Using Road Network (LRS) Routing for Practical Engineering Applications (Problem Solving)

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Outline:

1. Problem information, first thoughts, and choosing a solution
2. The perfect storm and great timing
3. Setting the data up
4. Running the procedure
5. Examining the results
6. Other uses for pgRouting

Problem:

Find all bridges, state and local, within 1 road mile of the Interstate

Solution:

pgRouting →pgr_withPoints

Problem

Survey was sent to our Bridge Division regarding Bridges within a road mile of the Interstate

2. How many bridges (state and local) in your state are within “reasonable access” of the Interstate?

Per the November 3, 2016 FHWA memo: "Reasonable access is defined in a September 30, 1992 NonRegulatory Supplement to 23 CFR Part 658 as at least **one-road-mile from access to and from the National Network of highways, which includes the Interstate System**, or further if the limits of a State’s reasonable access policy for food, fuel, repairs, and rest extend to facilities beyond one-road-mile."

Options:

1. pgRouting
2. Batch data through the Google Maps Directions API
3. Other spatial options/by hand

pgRouting

Pros:

1. Free to use
2. Easy to set up

Cons:

1. Haven’t used this solution much

Google Directions API

Pros:

1. Have API key
2. Google does routing well

Cons:

1. Rely on Google GeoCoding
2. Unable to control inputs or look at why things are happening
3. Would have to figure out batch fetches and storing the results for review

Other – Manual measurement solution

Pros:

1. Eyes on each record

Cons:

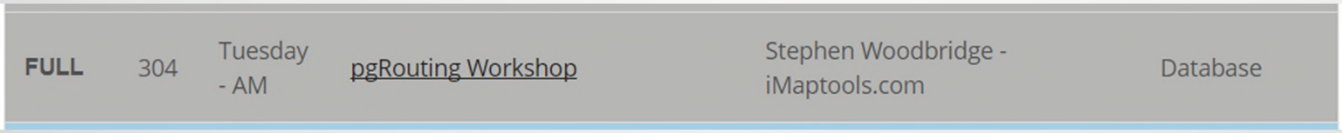
1. Too laborious
2. Could easily make a mistake or miss something

The perfect storm and great timing

FOSS4G Boston 2017

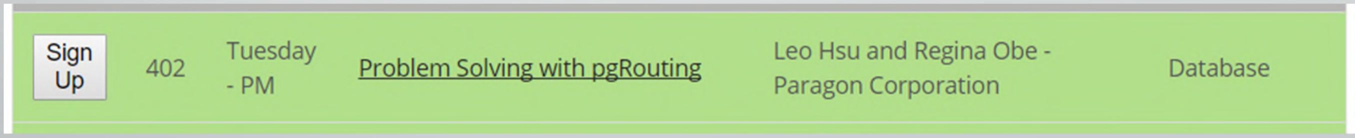
I had privilege of attending the workshops and the conference. Both were very beneficial.

pgRouting Workshops:



FULL	304	Tuesday - AM	pgRouting Workshop	Stephen Woodbridge - iMaptools.com	Database

http://workshop.pgrouting.org/2.4.11/en/index.html



Sign Up	402	Tuesday - PM	Problem Solving with pgRouting	Leo Hsu and Regina Obe - Paragon Corporation	Database

http://postgis.us/foss4g2017

FOSS4G Boston

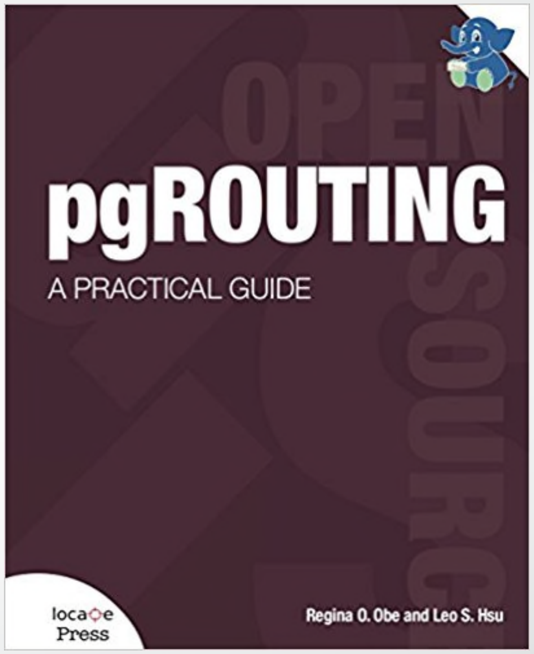
By that evening back at the hotel I had a version of our LRS network routing in a web browser using GeoServer and Openlayers.

Learned basics of routing and functions and did a few relatively straightforward examples.

From this experience I felt pretty confident that I could get the answer to the bridges within 1 road mile of the interstate.

FOSS4G Boston

Luckily I purchased this book:



Found the function and code that I needed in the book!

Setting the data up:

You will need to get Postgresql running and have PostGIS and pgRouting extensions installed.

Follow these instructions:
https://github.com/pgRouting/pgrouting/wiki/Download%3A-Windows

Setting the data up:

1. You need a nodes feature and a network feature
    1. Open Street Map Data
        1. Good tools to use this data exist osm2pgrouting
    2. I used our Arnold LRS
2. You could route without geometry, but it helps to visualize
3. LRS Control Point Feature is used to create the source and target information needed for routing.
4. This control point feature can be tied together with our Dyn seg'd MLRS output in a query.

```
select COUNTY ,ROUTE_ID ,PASS_DIR ,SEG_NO ,MP_START ,MP_END ,
(select route_class from route_class where route_class.sri = mlrs_dyn_out.sri)
as route_class,
SRI ,INV_NO ,GEOMETRYREVERSED ,COUNTY_ID ,ID1 ,M_LENGTH
,WM_VALIDFROM ,WM_VALIDTILL ,GEOMETRY,
(SELECT gt_control_point_id
FROM gt_control_measure
WHERE lrm_control_sequence     = 1
AND gt_control_measure.gt_lrm_id = id1
)
AS
 SOURCE,
 (SELECT gt_control_point_id
 FROM gt_control_measure
 WHERE lrm_control_sequence     = 2
 AND gt_control_measure.gt_lrm_id = id1
 )
AS
 TARGET
from mlrs_dyn_out;
```

Source and Target for Network from Control Points

MLRS Created from multiple procedures in Oracle

pgRouting produces an aggregate cost for a particular route request

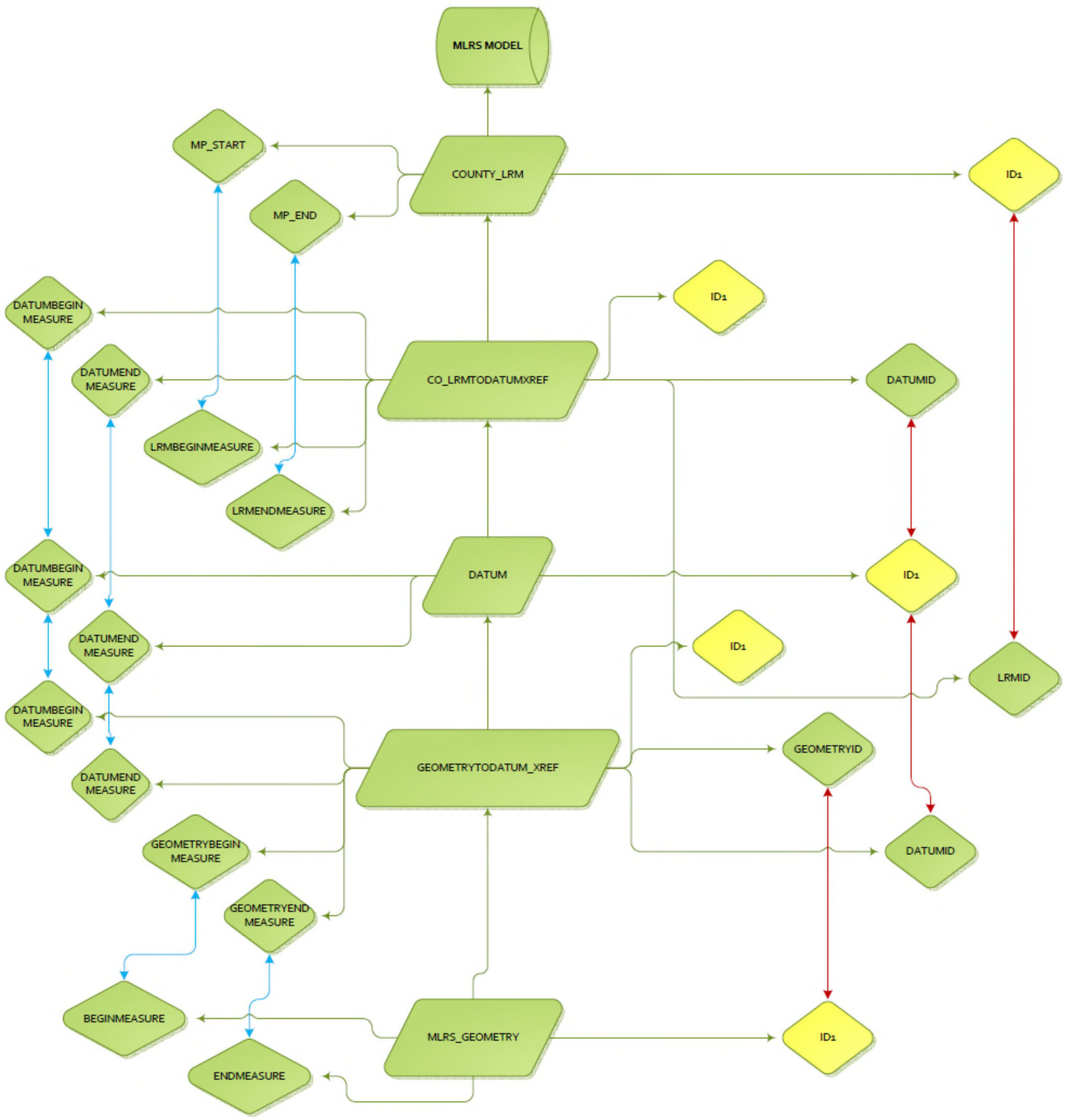
- This can be as simple as the length of the segments and partial segments used
- You could really use anything as your cost i.e. carbon emissions, congestion, LOS
- Any Data tied to the LRS can be used

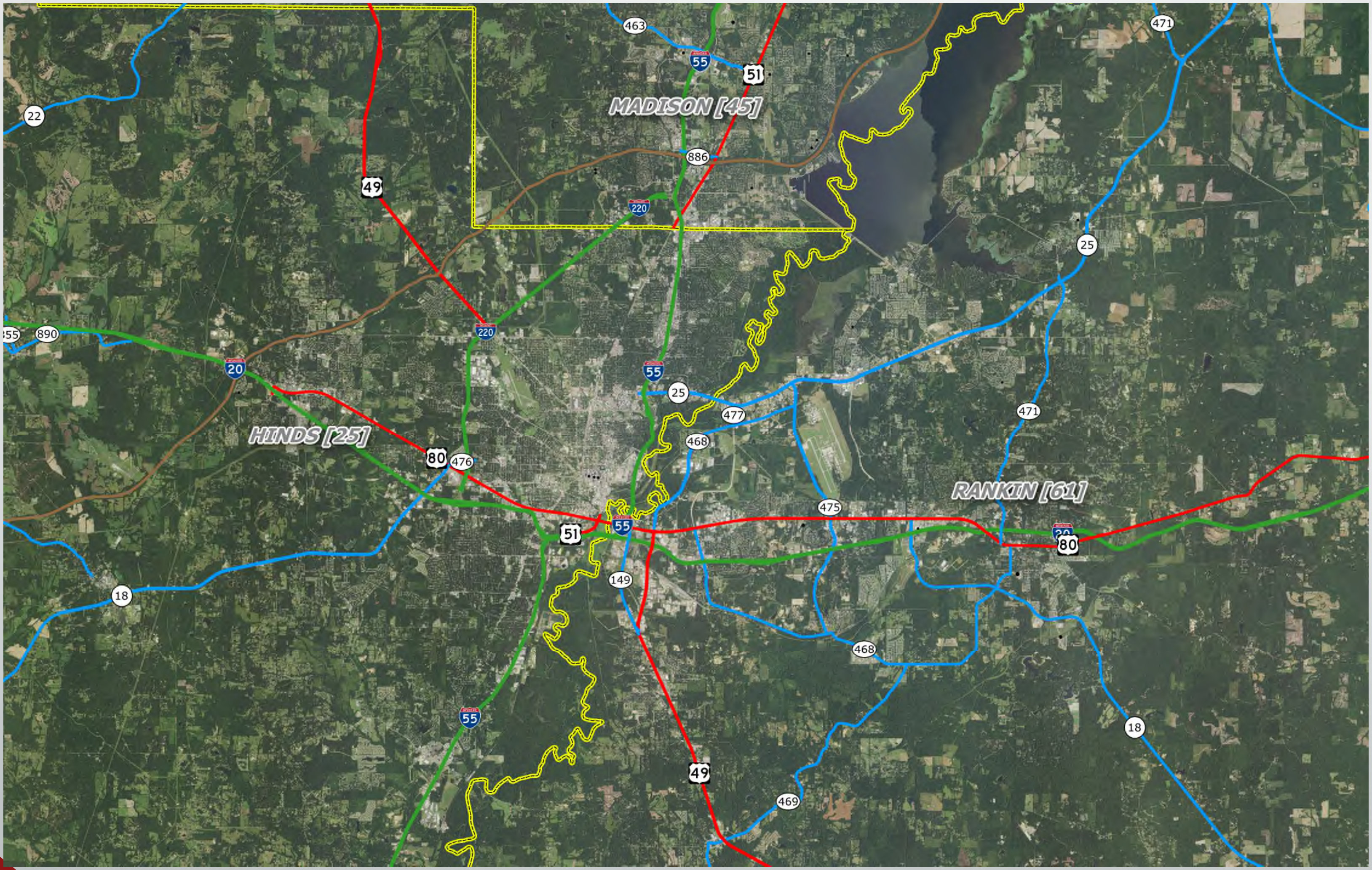
Other useful data items to tack on to your network include:

1. Speed Limit
2. **Divided Indicator**
3. **One way/ Two way indicator**
4. AADT
5. Capacity

LRS Basics

1. Using a linear geometry or set of linear geometries with defined measures to locate point or linear events
2. Project Stationing, Mile Posts on the Interstate, County Route Log Mile Referencing


