



# Healthy Ride Bike Share Research Project

## 2018 PennDOT TMA Annual Summit



**PITT** | SWANSON  
ENGINEERING

**Healthy**  
*ride*



**OTMA**  
Oakland Transportation  
Management Association

# Research Goal

- Determine the sustainable transportation benefits of the bike share system established in the Pittsburgh region, the Healthy Ride System (HRS)



# Tasks to Achieve the Goal

Task 1: Data Collection

Task 2: Analysis of Data

Task 3: Final Report



# Previous Research Summary

Literature Review  
User Survey



# Literature Review Summary

- [Bigazzi et al. 2016] examined the relationship between route selection and exposure to carbon emissions
- [Chunyan et al. 2015] discussed the effects of bike share programs on levels of greenhouse gas emissions (GHG) in Beijing, China
- [Li et al. 2016] examined the effects of bike-share use based on air quality, the researchers focused on the behavior of a bike-share users based on the ambient air quality
- Fishman et al. 2015] analyzed the repercussions of bike share programs in the active travel of populations in Australia, Great Britain and United States
- [Topalovic et al. 2016] found that in the town of Hamilton in Canada, bike share is used by a third of the member survey respondents to connect to transit, serving as a first-mile last-mile connector



# Literature Review Conclusions

- Increasing demand for alternative transportation due to climate change
- Primary mode switch biking/walking/transit -> bikeshare
- There is an opportunity to capitalize on linked trips by strategically placing bikeshare stations near transit stops
- Air quality and other environmental monitoring is better evaluated at the local level rather than at the regional level
- There is not a lot of data of the air quality or long-term economic benefits but bikeshare systems seem to encourage local business and economic activity.

# Healthy Ride Survey Methodology

- April 30, 2016 – August 22, 2016
- Emailed to all Healthy Ride Users
- Posted on Healthy Ride Website
- Available on Healthy Ride Facebook page



# 2016 Survey Results

- 22,602 active Healthy Ride users
- 13,640 inactive Healthy Ride users
- 443 respondents for the active users
- 109 respondents for the inactive users

# Survey Findings

Important information that can be used to determine the benefits to the transportation system:

- Frequent users replaced transit, walking and auto trips with bicycle trips.
- The largest shift came from transit usage although over 20% shifted from the auto mode.
- Significant personal shift in VMT was also reported from both transit and private auto modes users.



# Key Findings

- Specific travel characteristic data essential to determine the potential impact of the HRS system was collected
- Survey data coupled with route and frequency information can be used in a methodology
- This will result in the **estimate** of emission levels reductions in the region and Oakland



Frequent Users Mode Shift from Transit/Auto to HRS Travel Characteristics

Frequent users	Number in survey		Average	Total	Average trip time	Average distance 15mph	Personal VMT weekly
	(#)	(%)	trips/week	trips/week	minutes/trip	miles/trip	miles/week
Transit to HRS	23	30.6	3.2	73.6	22.73	5.6825	418.23
Auto to HRS	17	22.3	2.7	45.9	19.53	4.8825	224.15





# Evaluating the Air Quality Benefits And Developing a Methodology for Predicting Benefits

Task 1:  
Data Collection

# Task 1 Data Collection Tasks

1

Obtain the number and length of users on the roadway network to/from HRS stations (2016)

2

Create origin/destination matrix for one full year of data (2016)

3

Estimate the most likely routes and volumes of users between stations for bikes and vehicles trips replaced

