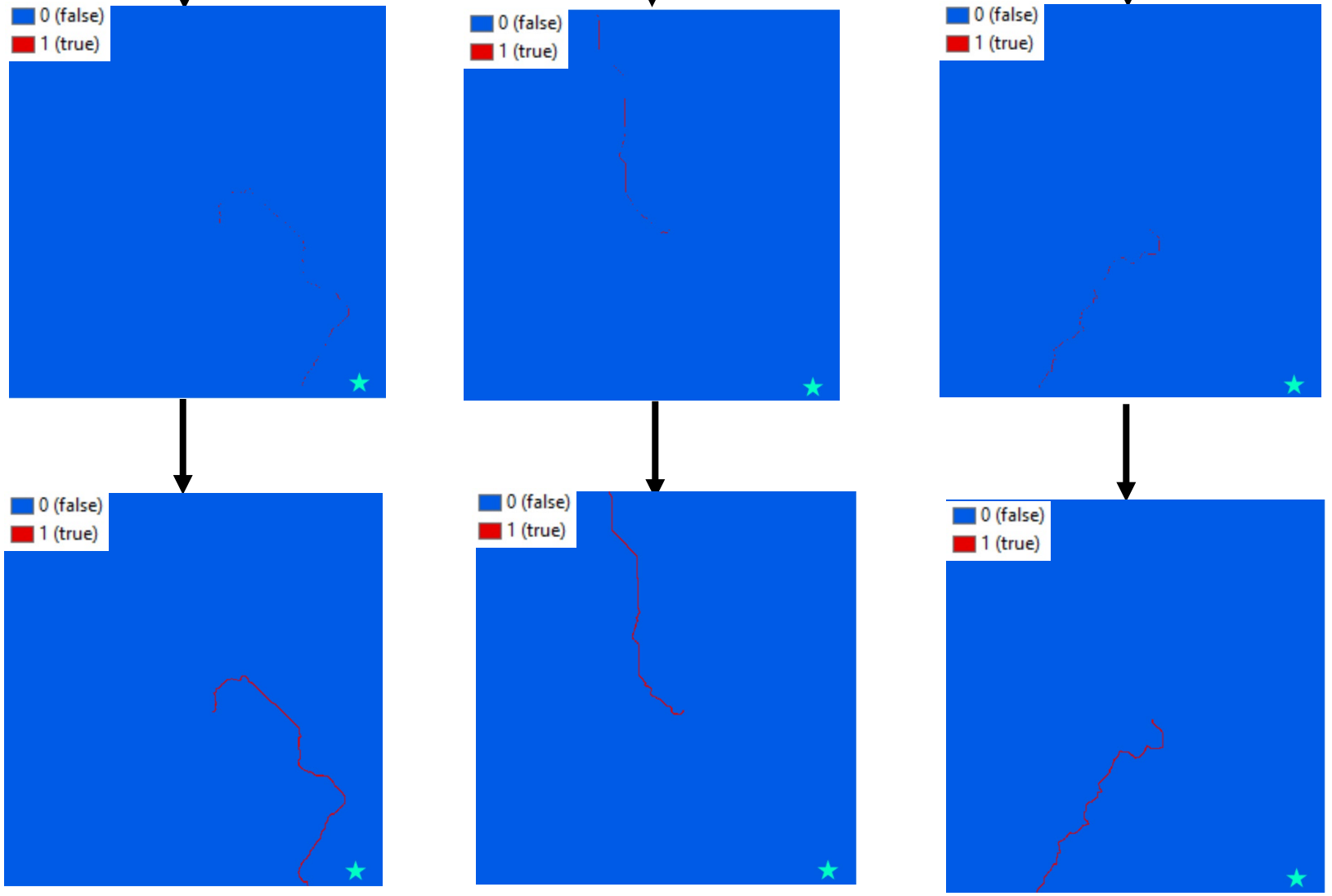



***Figure 1f/2f/3f: flowaccmax_1, flowaccmax_2, flowaccmax_3***

Description: true (1) and false map (0) for if pixel has experienced spill (for Presentation Purposes only)
Source: FOCAL_STATISCTICS(X), Maximum
X = "flowacc_1" (left), "flowacc_2" (center), "flowacc_3" (right)