MLRS MODEL
MP_START
COUNTY_LRM
ID1
MP_END
ID1
DATUMBEGIN MEASURE
DATUMEND MEASURE
CO_LRMTODATUMXREF
DATUMID
LRMBEGINMEASURE
LRMENDMEASURE
DATUMBEGIN MEASURE
DATUM
ID1
DATUMEND MEASURE
ID1
LRMID
DATUMBEGIN MEASURE
GEOMETRYID
DATUMEND MEASURE
GEOMETRYTODATUM_XREF
GEOMETRYBEGIN MEASURE
DATUMID
GEOMETRYEND MEASURE
BEGINMEASURE
MLRS_GEOMETRY
ID1
ENDMEASURE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55
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MADISON [45]
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886
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890
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20
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25
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18
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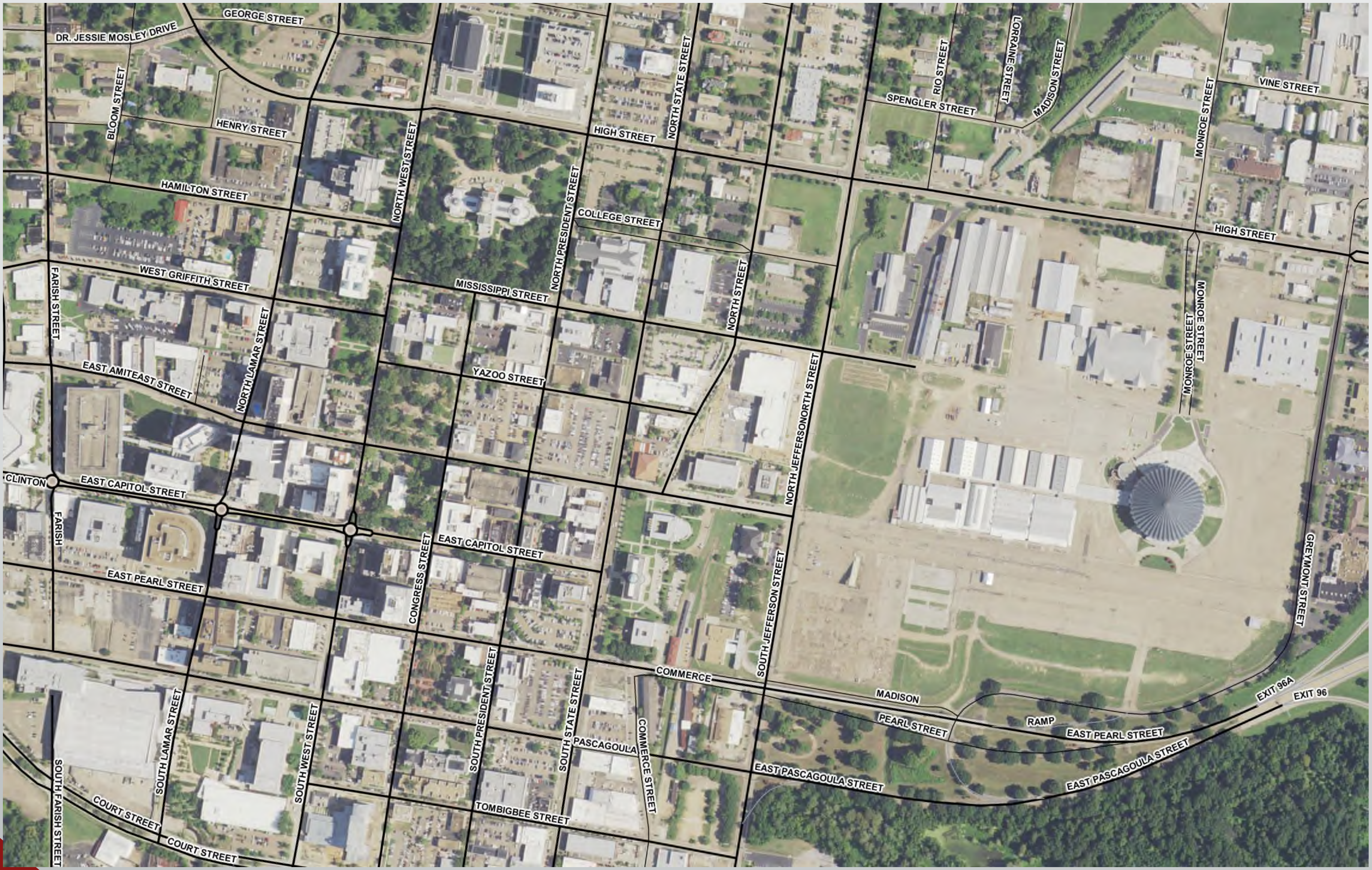
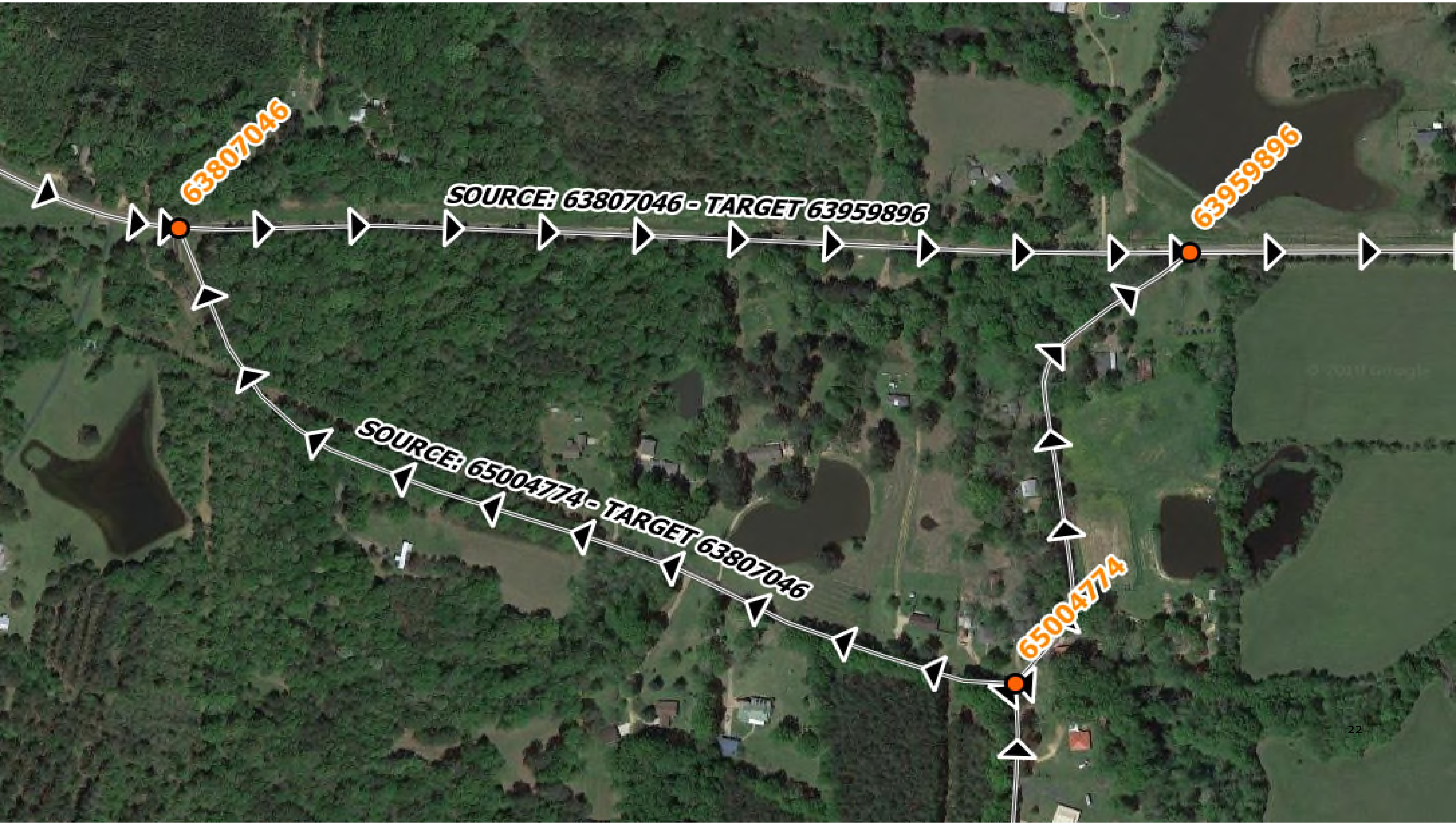
469


GEORGE STREET
DR. JESSIE MOSLEY DRIVE
BLOOM STREET
HENRY STREET
HAMILTON STREET
NORTH WEST STREET
HIGH STREET
NORTH STATE STREET
SPENGLER STREET
RIO STREET
LORRAINE STREET
MADISON STREET
VINE STREET
MONROE STREET
NORTH PRESIDENT STREET
COLLEGE STREET
HIGH STREET
WEST GRIFFITH STREET
FARISH STREET
MISSISSIPPI STREET
NORTH STREET
MONROE STREET
MONROE STREET
NORTH LAMAR STREET
EAST AMITEEAST STREET
YAZOO STREET
NORTH JEFFERSONORTH STREET
CLINTON
EAST CAPITOL STREET
FARISH
EAST CAPITOL STREET
CONGRESS STREET
EAST PEARL STREET
SOUTH JEFFERSON STREET
GREYMONT STREET
COMMERCE
MADISON
PEARL STREET
RAMP
EAST PEARL STREET
EXIT 96A
EXIT 96
EAST PASCAGOULA STREET
EAST PASCAGOULA STREET
PASCAGOULA
COMMERCE STREET
SOUTH STATE STREET
SOUTH PRESIDENT STREET
TOMBIGBEE STREET
SOUTH WEST STREET
SOUTH LAMAR STREET
COURT STREET
COURT STREET
SOUTH FARISH STREET


63807046
SOURCE: 63807046 - TARGET 63959896
63959896
SOURCE: 65004774 - TARGET 63807046
65004774

If direction of route doesn’t matter, the base network with source and target is sufficient for routing

In this problem we were dealing with emergency vehicles and the assumption of direction didn’t matter was made

For practical/normal routing you would want to use a directed graph and only travel down the route in the appropriate direction

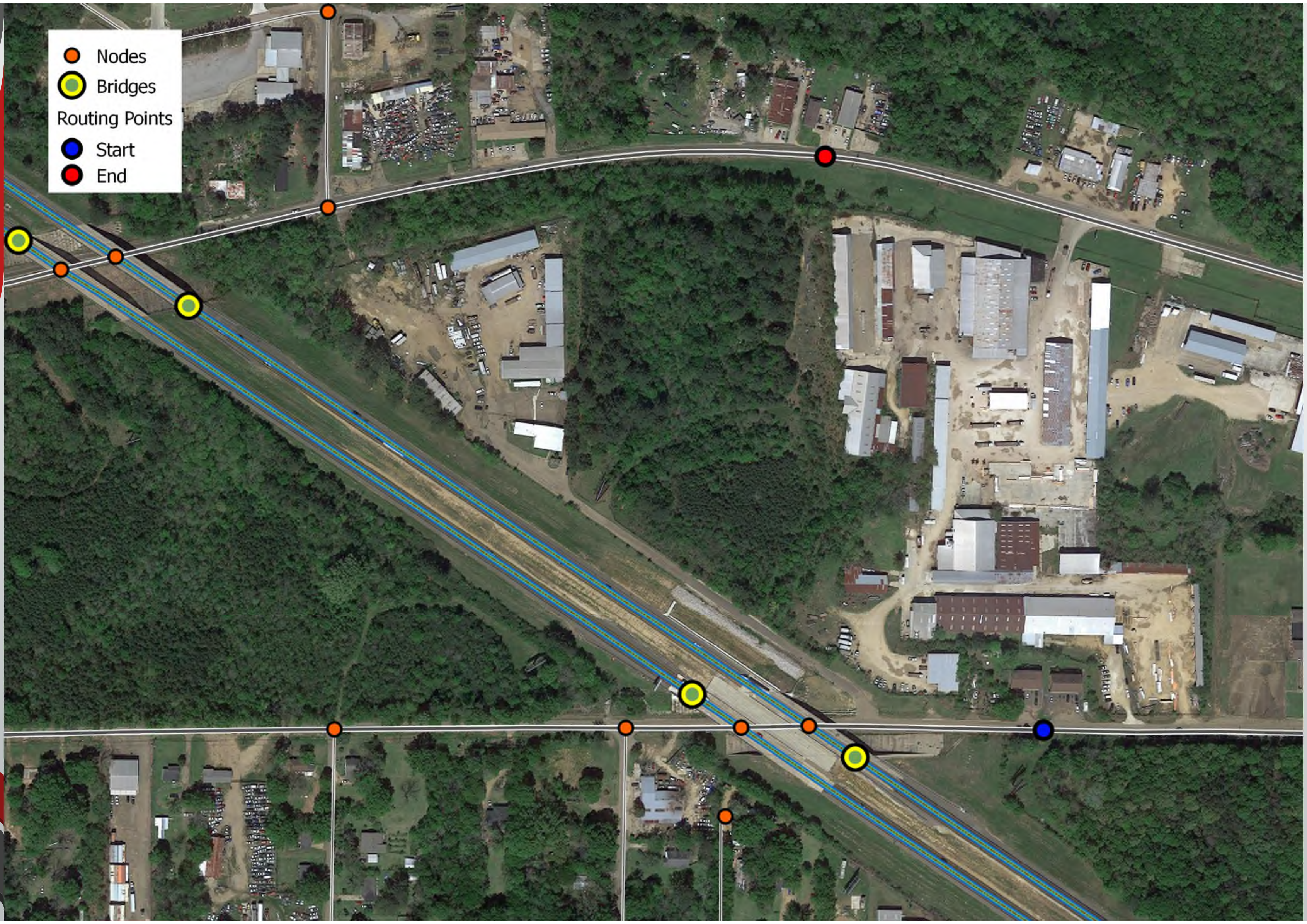
Cost and Reverse cost will dictate the directed graph routes

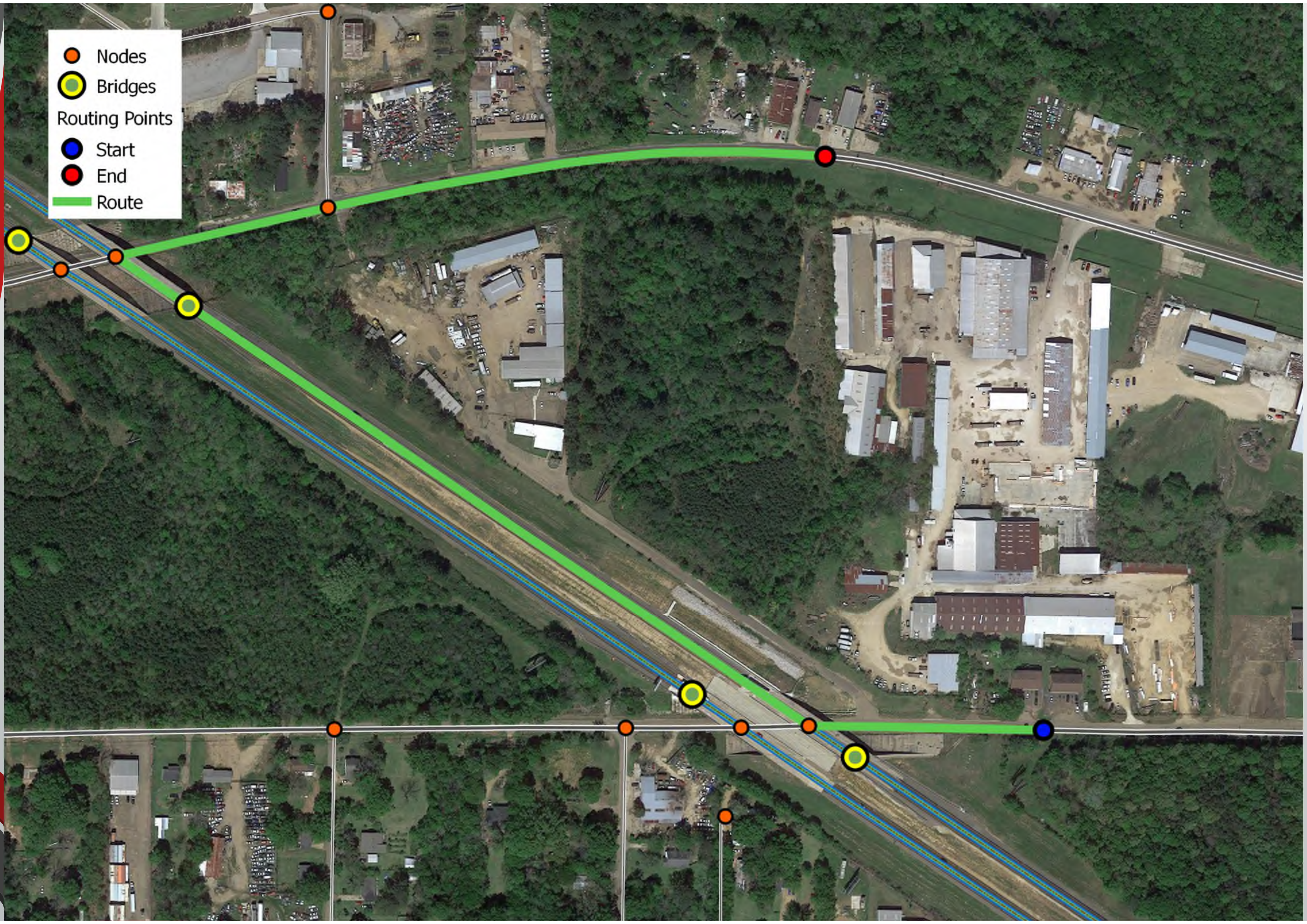
If you don't have nodes with the source and target information, pgRouting provides a tool to create this based on the Geometry relationships and vertices connections.

pgRouting also has built in analysis functions to find common issues with graphs or networks

You can run these to find dead ends and connected nodes without breaks in the network

You really put your network under the microscope when you start routing on it!!