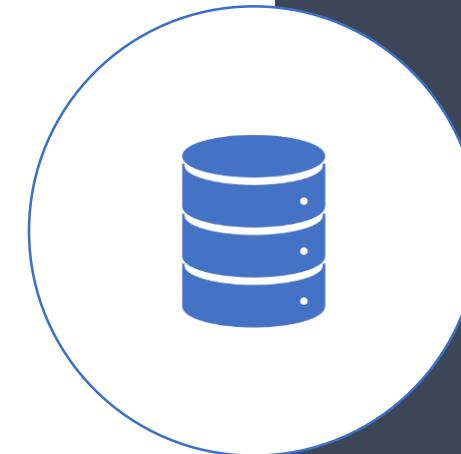
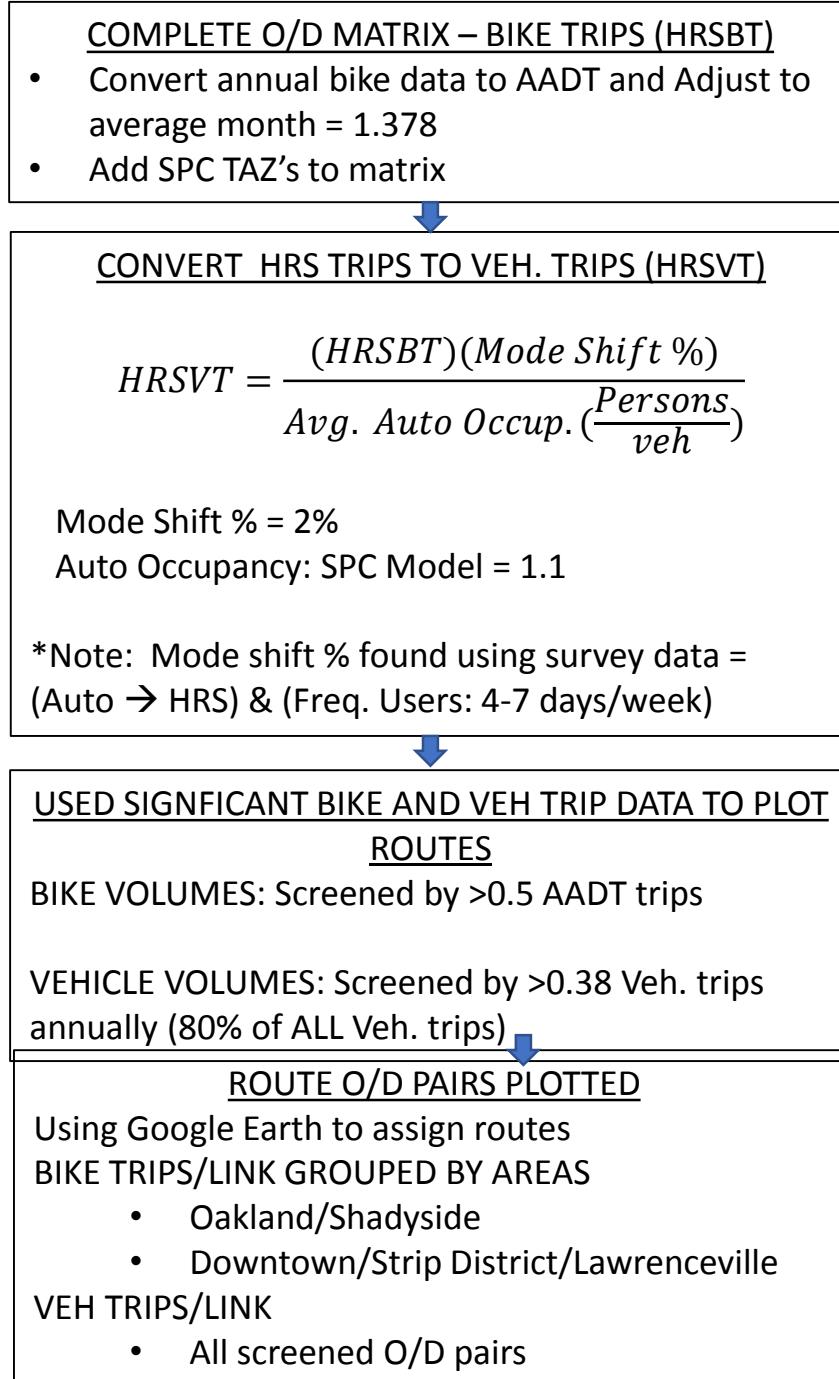
# General Data Requirements

- Number of bikes tracked by hour of the day and total for each day/year
- The origin and destination matrix for all trips by bikeshare station ( by direction)
- The total number of reduced vehicle trips by SPC link in model
- The total number of reduced vehicle trips by other links outside of the model
- A map of HRS average daily trips by link shown graphically by volume to select an Oakland study area



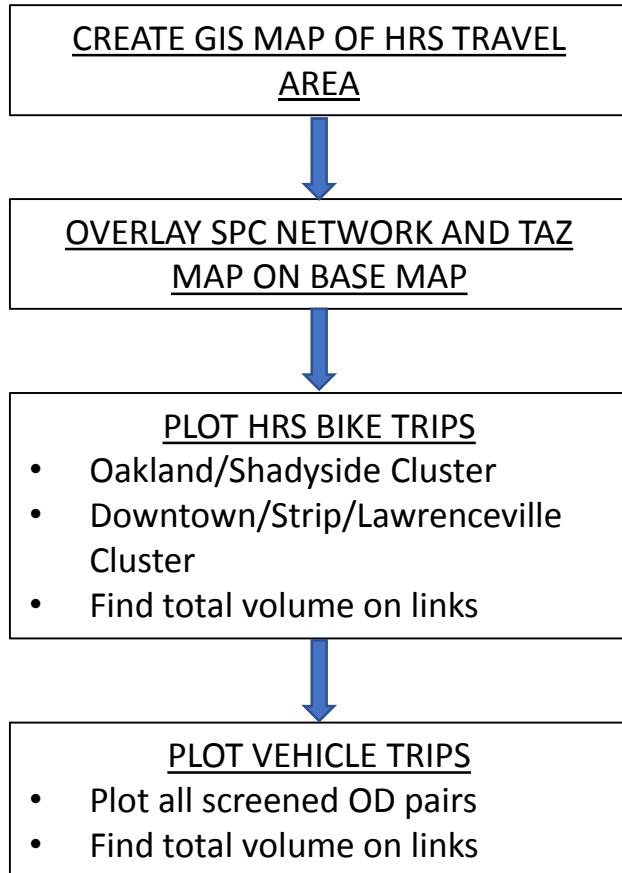
# General Analysis Process:

## HRS Trip Data Conversion to Vehicle trips and Routes



# General Analysis Process:

Creation of GIS Model,  
Coordination and Plotting  
of Bike and Vehicle Trips  
with SPC Model



# Data Developed for Regional Impact Analysis

- List of SPC links and off network links that have more than 0.38 annual vehicle trips from bikeshare trip reductions per day for each O/D pair.
- ADT map and list of all HRS trip reductions on all links with multiple route usage by HRS vehicle replacement trips
- 856 Annual Vehicle Trips are estimated to be replaced by HRS that are frequent daily users.



# Data Developed for Oakland Local analysis

- Map showing ADT HRS trips for all links (on and off SPC network) in Oakland
- An origin and destination matrix and maps for HRS trips in Oakland
- Map showing HRS stations in Oakland



# Data Collected for Oakland Local analysis

- For Selected Oakland Corridor:
  - AM and PM peak hour turning movements for all key intersections showing vehicular, bus and bicycle (HRS + other bikes) volumes
  - Estimated vehicular volumes reductions due to HRS operations
  - Study area changes in delays, LOS and emissions with and without HRS/all bikes
  - Estimated ADT link reductions
  - Estimated VMT reduction for study area

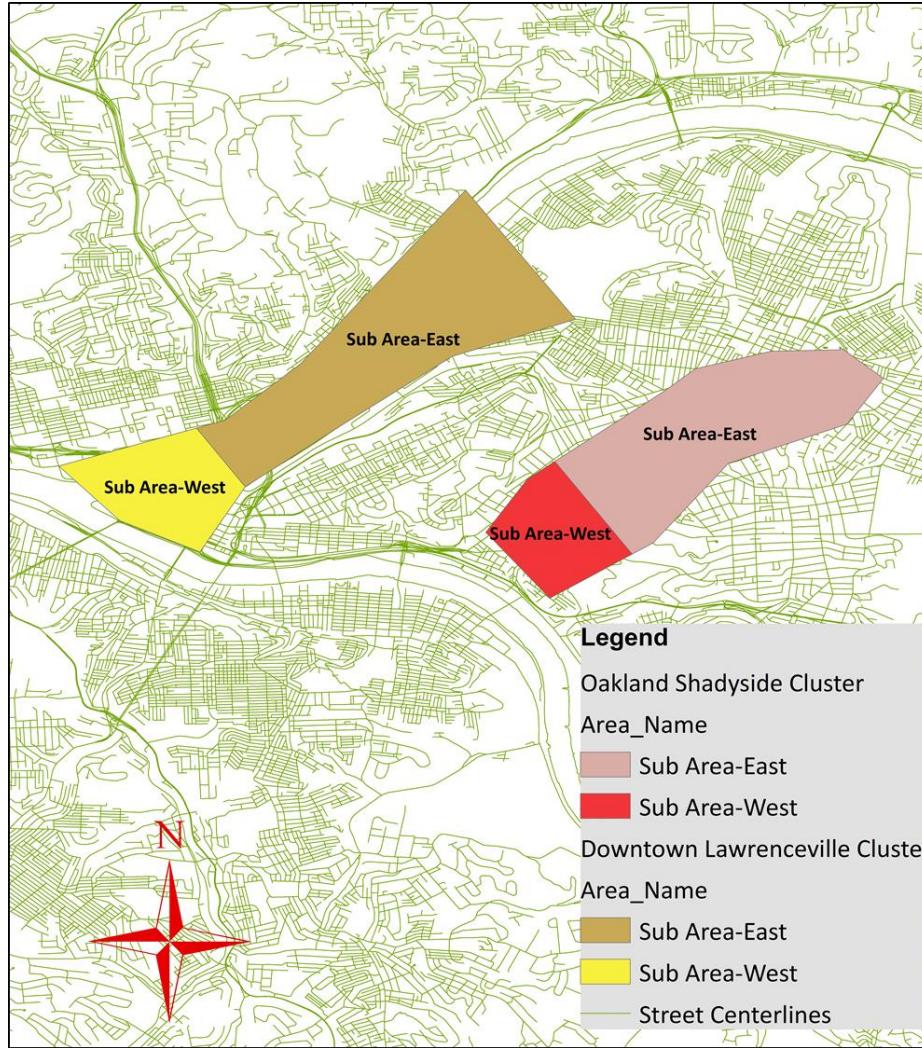


# OD Matrix

# GIS Map Layers

Presentation of  
Results

# OD Matrix: Clusters



# OD Matrix: Oakland-Shadyside Cluster

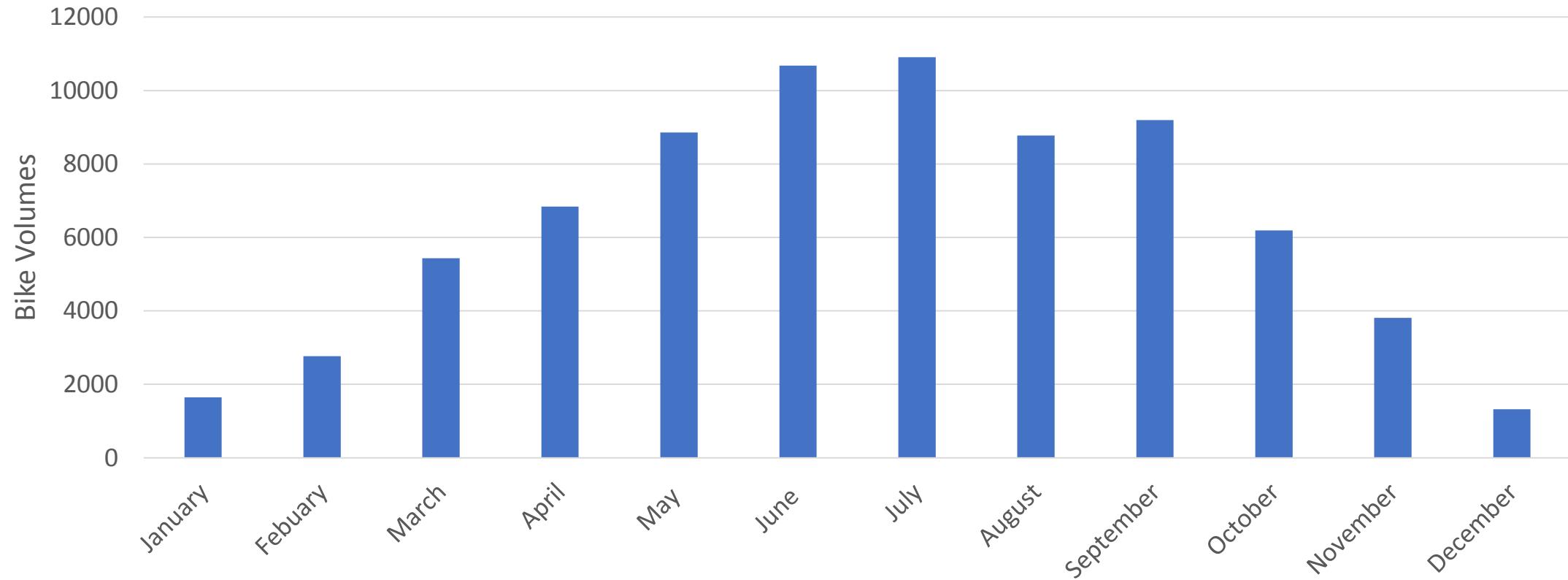
Origin		Destination				Trip Data		