# Step g: Determine Costs

Since any pixel that has the chemical (no matter what value) is impassable, we want to set their cost in the original cost pixel to NoData so they are impassible

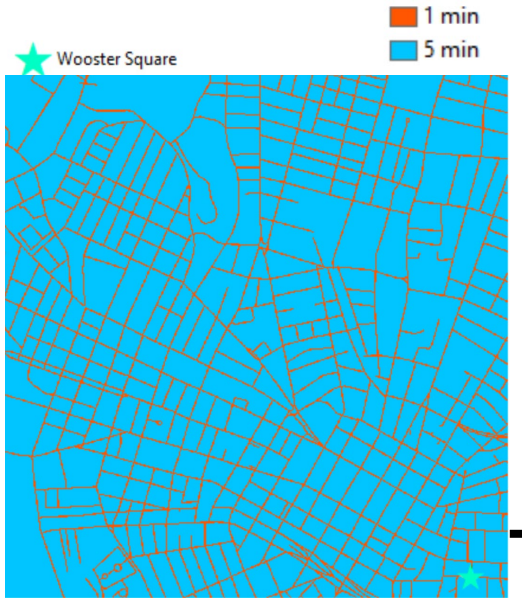



***Figure 0g. cost_pre***

Description: cost of travel (1 for roads, 5 for non-roads) before the spill

Source: RECLASSIFY("streets"):