Nodes
Bridges
Routing Points
Start
End


Nodes
Bridges
Routing Points
Start
End
Route

These issues aren’t found with the utilities
We are still sorting through some issues that haven’t come up until we started routing

“Other than normal maintenance I think this will be the last thing we have to fix!”

-Evan Wright 2013,14,15,n…

Loading the data: shp2pgsql or –gui

Tip: Check your geometry type and make sure it isn't multiline when it is loaded in postgis.

You can convert to a regular polyline if need be.

Dijkstra will run on multiline

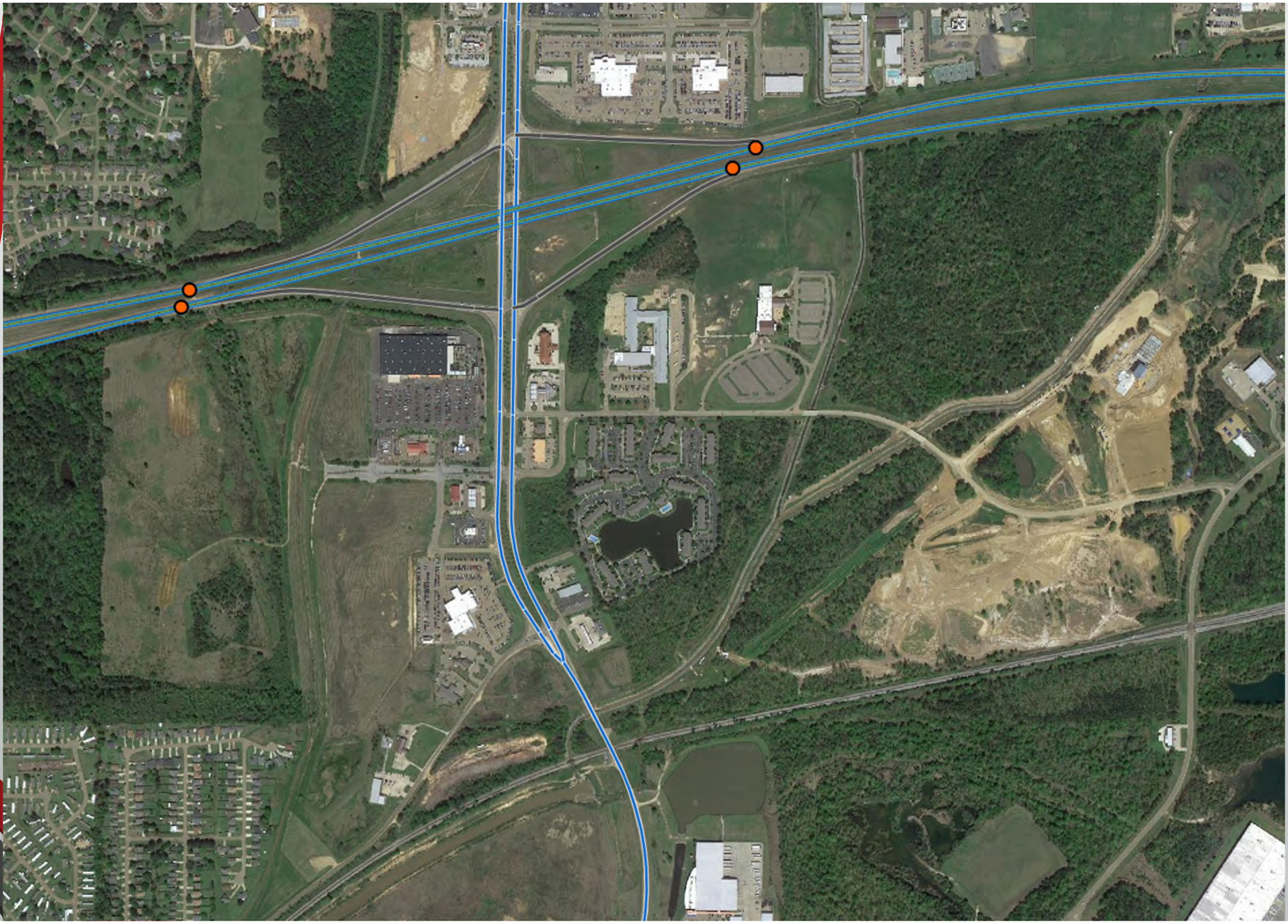
Anything calculating a partial cost will not work with multiline (for me this was the case)

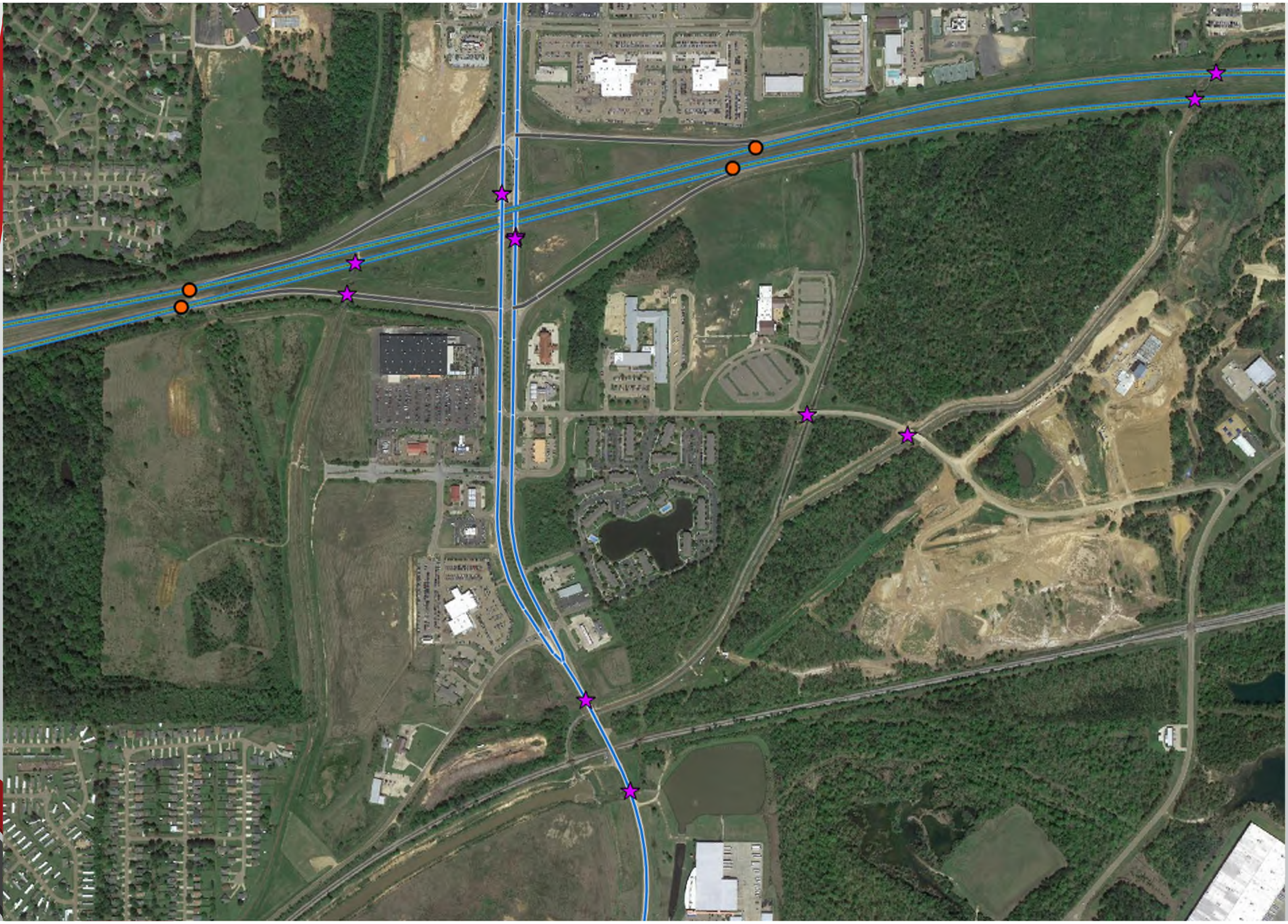
Network and Nodes loaded, now what?

Identify the nodes that we will use to say we’ve reached the interstate.

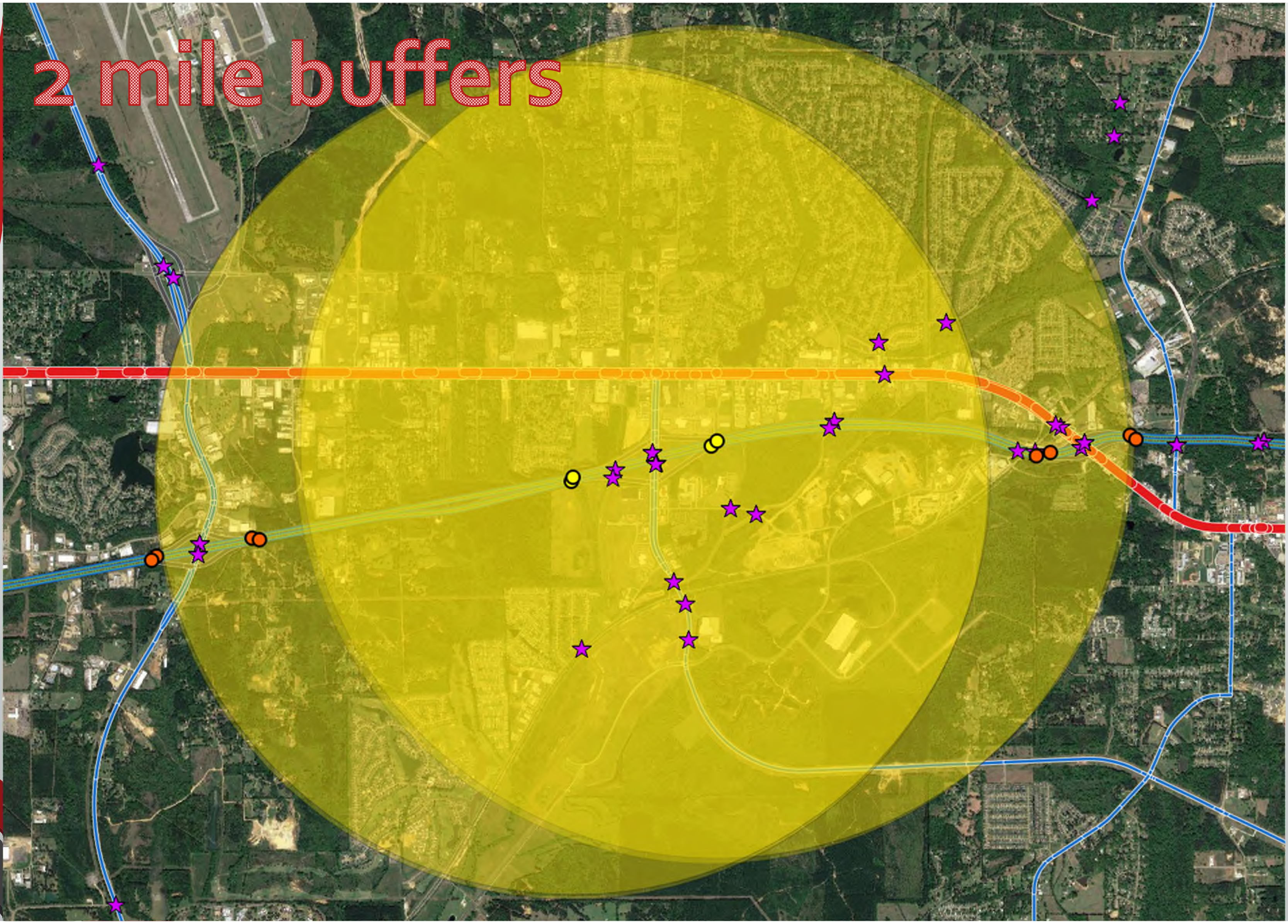
Select nodes that are a source or target for a network link with route class of IH (Interstate) and a RAMP link

```
id in
(
select a.id from
(
select source as id from mdot_lrs where route_clas = 'IH'
union
select target as id from mdot_lrs where route_clas = 'IH')a
inner join
(
select source as id from mdot_lrs where route_clas = 'RAMP'
union
select target as id from mdot_lrs where route_clas = 'RAMP')b
on a.id = b.id)
```