Station Num	Station Name	TAZ	Station Num	Station Name	TAZ	Annual Bike Trips (2016)	AADT Bike Trips (adjusted)	Average Duration (Mins)
1038	Boulevard of the Allies & Parkview Ave	983	1041	Fifth Ave & S Bouquet	27	555	2.090	6.267
1029	Alder St & S Highland Ave	59	1028	Penn Ave & Putnam St (Bakery Sq)	60	472	1.777	5.906
1041	Fifth Ave & S Bouquet	27	1038	Boulevard of the Allies & Parkview Ave	983	467	1.758	6.817
1038	Boulevard of the Allies & Parkview Ave	983	1037	Frew St & Schenley Dr	38	430	1.619	6.165
1037	Frew St & Schenley Dr	38	1038	Boulevard of the Allies & Parkview Ave	983	396	1.491	6.301
1028	Penn Ave & Putnam St (Bakery Sq)	60	1029	Alder St & S Highland Ave	59	276	1.039	6.499
1039	Atwood St & Bates	29	1041	Fifth Ave & S Bouquet	27	249	0.937	5.079
1036	Schenley Dr at Schenley Plaza	28	1038	Boulevard of the Allies & Parkview Ave	983	234	0.881	9.17
1038	Boulevard of the Allies & Parkview Ave	983	1036	Schenley Dr at Schenley Plaza	28	233	0.877	7.891
1041	Fifth Ave & S Bouquet	27	1039	Atwood St & Bates	29	205	0.772	4.839
1034	Ellsworth Ave & N Neville St	42	1037	Frew St & Schenley Dr	38	190	0.715	8.323
1037	Frew St & Schenley Dr	38	1034	Ellsworth Ave & N Neville St	42	181	0.681	8.648
1038	Boulevard of the Allies & Parkview Ave	983	1040	Bigelow Blvd & Fifth Ave	27	163	0.614	7.486
1024	S Negley Ave & Baum Blvd	44	1036	Schenley Dr at Schenley Plaza	28	156	0.587	17.6
1034	Ellsworth Ave & N Neville St	42	1033	Ivy St & Walnut St	43	147	0.553	13.851
1043	Coltart Ave & Forbes Ave	29	1044	Zulema St & Coltart Ave	29	134	0.505	3.615