- 1→ 1
- NoData → 5

***Figure 1f/2f/3f: Figure 1e/2e/3e: flowacc_1, flowacc_2, flowacc_3***

Description: true (1) and false map (0) for if pixel has experienced spill

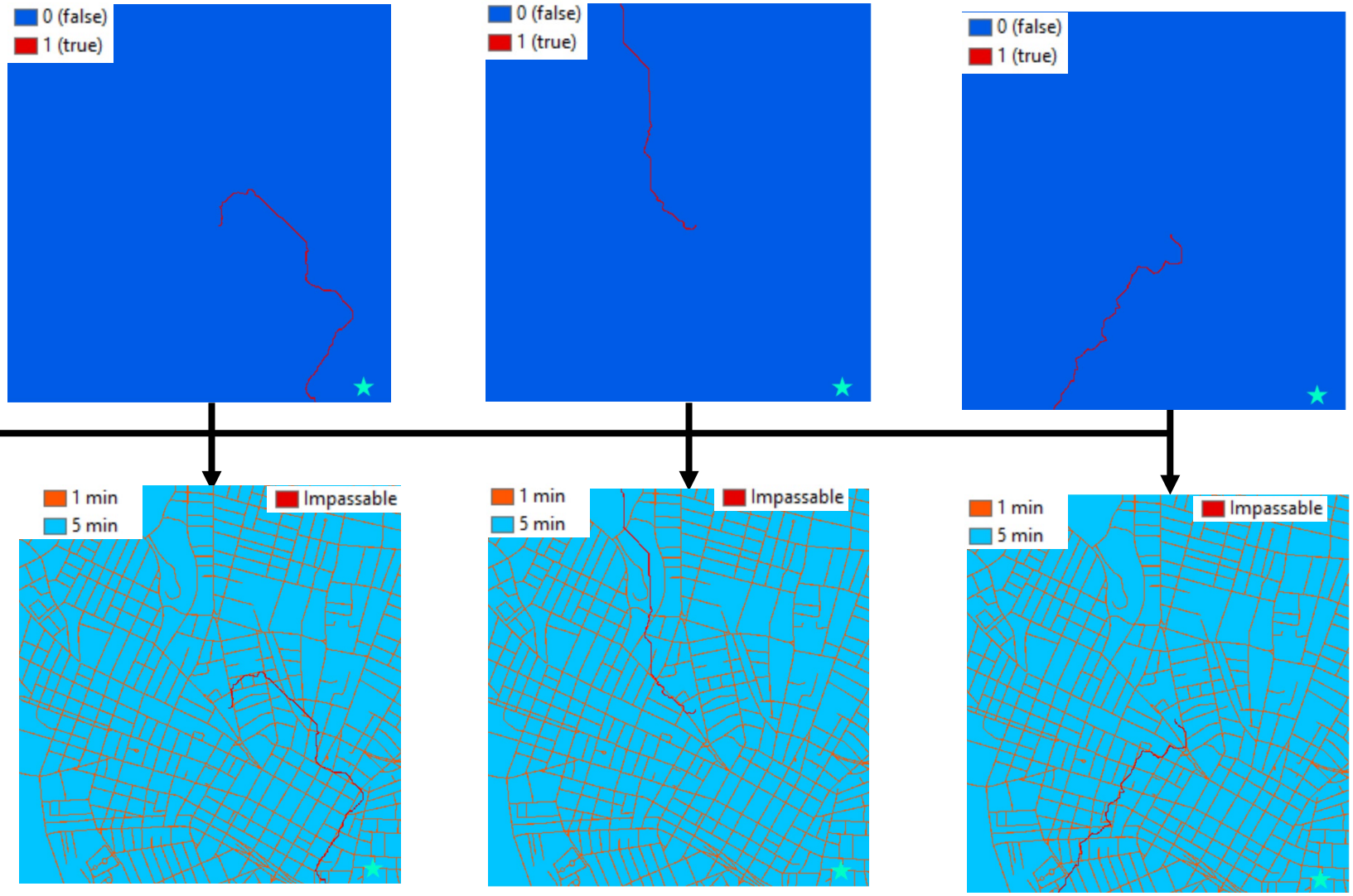



***Figure 1g/2g/3g: cost_1, cost_2, cost_3***

Description: cost of travel (1 for roads, 5 for non-roads, NoData for impassable) after spill for each starting spill location

Source: RASTER CALCULATOR(Con(X == 0, "cost_pre))

X = "flowacc_1" (left), "flowacc_2" (center), "flowacc_3" (right)

# Step h-i: Travel Time

We can use the new costs (which spill regions blocked out and make impassable) to calculate travel times, and the differences as well.

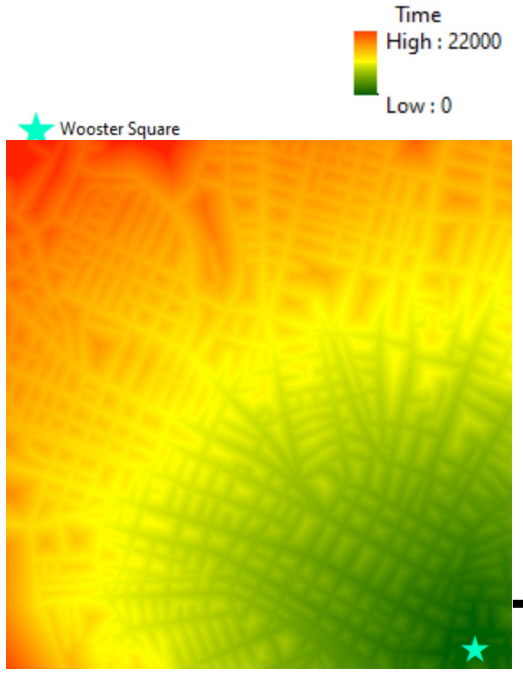



***Figure 0h. time_pre***

Description: time to travel before the spill
Source: COST DISTANCE
- Input Raster: "WoosterSquare"
- Input Cost: "cost_pre"

***Figure 1g/2g/3g: cost_1, cost_2, cost_3***

Description: cost of travel (1 for roads, 5 for non-roads, NoData for impassable) after spill for each starting spill location