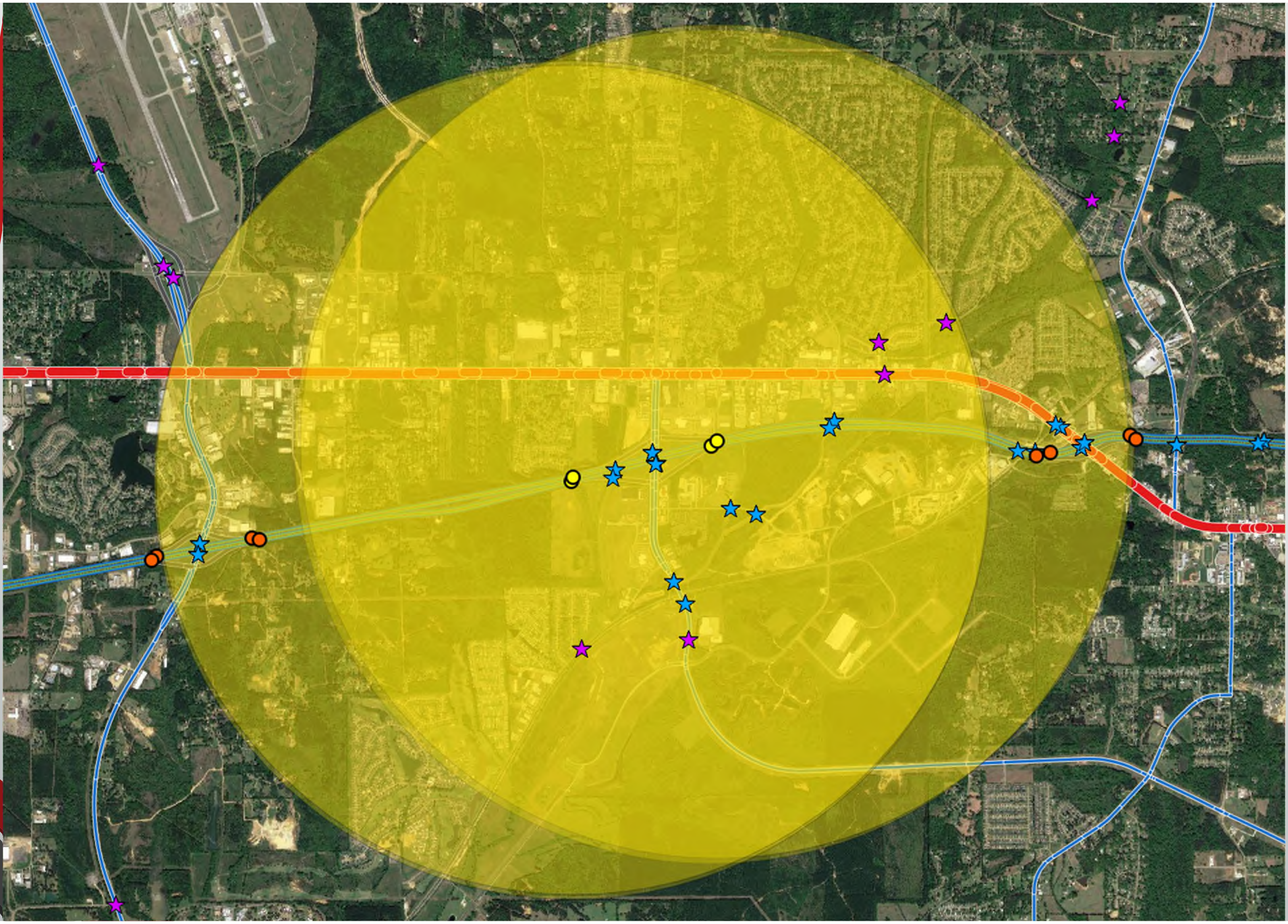


2 mile buffers



Steps to final product:

1. Table with ID of Bridge and ID of Network Node at Interstate
2. Create function that accepts these ids and grabs the geometries from the right table and passes it to the with points function
3. SQL loop query to pass one row at a time to the function and write results to a table
4. Query table for Node ID and Bridge ID that have max cost <= 1 Mile

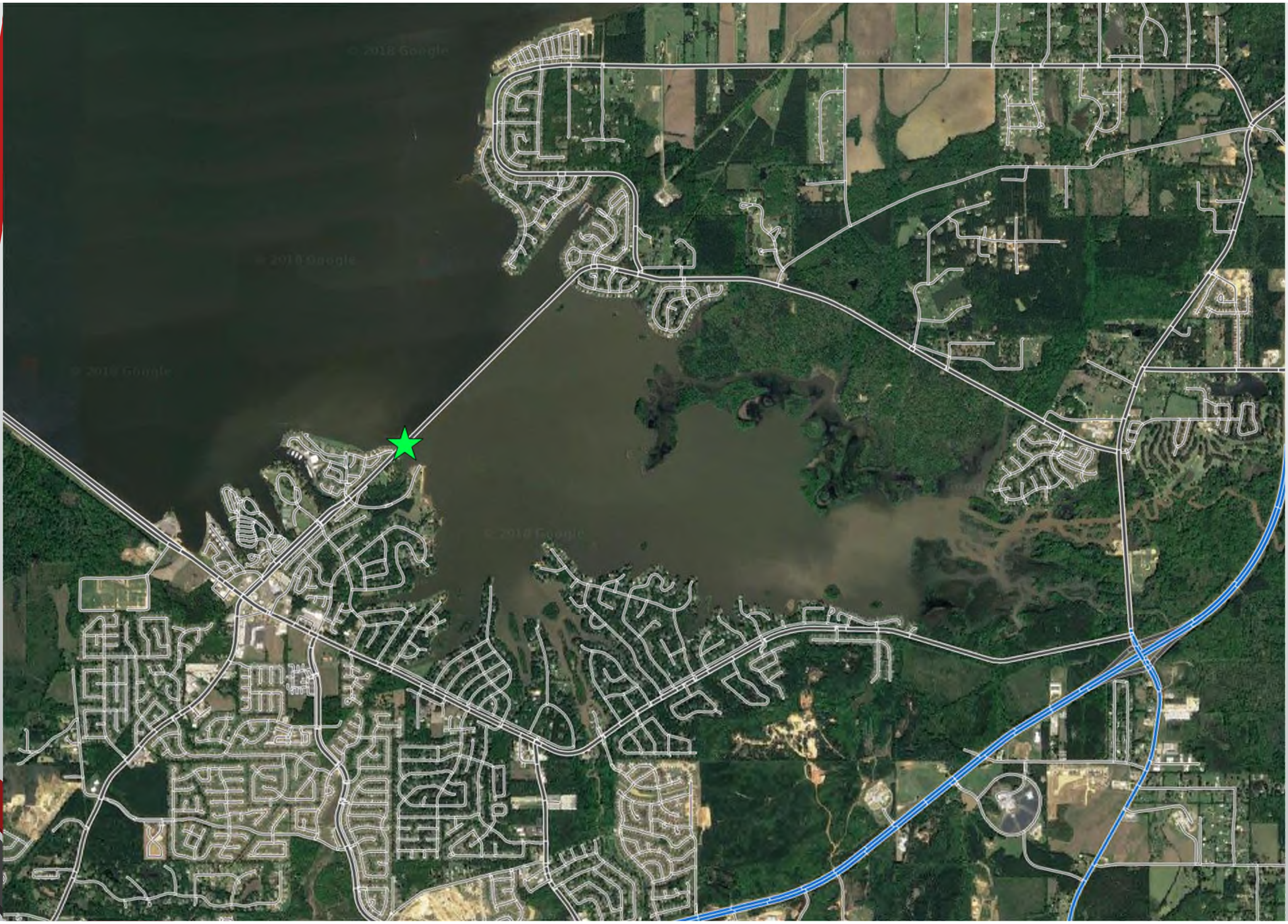


Final Thoughts:

1. Using a directed graph is ideal
2. Need to have 1 way attributed when doing this
3. Channels and Crossovers are VERY important to your base network

What other uses are there?

Still thinking of Bridges:
1. Detour Length Calculations for Bridges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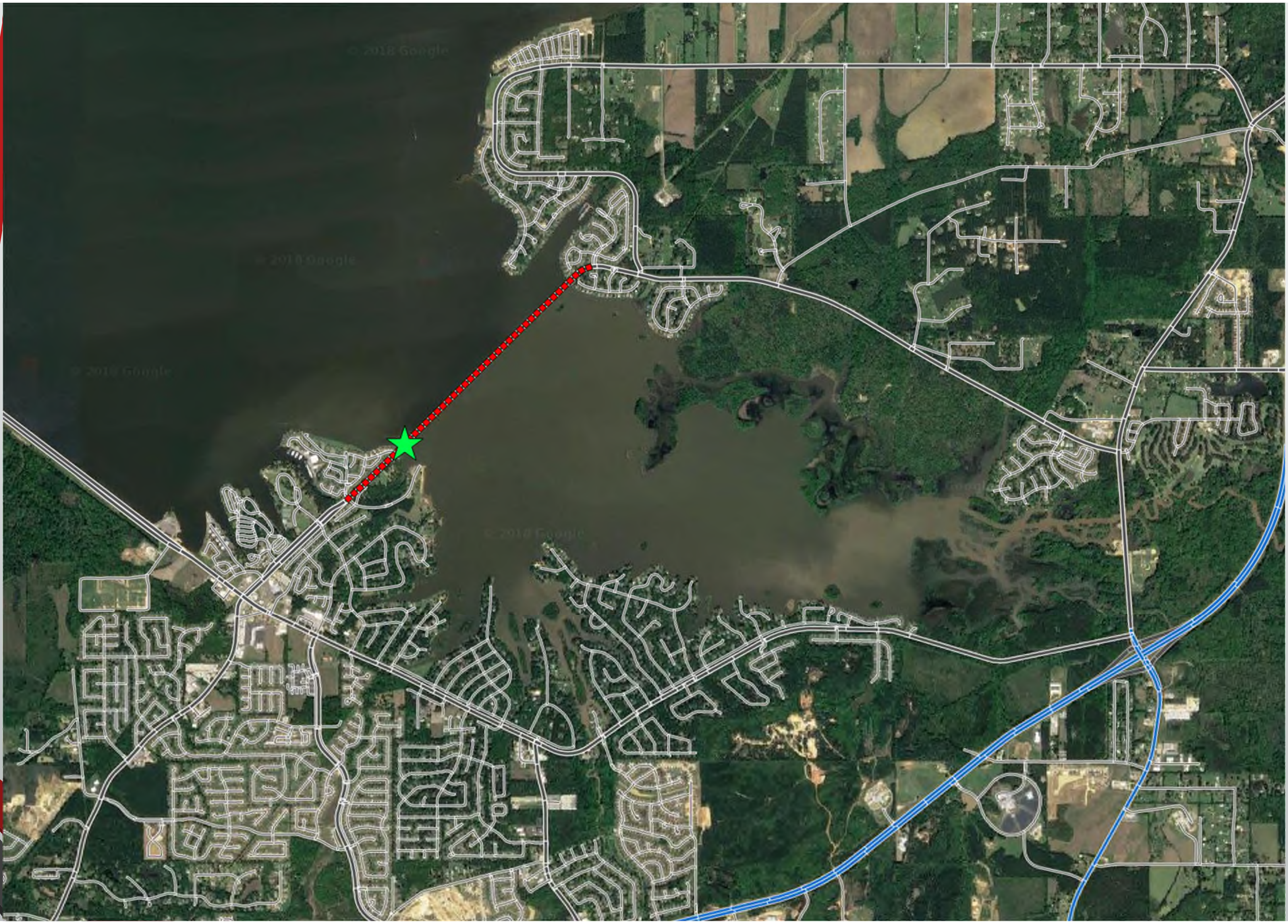
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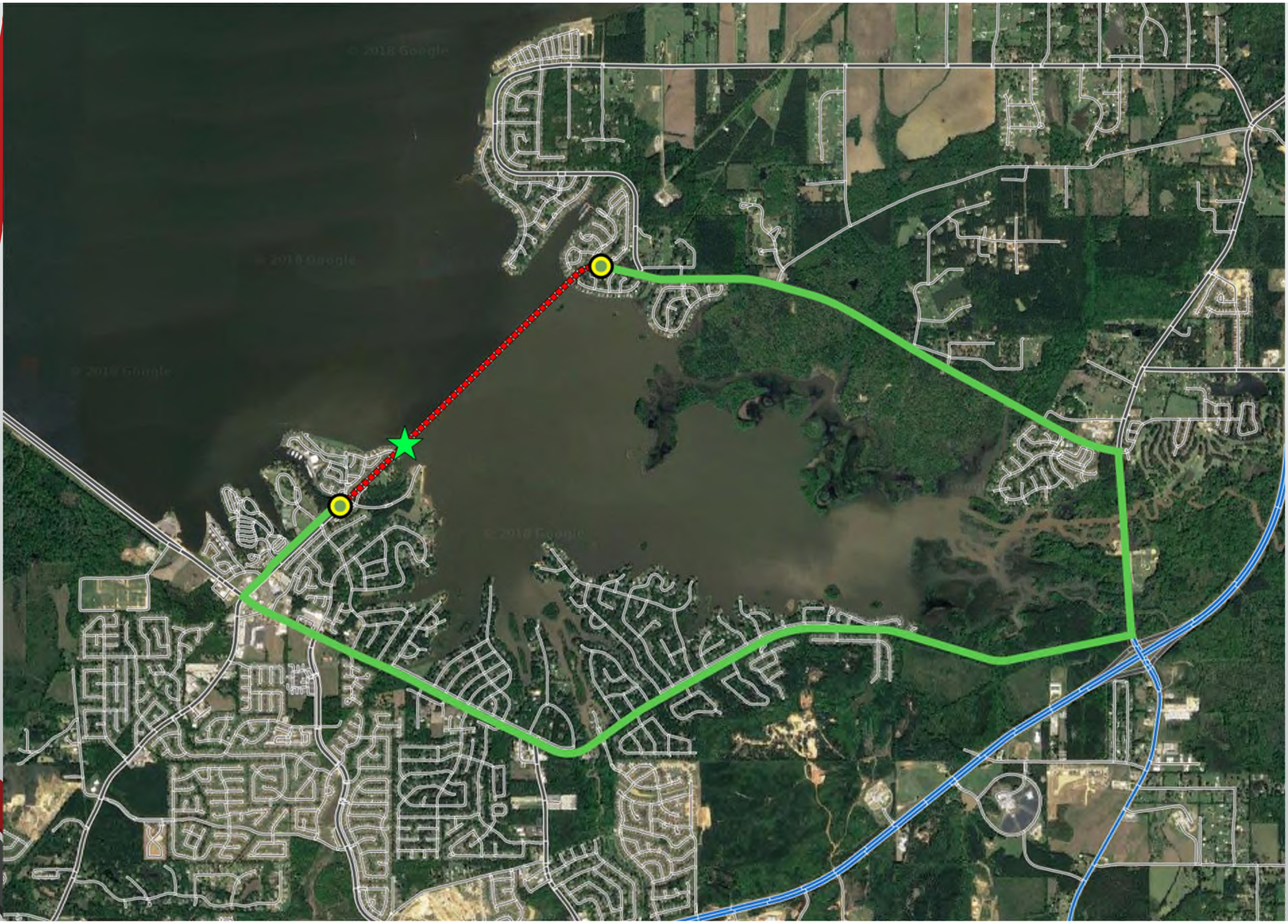
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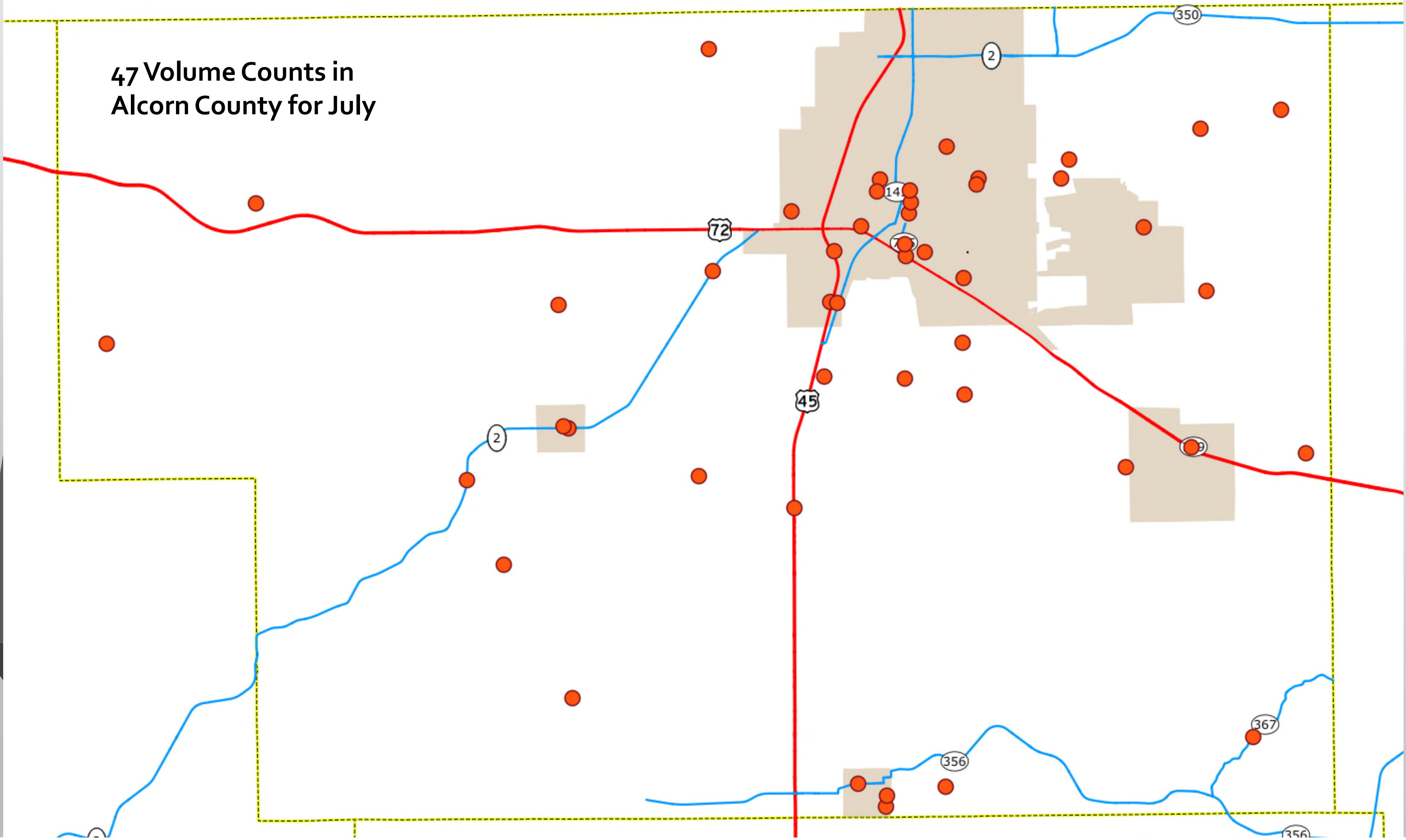
Portable Traffic Count Placement Order and Route:

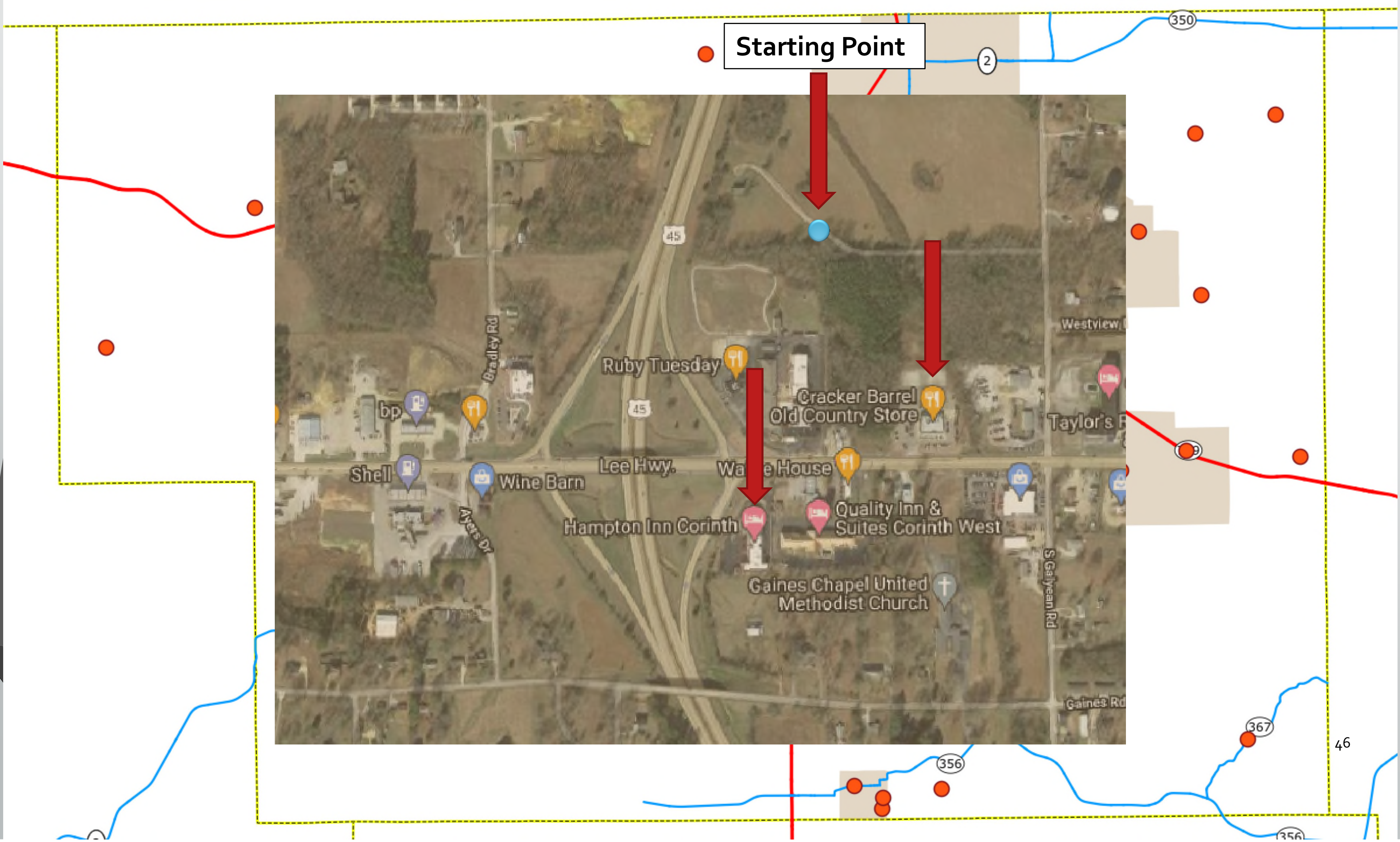
1. What is a good guess at best placement order
2. Route to the sites

47 Volume Counts in Alcorn County for July

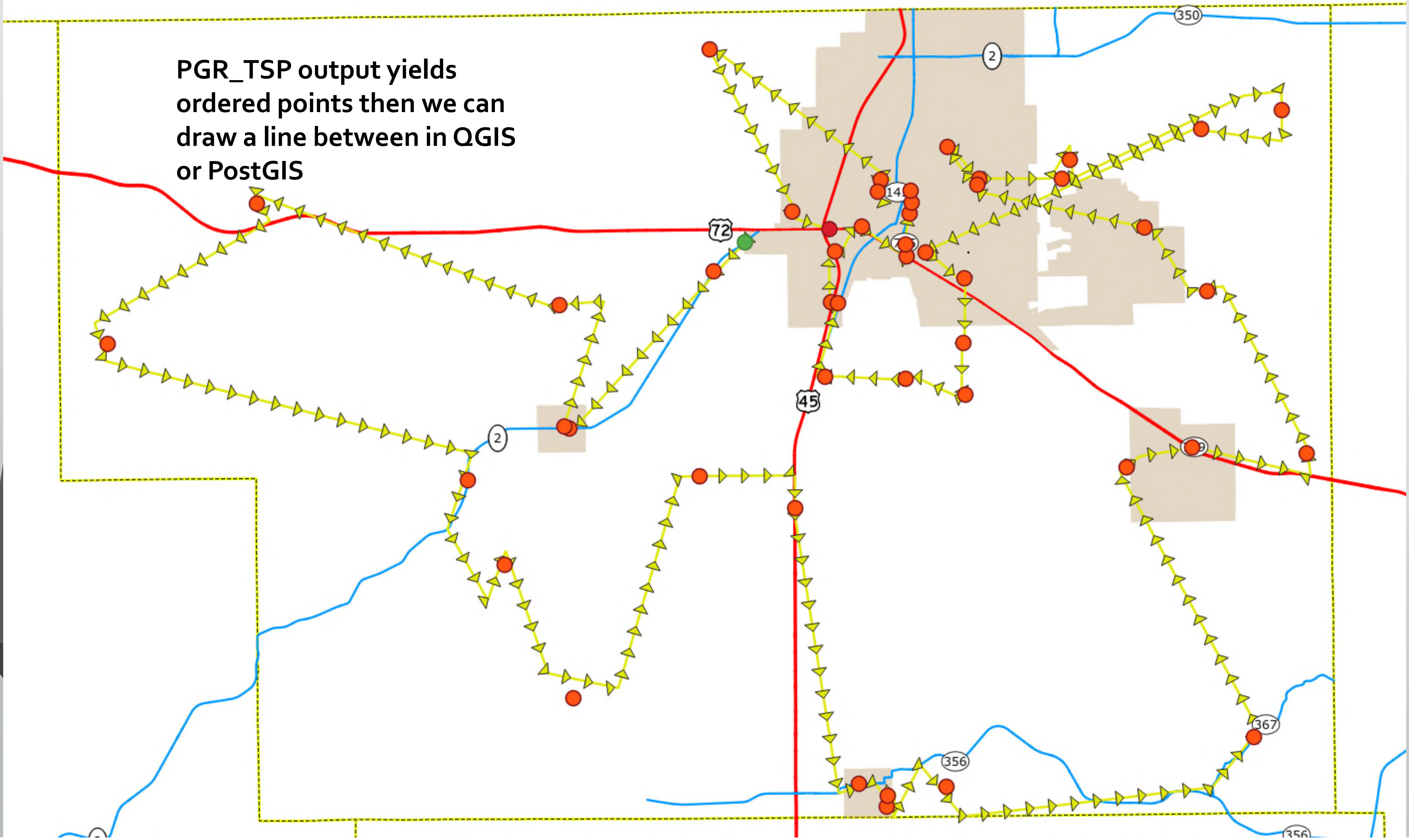


How to tackle the order and route?

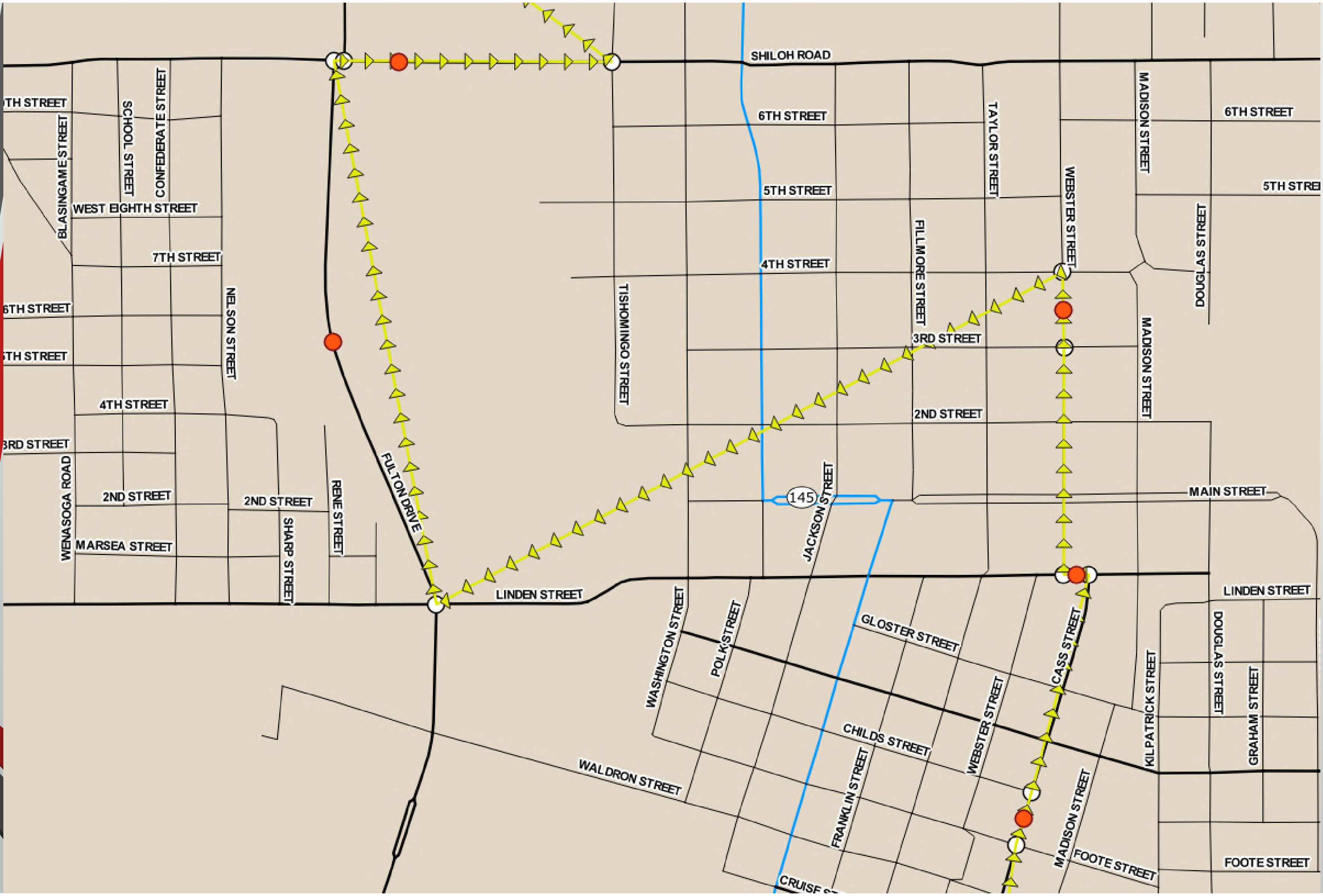
1. Traveling Salesman Problem (TSP)
   Finds shortest route that visits all points once and returns to origin.
2. How applicable is this to a roadway system.
3. How can we mitigate the jumping that doesn’t make driving sense.
4. Associate each count point to it’s roadway piece and then use both start and end vertex in order to force the routing to traverse the entire path.
5. Alternate thought is to utilize points along each count route, leading to and away, from each count point to further reinforce the route and tie it more to the road