# OD Matrix: Downtown-Strip District-Lawrenceville Cluster

Origin			Destination			Trip Data		
Station Num	Station Name	TAZ	Station Num	Station Name	TAZ	Annual Bike Trips (2016)	AADT Bike Trips (adjusted)	Average Duration (Mins)
1017	21st St & Penn Ave	14	1010	10th St & Penn Ave	968	449	1.690	11.3
1010	10th St & Penn Ave	968	1016	17th St & Penn Ave	14	382	1.438	6.7
1000	Liberty & Stanwix	1	1017	21st St & Penn Ave	14	342	1.288	19.1
1016	17th St & Penn Ave	14	1010	10th St & Penn Ave	968	342	1.288	7.6
1017	21st St & Penn Ave	14	1001	Forbes Ave & Market Sq	3	316	1.190	16.7
1010	10th St & Penn Ave	968	1017	21st St & Penn Ave	14	315	1.186	9.7
1001	Forbes Ave & Market Sq	3	1017	21st St & Penn Ave	14	293	1.103	16.6
1017	21st St & Penn Ave	14	1000	Liberty & Stanwix	1	289	1.088	19.4
1016	17th St & Penn Ave	14	1000	Liberty & Stanwix	1	224	0.843	14.2
1012	North Shore Trail & Ft Duquesne	997	1001	Forbes Ave & Market Sq	3	222	0.836	25.7
1000	Liberty & Stanwix	1	1001	Forbes Ave & Market Sq	3	208	0.783	65.7
1001	Forbes Ave & Market Sq	3	1016	17th St & Penn Ave	14	208	0.783	20.6
1013	Isabella St & Federal St	996	1017	21st St & Penn Ave	14	204	0.768	24.7
1017	21st St & Penn Ave	14	1013	Isabella St & Federal St	996	202	0.761	24.5
1017	21st St & Penn Ave	14	1011	Fort Duquesne Blvd & 7th	5	197	0.742	16.5
1001	Forbes Ave & Market Sq	3	1012	North Shore Trail & Ft Duquesne Bridge	997	195	0.734	20.8
1016	17th St & Penn Ave	14	1001	Forbes Ave & Market Sq	3	194	0.730	16.5
1018	37th St & Butler St	22	1010	10th St & Penn Ave	968	189	0.712	20.7
1000	Liberty & Stanwix	1	1016	17th St & Penn Ave	14	184	0.693	18.5
1001	Forbes Ave & Market Sq	3	1000	Liberty & Stanwix	1	184	0.693	65.7
1017	21st St & Penn Ave	14	1019	42nd St & Butler St		179	0.674	22.3
1019	42nd St & Butler St		1017	21st St & Penn Ave	14	172	0.648	19.7
1012	North Shore Trail & Ft Duquesne	997	1000	Liberty & Stanwix	1	157	0.591	40.9
1011	Fort Duquesne Blvd & 7th	5	1017	21st St & Penn Ave	14	155	0.584	21.3
1012	North Shore Trail & Ft Duquesne	997	1013	Isabella St & Federal St	996	155	0.584	65.8
1010	10th St & Penn Ave	968	1000	Liberty & Stanwix	1	153	0.576	22.1
1019	42nd St & Butler St		1010	10th St & Penn Ave	968	153	0.576	27.2
1001	Forbes Ave & Market Sq	3	1010	10th St & Penn Ave	968	144	0.542	29.3
1013	Isabella St & Federal St	996	1012	North Shore Trail & Ft Duquesne Bridge	997	144	0.542	47.0
1016	17th St & Penn Ave	14	1003	First Ave & Smithfield St	6	138	0.520	12.1
1017	21st St & Penn Ave	14	1018	37th St & Butler St	22	138	0.520	15.1
1000	Liberty & Stanwix	1	1020	42nd St & Penn Ave	45	134	0.505	18.7