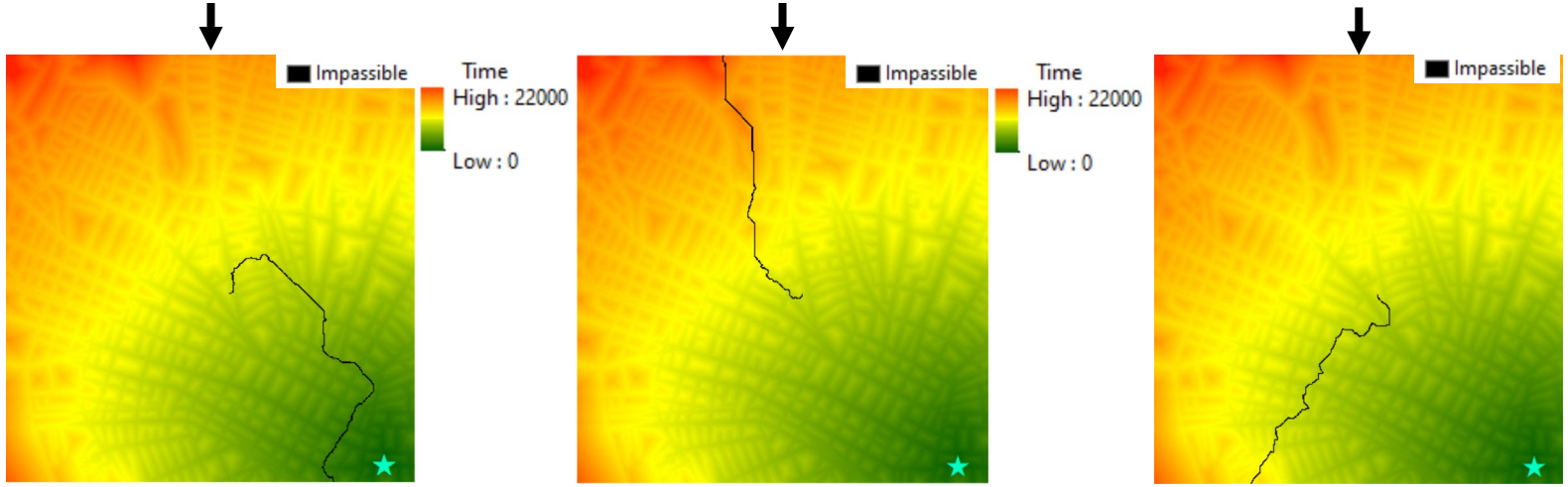



***Figure 1h/2h/3h: time_1, time_2, time_3***

Description: time to travel after the spill
Source: COST DISTANCE
- Input Raster: "WoosterSquare"
- Input Cost: "cost_1" (left), "cost_2" (center), "cost_3" (right)

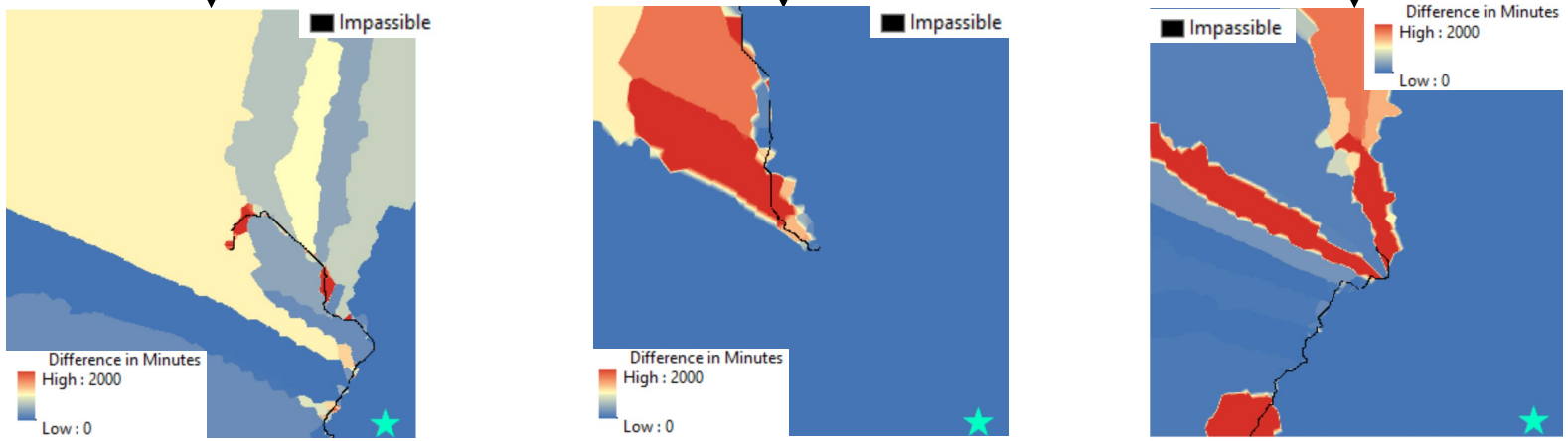
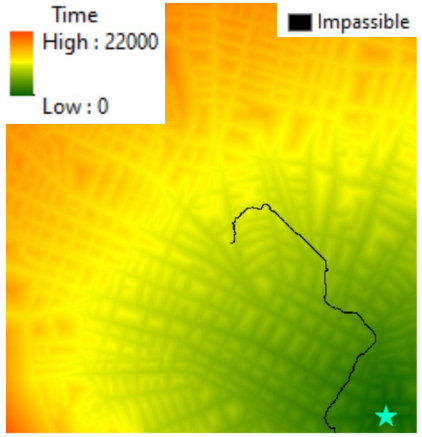