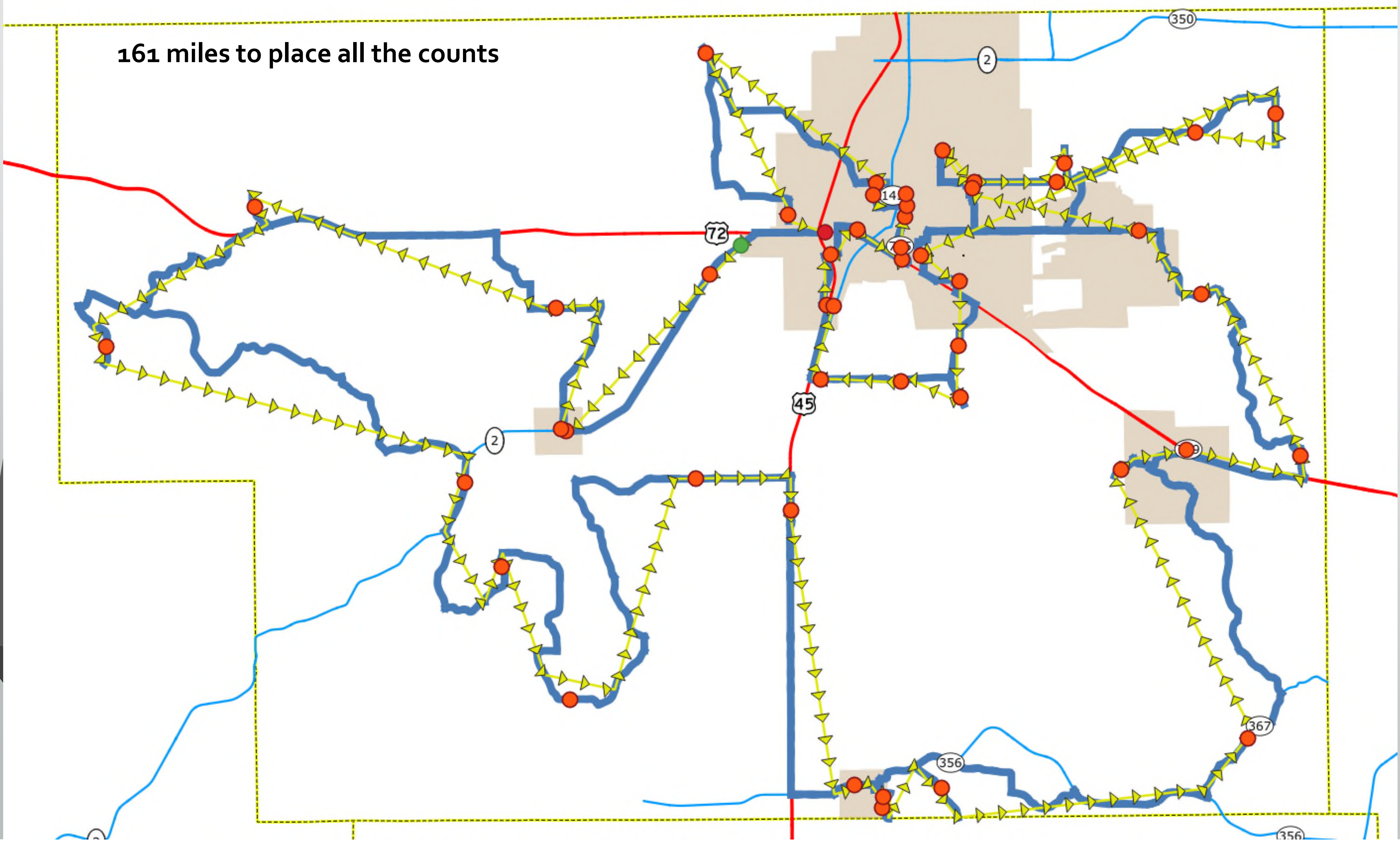
Starting Point



PGR_TSP output yields ordered points then we can draw a line between in QGIS or PostGIS


SHILOH ROAD
TH STREET
SCHOOL STREET
CONFEDERATE STREET
BLASINGAME STREET
WEST EIGHTH STREET
7TH STREET
6TH STREET
TH STREET
NELSON STREET
4TH STREET
3RD STREET
WENASOGA ROAD
2ND STREET
2ND STREET
MARSEA STREET
SHARP STREET
RENE STREET
FULTON DRIVE
LINDEN STREET
6TH STREET
5TH STREET
4TH STREET
TISHOMINGO STREET
TAYLOR STREET
FILLMORE STREET
3RD STREET
2ND STREET
145
JACKSON STREET
MAIN STREET
WEBSTER STREET
MADISON STREET
6TH STREET
5TH STREE
DOUGLAS STREET
MADISON STREET
LINDEN STREET
WASHINGTON STREET
POLK STREET
GLOSTER STREET
CASS STREET
WEBSTER STREET
CHILDS STREET
KILPATRICK STREET
DOUGLAS STREET
GRAHAM STREET
WALDRON STREET
FRANKLIN STREET
MADISON STREET
FOOTE STREET
FOOTE STREET
CRUISE ST

161 miles to place all the counts

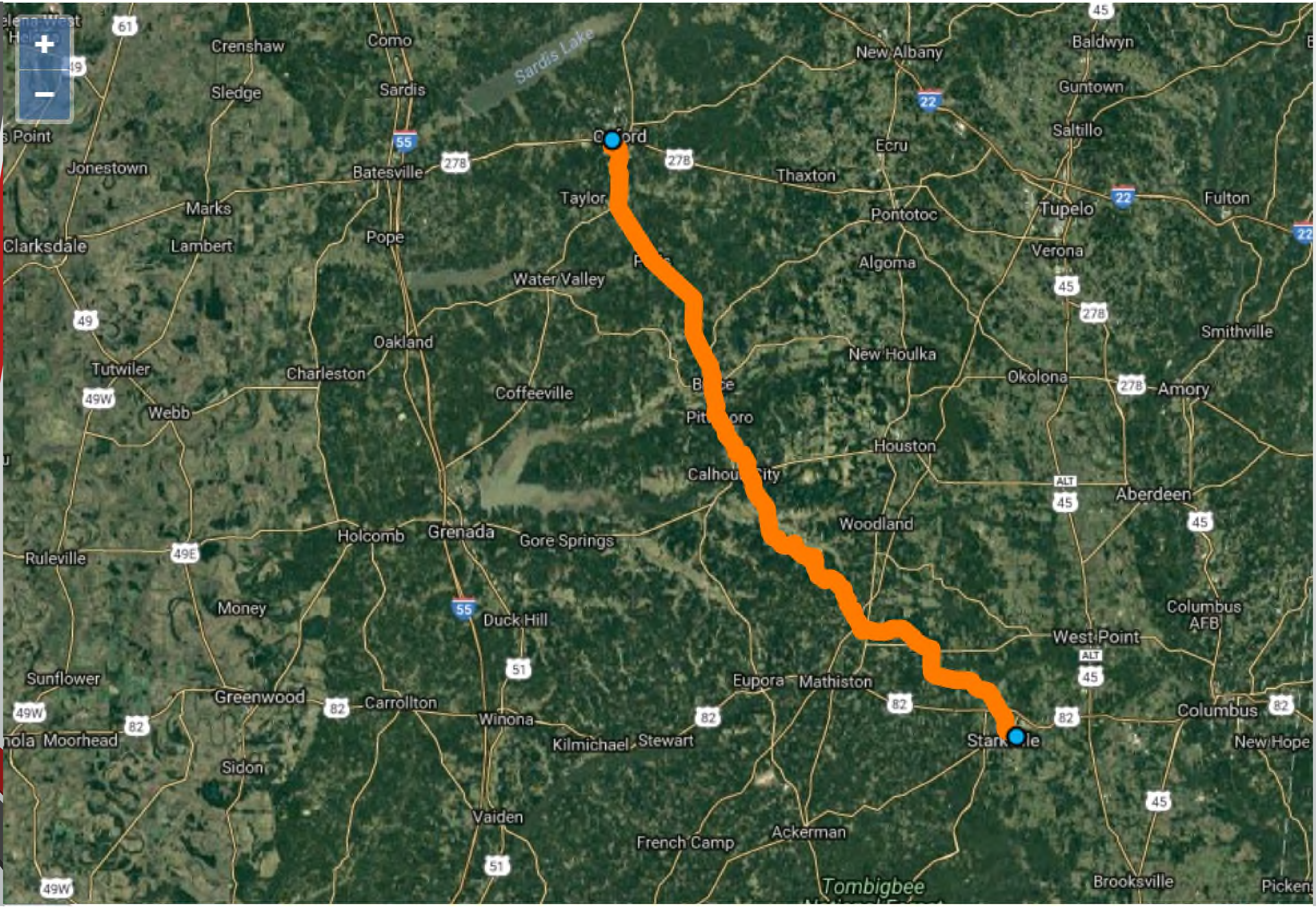


Other Thoughts:

1. How practical is it to try and do 47 counts in one trip?
2. Should counts be divided by part of the county?
3. Could estimate total drive time based on length and speed limit to see what could be done.

Web Based Routing

1. Could use to find “path” for project/query extents
   1. Control input and determine what routes to use
   2. Can either create views for specific route type or modify the query in real time which is a very powerful feature that distinguishes this solution from others
   3. Could look up AADT values, FC values, anything tied to LRS could be identified and quantified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−
61
45
Crenshaw
Como
Sardis Lake
New Albany
Baldwyn
49
Sledge
Sardis
22
Guntown
Point
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Ecru
Saltillo
278
Jonestown
Batesville
278
Thaxton
22
Fulton
Taylor
Tupelo
Marks
Pontotoc
Pope
22
Clarksdale
Lambert
Algoma
Verona
Water Valley
45
278
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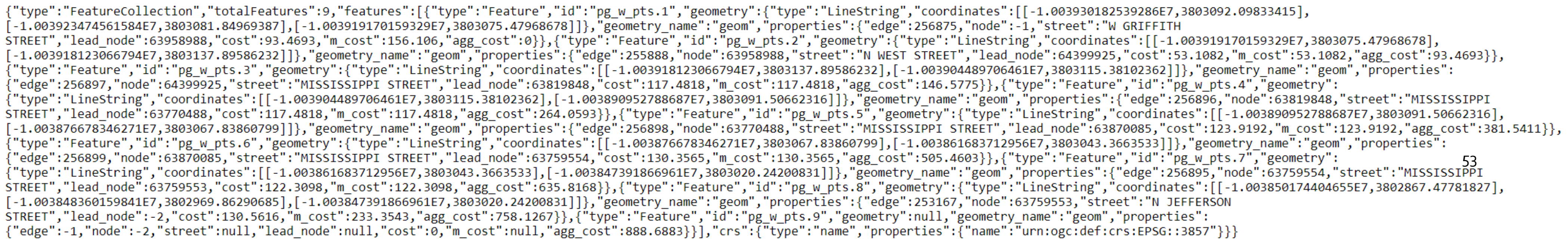
Oakland
Smithville
New Houlka
Tutwiler
Charleston
Okolona
278
Amory
49W
Coffeeville
Webb
Houston
ALT
45
Aberdeen
Woodland
45
Holcomb
Grenada
Gore Springs
Ruleville
49E
Money
55
Duck Hill
Columbus AFB
West Point
ALT
45
51
Sunflower
Eupora
Mathiston
Greenwood
82
Carrollton
82
82
82
Columbus
82
49W
Winona
82
Moorhead
Kilmichael
Stewart
New Hope
Sidon
45
Vaiden
French Camp
Ackerman
51
Tombigbee
Brooksville
49W
Picken

Parameterized View in GeoServer

WFS Call with OpenLayers

http://localhost:8080/geoserver/ows?service=WFS&version=2.0.0&request=GetFeature&typeName=pgrouting:pg_w_pts&outputformat=application/json&srsname=EPSG:3857&viewparams=x1:-90.18458035859194;y1:32.30257251737373;x2:-90.17740240151231;y2:32.30085486024471