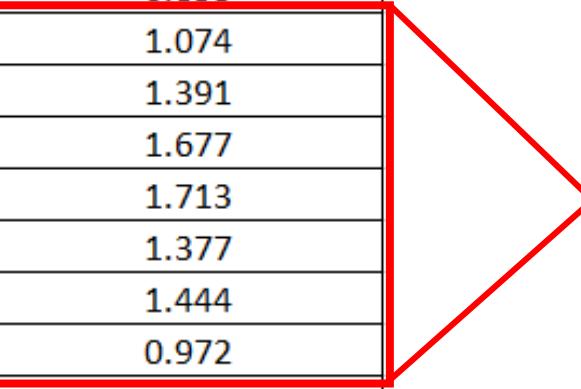
## Variation of HRS Trips by Temporal Distribution

2016 HRS Data: Monthly Variation



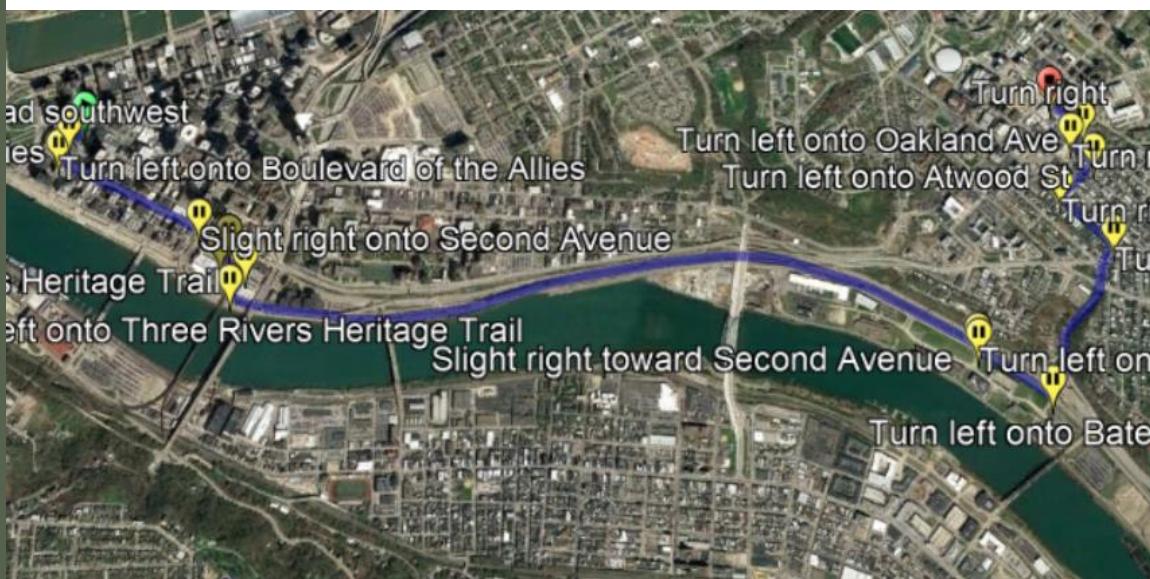
## Variation of HRS Trips by Temporal Distribution

Month	Total Trips	Adjustment factors (Based on total trips)
January	1645	0.258
February	2765	0.434
March	5433	0.853
April	6839	1.074
May	8857	1.391
June	10677	1.677
July	10910	1.713
August	8772	1.377
September	9196	1.444
October	6191	0.972
November	3811	0.598
December	1323	0.208
Average	6368	