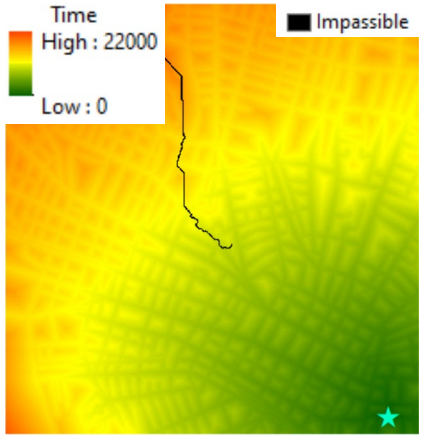

***Figure 1i/2i/3i: timediff_1, timediff_2, timediff_3***

Description: difference in travel time compared to before spill
Source: RASTER CALCULATOR(X – "time_pre")
X = "time_1" (left), "time_2" (center), "time_3" (right)

# Step j: Travel Flow Direction

Use Traffic Time to generate flow direction



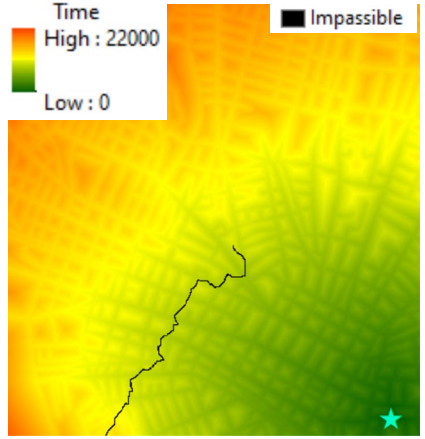




***Figure 1h/2h/3h: time_1, time_2, time_3***

Description: time to travel after the spill

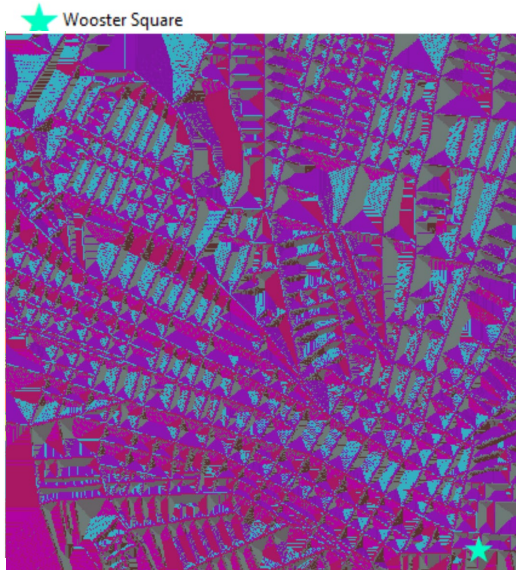
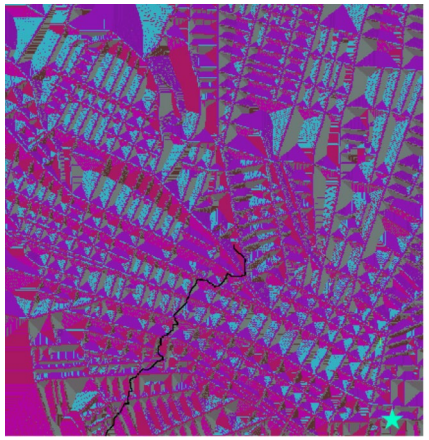