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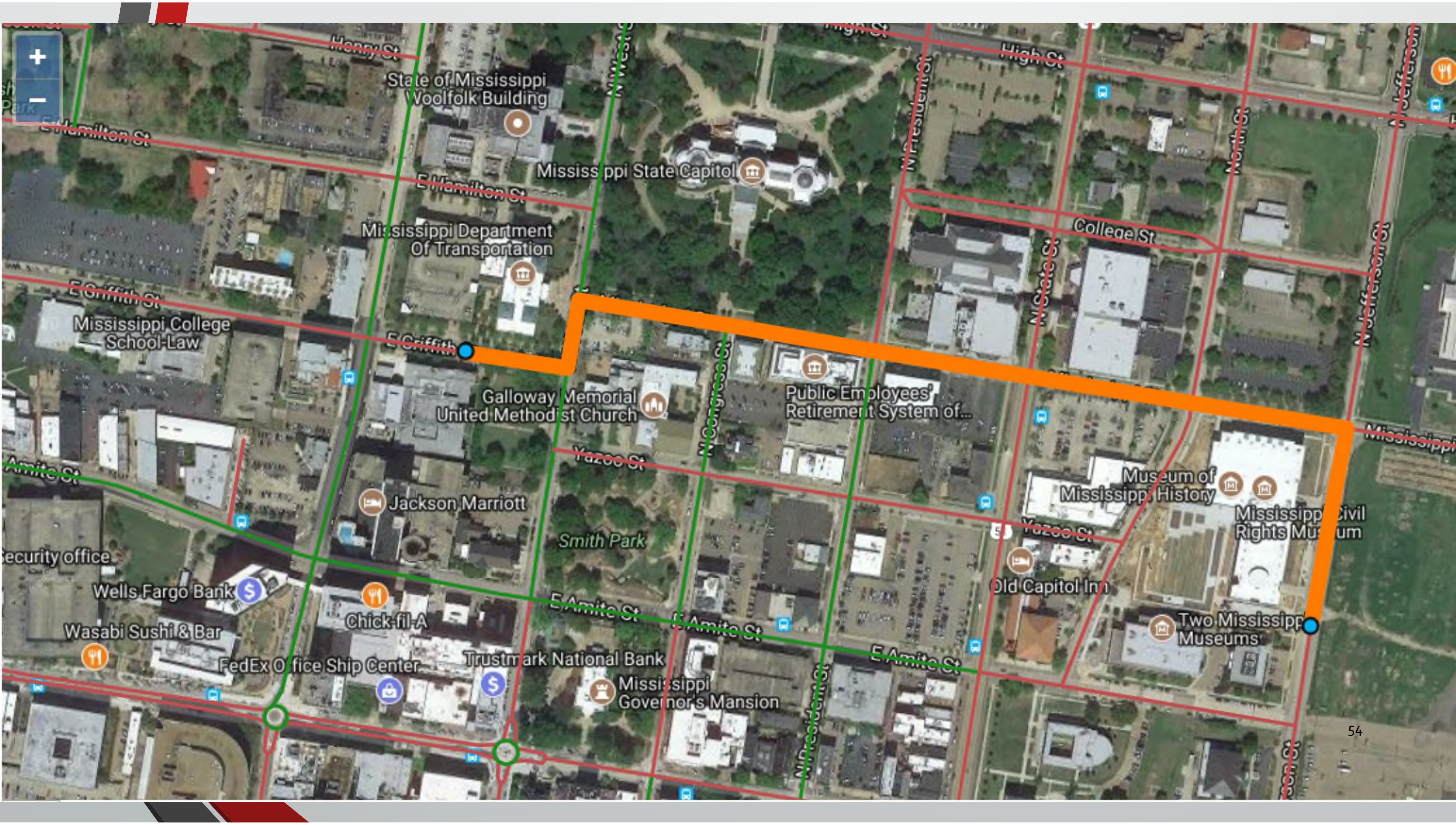
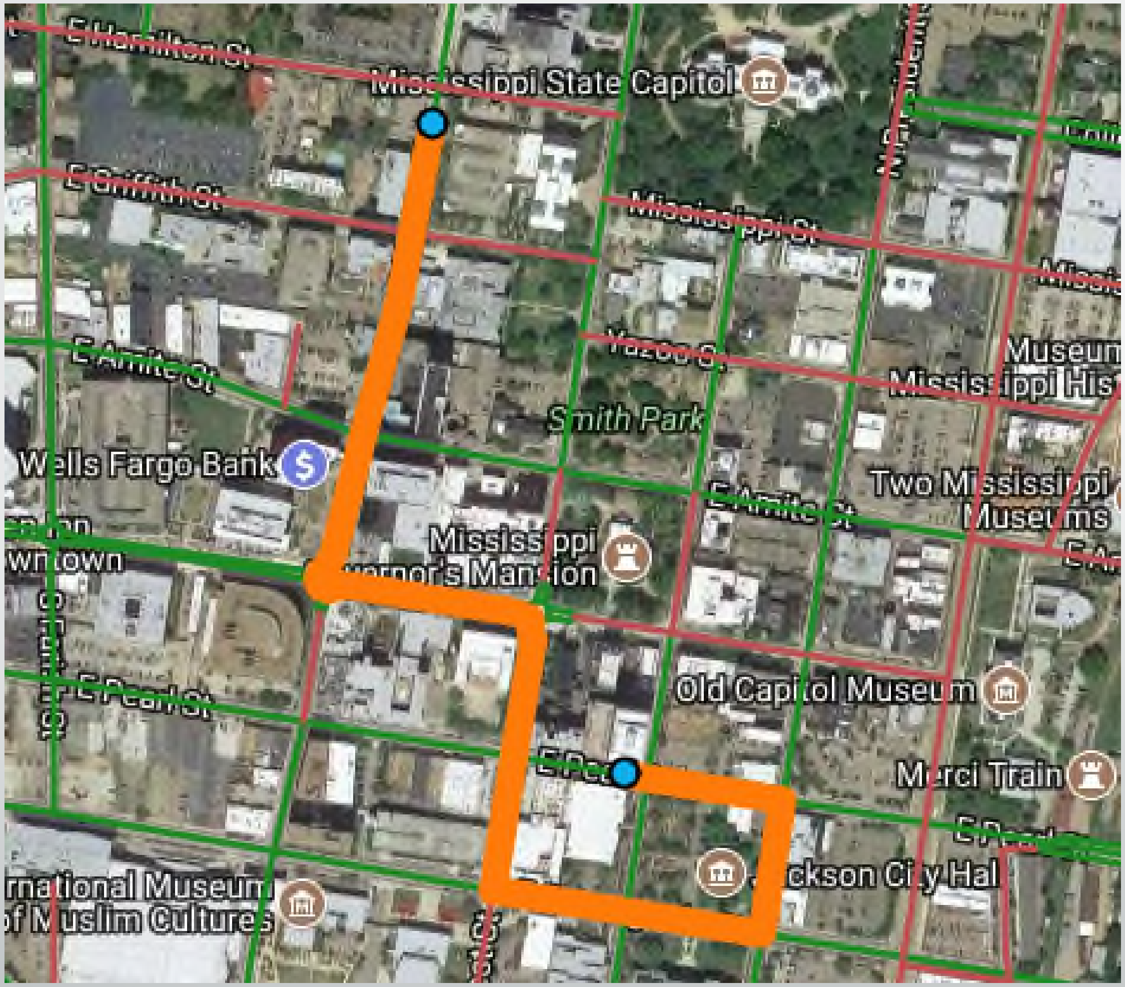
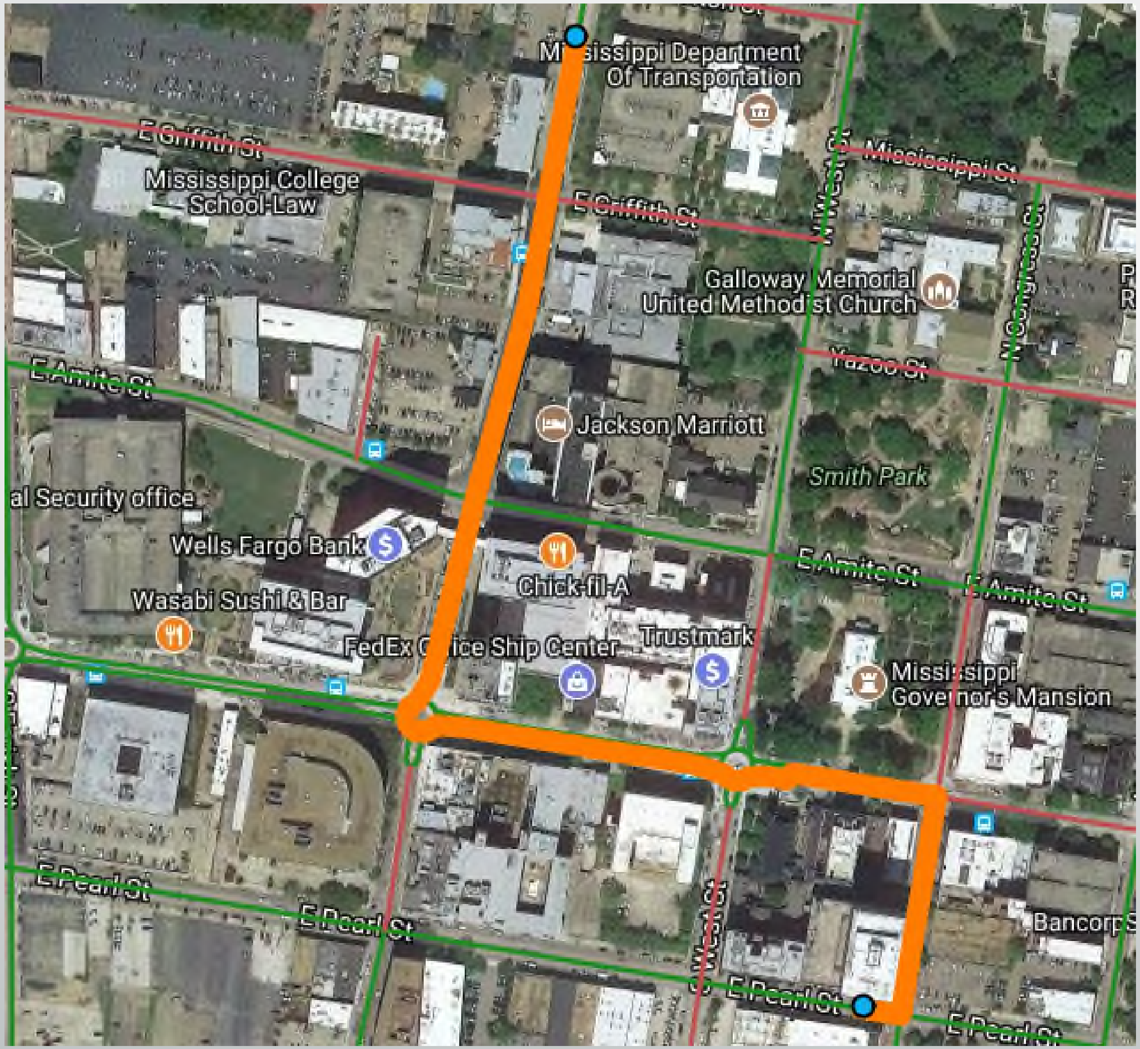

Henry St
State of Mississippi Woolfolk Building
E Hamilton St
N West St
High St
Mississippi State Capitol
N President St
E Hamilton St
College St
North St
N Jefferson St
Mississippi Department Of Transportation
E Griffith St
N State St
Mississippi College School Law
E Griffith
Galloway Memorial United Methodist Church
N Congress St
Public Employees' Retirement System of...
Mississippi
Yazoo St
Museum of Mississippi History
Mississippi Civil Rights Museum
Amite St
Jackson Marriott
Yazoo St
Smith Park
Security office
Old Capitol Inn
Wells Fargo Bank
Chick-fil-A
E Amite St
E Amite St
E Amite St
Two Mississippi Museums
Wasabi Sushi & Bar
FedEx Office Ship Center
Trustmark National Bank
Mississippi Governor's Mansion
N President St

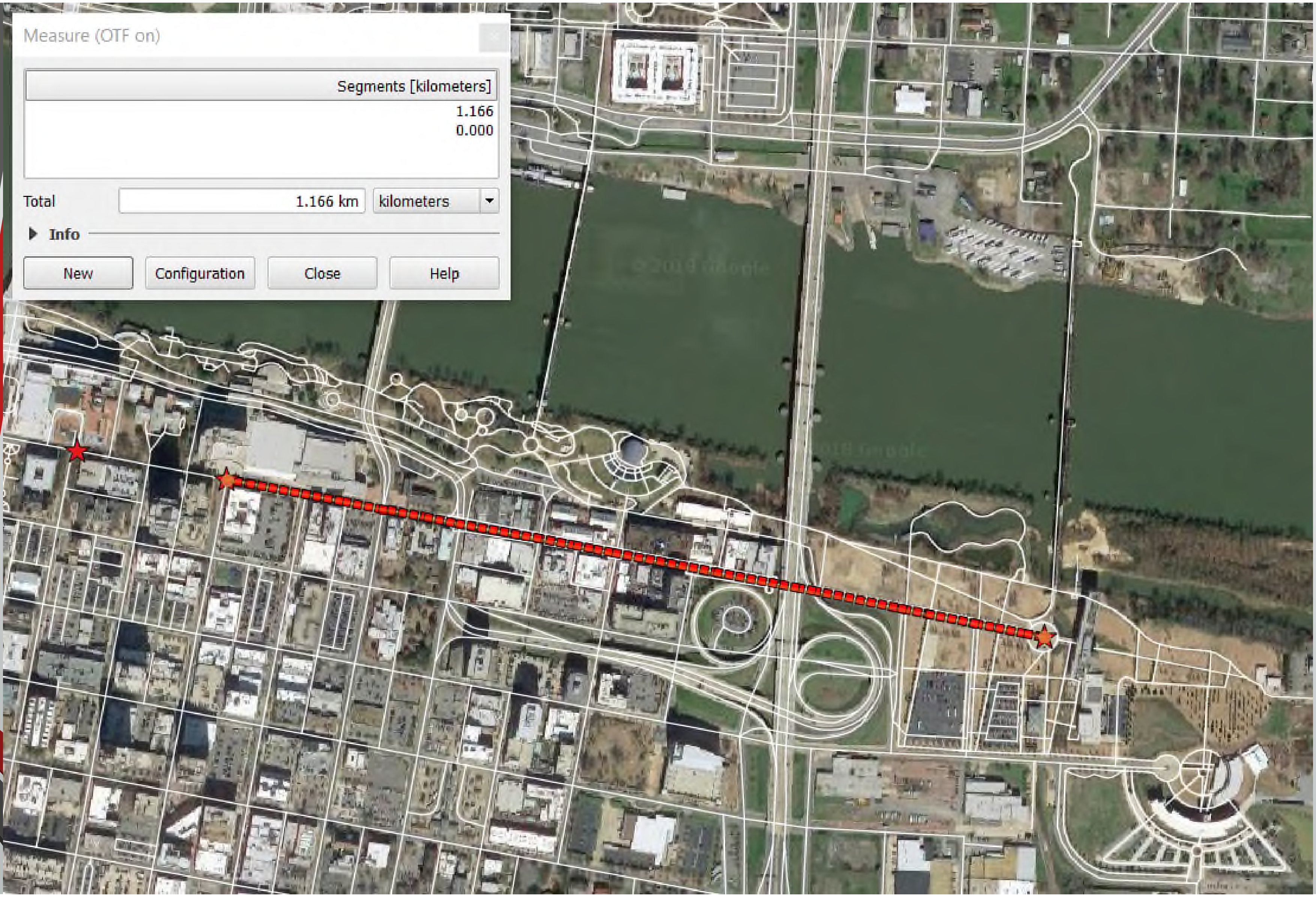

E Hamilton St
Mississippi State Capitol
E Griffith St
Mississippi St
N State St
E Amite St
Yazoo St
Smith Park
Museum
Mississippi His
Wells Fargo Bank
Two Mississippi Museums
Downtown
Mississippi Governor's Mansion
E Amite St
Old Capitol Museum
E Pearl St
Merci Train
E Pearl St
Jackson City Hall
International Museum of Muslim Cultures


Mississippi Department
Of Transportation
E Griffith St
Mississippi College
School Law
E Griffith St
N West St
E Mississippi St
Galloway Memorial
United Methodist Church
N Congress St
Yazoo St
E Amite St
Jackson Marriott
Smith Park
al Security office
Wells Fargo Bank
Chick-fil-A
E Amite St
E Amite St
Wasabi Sushi & Bar
FedEx Office Ship Center
Trustmark
Mississippi
Governor's Mansion
E Pearl St
E Pearl St
S West St
E Pearl St
E Pearl St
Bancorp S

Point of Interest Routing

Hotel to Clinton Library

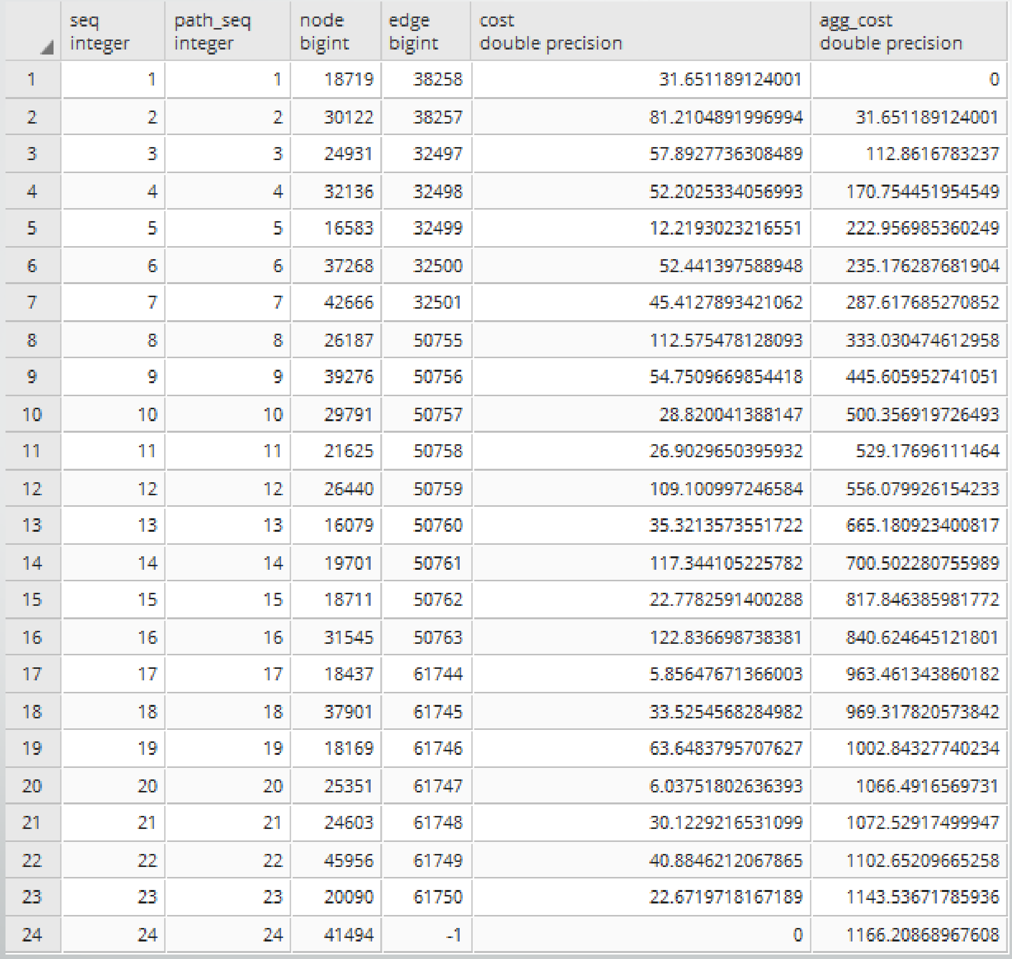
1. Downloaded the OSM data for Little Rock area
2. Loaded it in PostGIS with osm2pgrouting