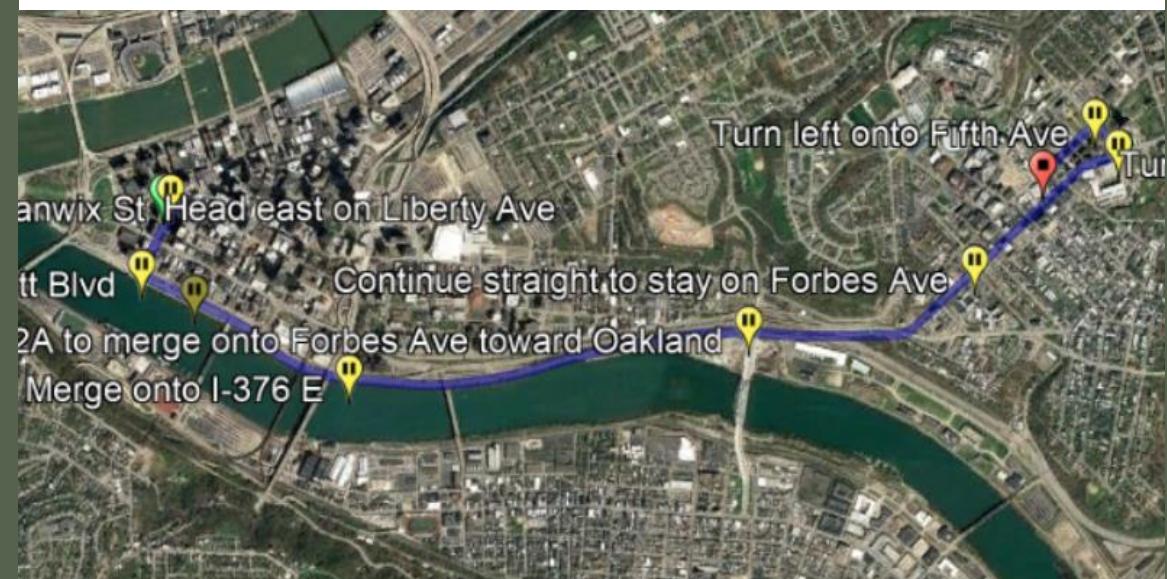


Average of high months used to adjust AADT bike trips = 1.378

## Routing Method Using Google Earth: **Liberty Ave & Stanwix St to S Bouquet St & Fifth Ave**

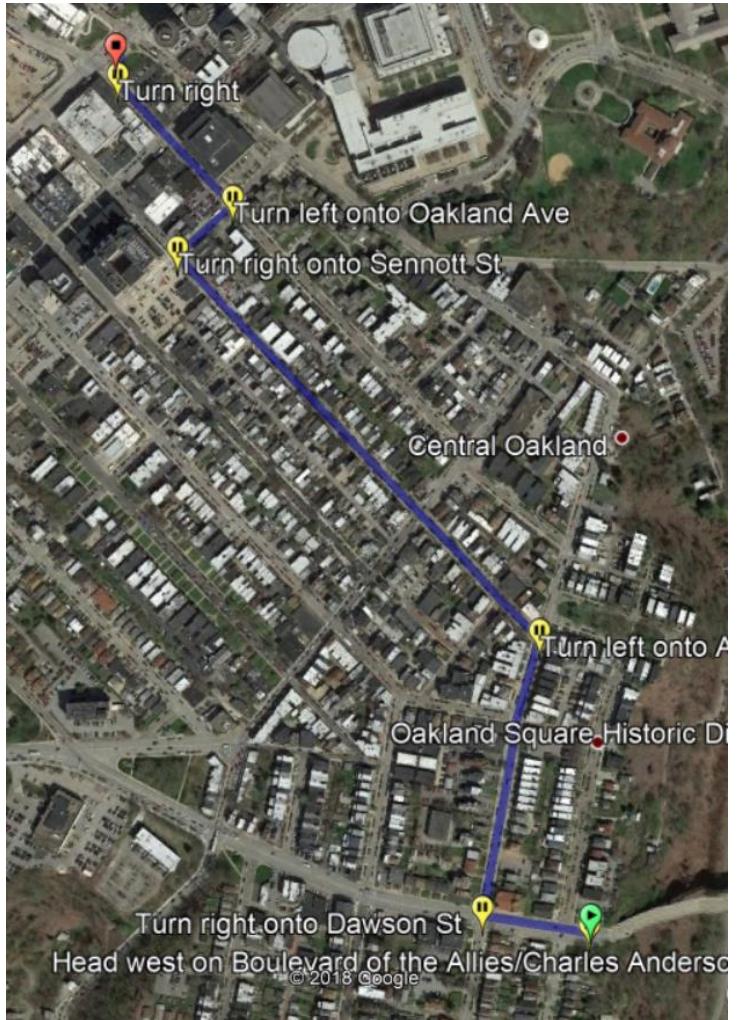


Bicycle Route



Car Route

# Comparison of Google Route Duration VS HRS Average Trip Duration



Blvd Of The Allies & Parkview Ave  