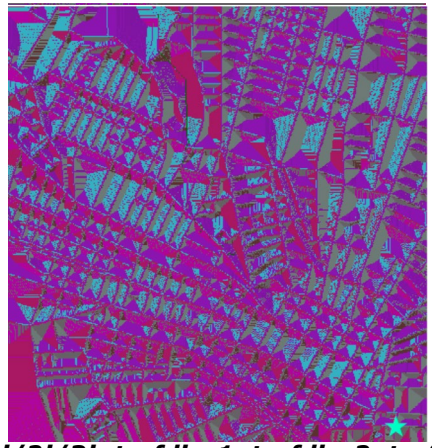

***Figure 0j. trafdir_pre***

Description: flow direction of traffic before the spill

Source: FLOW DIRECTION

- Input Surface Raster: "time_pre"





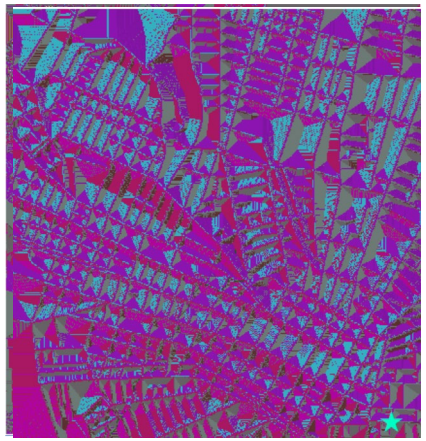


***Figure 1j/2j/3j: trafdir_1, trafdir_2, trafdir_3***

Description: flow direction of traffic after the spill

Source: FLOW DIRECTION

- Input Surface Raster: "time_1" (left), "time_2" (center), "time_3" (right)

# Step k-l: Traffic Accumulation

We can use the traffic directions to calculate traffic accumulation, and the differences as well.


***Figure 0k. trafacc_pre***

Description: flow accumulation of traffic before the spill
Source: FLOW ACCUMULATION

- Input Flow Direction: "trafdir_pre"