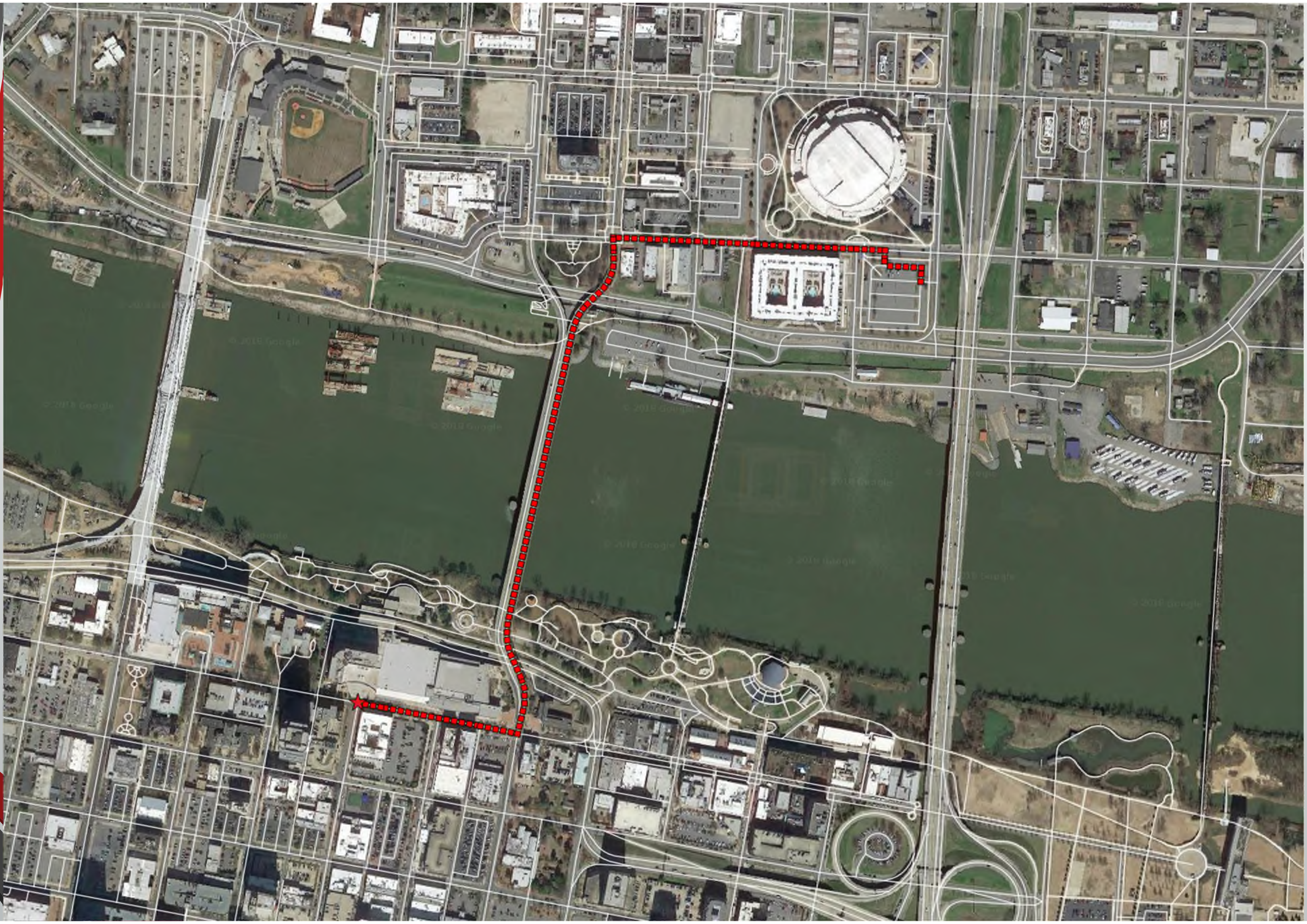
Measure (OTF on)

```
Segments [kilometers]
                1.166
                0.000
```

Total 1.166 km kilometers



	seq integer	path_seq integer	node bigint	edge bigint	cost double precision	agg_cost double precision
1	1	1	18719	38258	31.651189124001	0
2	2	2	30122	38257	81.2104891996994	31.651189124001
3	3	3	24931	32497	57.8927736308489	112.8616783237
4	4	4	32136	32498	52.2025334056993	170.754451954549
5	5	5	16583	32499	12.2193023216551	222.956985360249
6	6	6	37268	32500	52.441397588948	235.176287681904
7	7	7	42666	32501	45.4127893421062	287.617685270852
8	8	8	26187	50755	112.575478128093	333.030474612958
9	9	9	39276	50756	54.7509669854418	445.605952741051
10	10	10	29791	50757	28.820041388147	500.356919726493
11	11	11	21625	50758	26.9029650395932	529.17696111464
12	12	12	26440	50759	109.100997246584	556.079926154233
13	13	13	16079	50760	35.3213573551722	665.180923400817
14	14	14	19701	50761	117.344105225782	700.502280755989
15	15	15	18711	50762	22.7782591400288	817.846385981772
16	16	16	31545	50763	122.836698738381	840.624645121801
17	17	17	18437	61744	5.85647671366003	963.461343860182
18	18	18	37901	61745	33.5254568284982	969.317820573842
19	19	19	18169	61746	63.6483795707627	1002.84327740234
20	20	20	25351	61747	6.03751802636393	1066.4916569731
21	21	21	24603	61748	30.1229216531099	1072.52917499947
22	22	22	45956	61749	40.8846212067865	1102.65209665258
23	23	23	20090	61750	22.6719718167189	1143.53671785936
24	24	24	41494	-1	0	1166.20868967608


© 2019 Google

Catchment Areas:

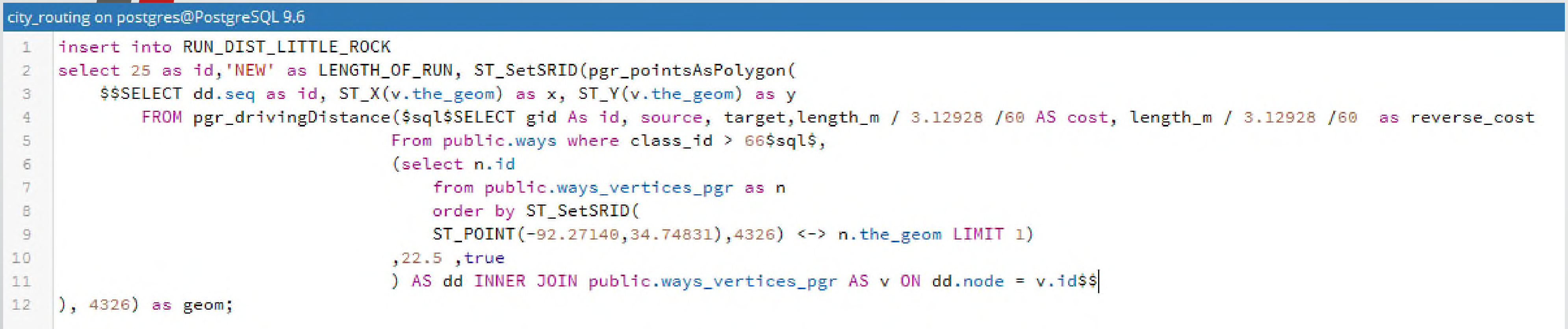
I enjoy running and especially enjoy running in new cities so how far can I run at 7 miles an hour in 45 minutes? 22.5 minutes in one direction.

What kind of routes do I want to run on?

Using same OSM data I created catchment areas based on the class id of routes.

1. Any route
2. No Major Routes

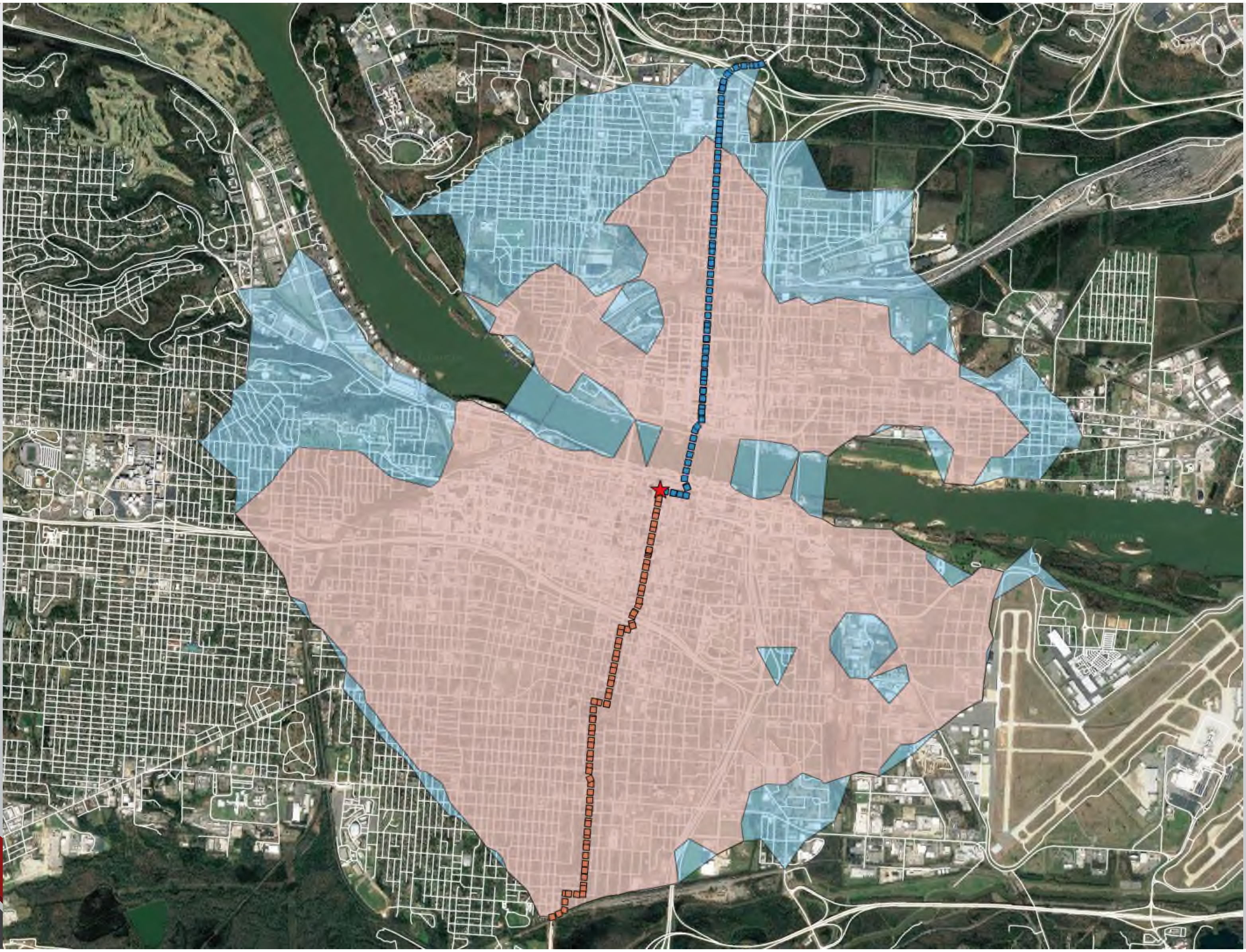
Does direction matter when you are pedestrian



```sql
insert into RUN_DIST_LITTLE_ROCK
select 25 as id,'NEW' as LENGTH_OF_RUN, ST_SetSRID(pgr_pointsAsPolygon(
    $$SELECT dd.seq as id, ST_X(v.the_geom) as x, ST_Y(v.the_geom) as y
        FROM pgr_drivingDistance($sql$SELECT gid As id, source, target,length_m / 3.12928 /60 AS cost, length_m / 3.12928 /60  as reverse_cost
                                From public.ways where class_id > 66$sql$,
                                (select n.id
                                    from public.ways_vertices_pgr as n
                                    order by ST_SetSRID(
                                    ST_POINT(-92.27140,34.74831),4326) <-> n.the_geom LIMIT 1)
                                ,22.5 ,true
                                ) AS dd INNER JOIN public.ways_vertices_pgr AS v ON dd.node = v.id$$
), 4326) as geom;
```

General code from pgRouting book, modified for running speed dictating cost.

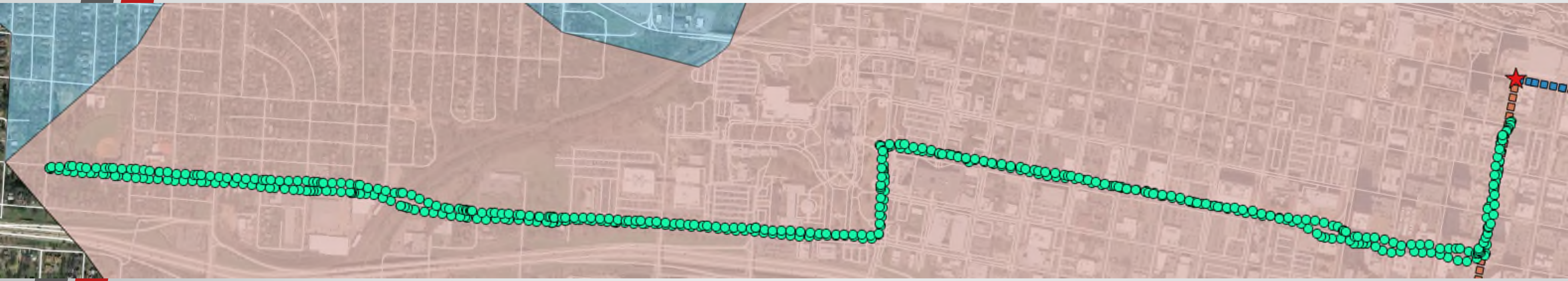
Make sure units of cost match the units you specify for distance in the function call.



How accurate was our catchment area??

Tested the morning of my presentation!

Actual Average speed 6.92 mph. Only ran for 43:18.



Observations:

On Street lighting → B

Capitol Building → A+

Sidewalks → B+

Hills → A

Future Plans:

1. Move data off of my Surface Laptop to a server

   Done

2. Publish newest version of LRS with routing info

   Done

3. Import OSM data as well to route on and compare

4. Optimize routing queries

   In Progress

5. Eliminate dead ends

   In Progress

6. Apply to other problems in DOT

   a. Use Travelling Salesman Problem to order the collection of traffic data and HPMS sample data

      Done!!

Thank you! Any Questions?