***Figure 1i/2i/3i: timediff_1, timediff_2, timediff_3***

Description: difference in travel time compared to before spill

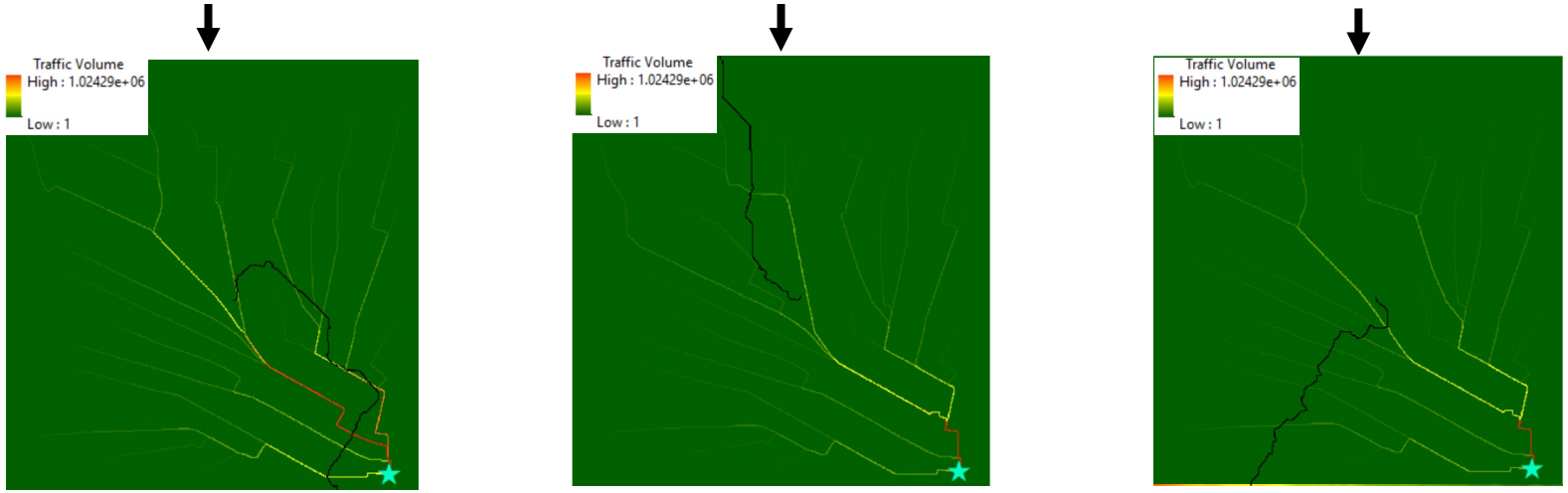


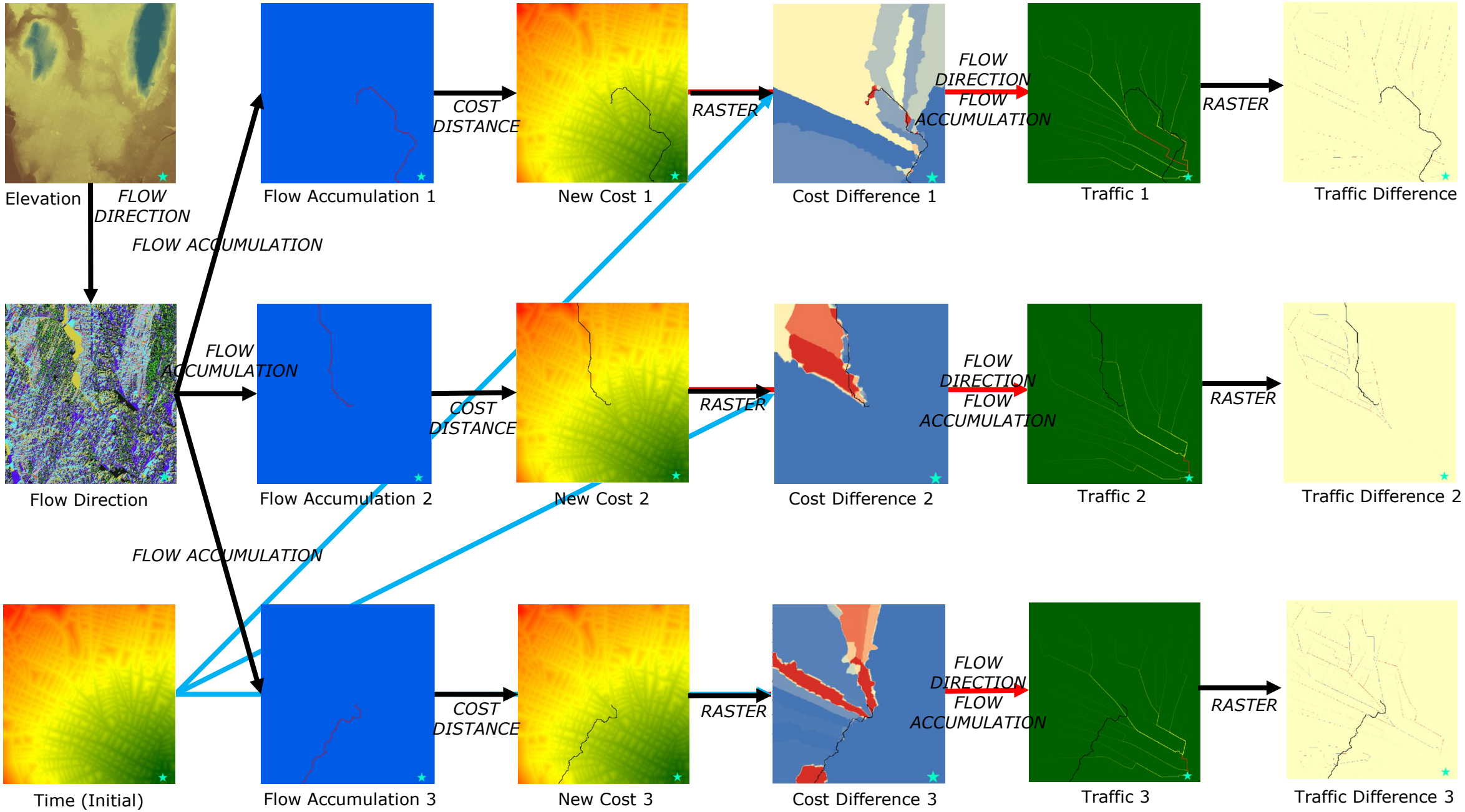

***Figure 1k/2k/3k: traffacc_1, trafacc_2, trafacc_3***

Description: flow accumulation of traffic after spilll
Source: FLOW ACCUMULATION

- Input Flow Direction: "trafdir_1" (left), "trafdir_2" (center), "trafdir_3" (right)


***Figure 1l/2l/3l: traffdif_1, traffdif_2, traf_diff_3***

Description: difference in traffic accumulation compared to before spill
Source: RASTER CALCULATOR(X – "trafacc_pre")
X = "trafacc _1" (left), "trafacc _2" (center), "trafacc _3" (right)


Elevation
FLOW DIRECTION
FLOW ACCUMULATION
Flow Accumulation 1
COST DISTANCE
New Cost 1
RASTER
Cost Difference 1
FLOW DIRECTION
FLOW ACCUMULATION
Traffic 1
RASTER
Traffic Difference
Flow Direction
FLOW ACCUMULATION
Flow Accumulation 2
COST DISTANCE
New Cost 2
RASTER
Cost Difference 2
FLOW DIRECTION
FLOW ACCUMULATION
Traffic 2
RASTER
Traffic Difference 2
FLOW ACCUMULATION
Time (Initial)
Flow Accumulation 3
COST DISTANCE
New Cost 3
RASTER
Cost Difference 3
FLOW DIRECTION
FLOW ACCUMULATION
Traffic 3
RASTER
Traffic Difference 3

# Analysis: Travel Time

There are a couple different ways we can consider changes in travel time.

- Average travel time
- Average change in travel time

Average travel time can be accessed by properties in the travel cost maps (figure h's) and average change in travel time can be accessed by properties in the travel cost difference maps (figure i's).

| | Pre-Spill | Spill 1 | Spill 2 | Spill 3 |
|---|---|---|---|---|
| Average Travel Time | 9893 | 9921 | 9973 | 9951 |
| Average Change in Travel Time | - | 24.59 | 81.25 | 56.95 |

In both cases, travel time increased the most with spill 2.

# Analysis: Traffic Accumulation

While it is interesting to use the difference in traffic accumulation to see where traffic has increased and decreased, to analyze the overall accumulation we actually only need the traffic accumulation plots (figure k's). Since the cost of travelling to Wooster Square is 0, Wooster Square is a sink (most downstream pixel) within the Time Cost layers (figure h's). Thus, it will have the maximum traffic accumulation number. We can simply access the maximum accumulation value within the raster layer.

| | |
|---|---|
| Min | 0 |
| Max | 1024291 |
| Mean | 820.411859288937 |
| Std dev. | 15032.95798507086 |

| | |
|---|---|
| Min | 0 |
| Max | 1028887 |
| Mean | 816.9131458962997 |
| Std dev. | 13899.08840703852 |

| | |
|---|---|
| Min | 0 |
| Max | 1023574 |
| Mean | 834.4592566219336 |
| Std dev. | 15070.06729487323 |

| | |
|---|---|
| Min | 0 |
| Max | 1023825 |
| Mean | 823.9024386617682 |
| Std dev. | 15018.99612743079 |

Accumulation Maxes of Original (top left), Spill 1 (top right), Spill 2 (bottom left), Spill 3 (bottom right).

Spill 2 has the lowest maximum value, meaning that at Wooster Square, only 1023574 pixels have a path to Wooster Square. Assuming each customer is willing to travel for an unlimited amount of time, Spill 2 would reduce the accessibility to Wooster Square the most.

Since both traffic accumulation decreased most with spill 2 (bit closer to door) and travel time increased more with spill 2, I believe that in order to sabotage Pepe and Sally and deter people from travelling to Wooster Square, we should report the spill at site 2.