to Fifth Ave & S Bouquet

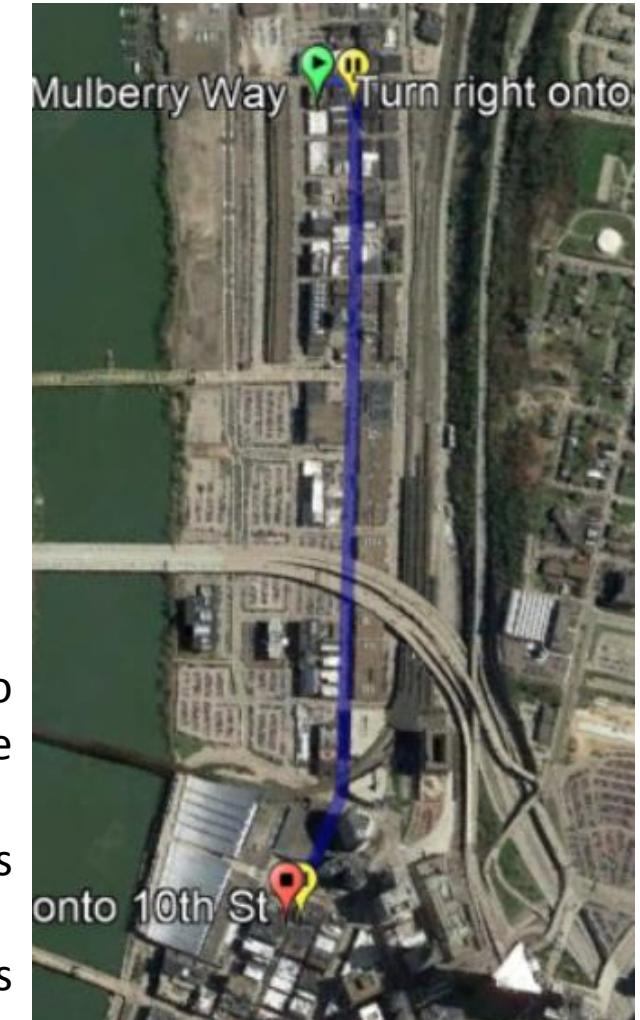
Google Duration: 5 mins

Average Duration: 6.25 mins

21<sup>st</sup> St & Penn Ave to  
Fifth Ave & 10<sup>th</sup> St & Penn Ave

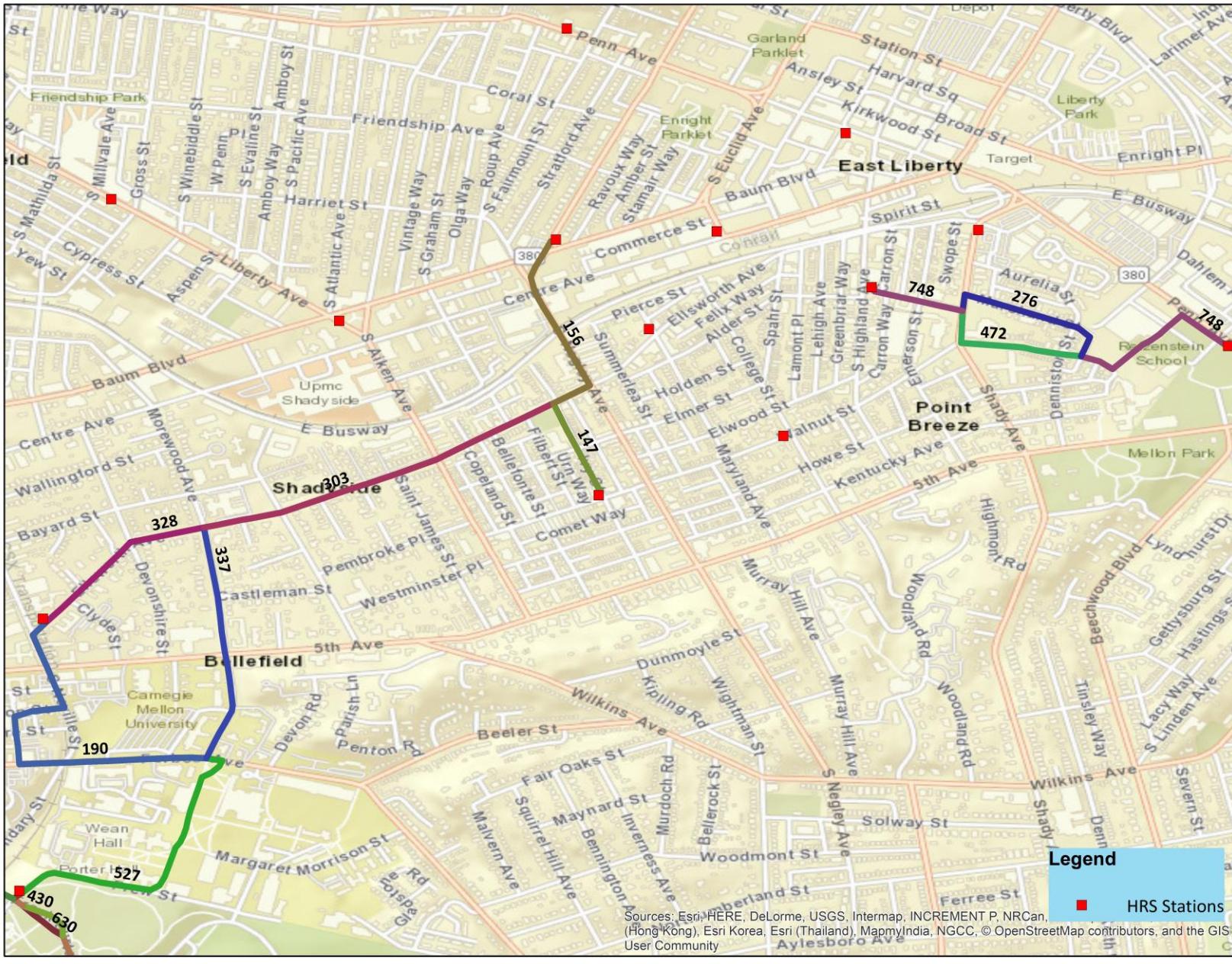
Google Duration: 5 mins

Average Duration: 11.3 mins

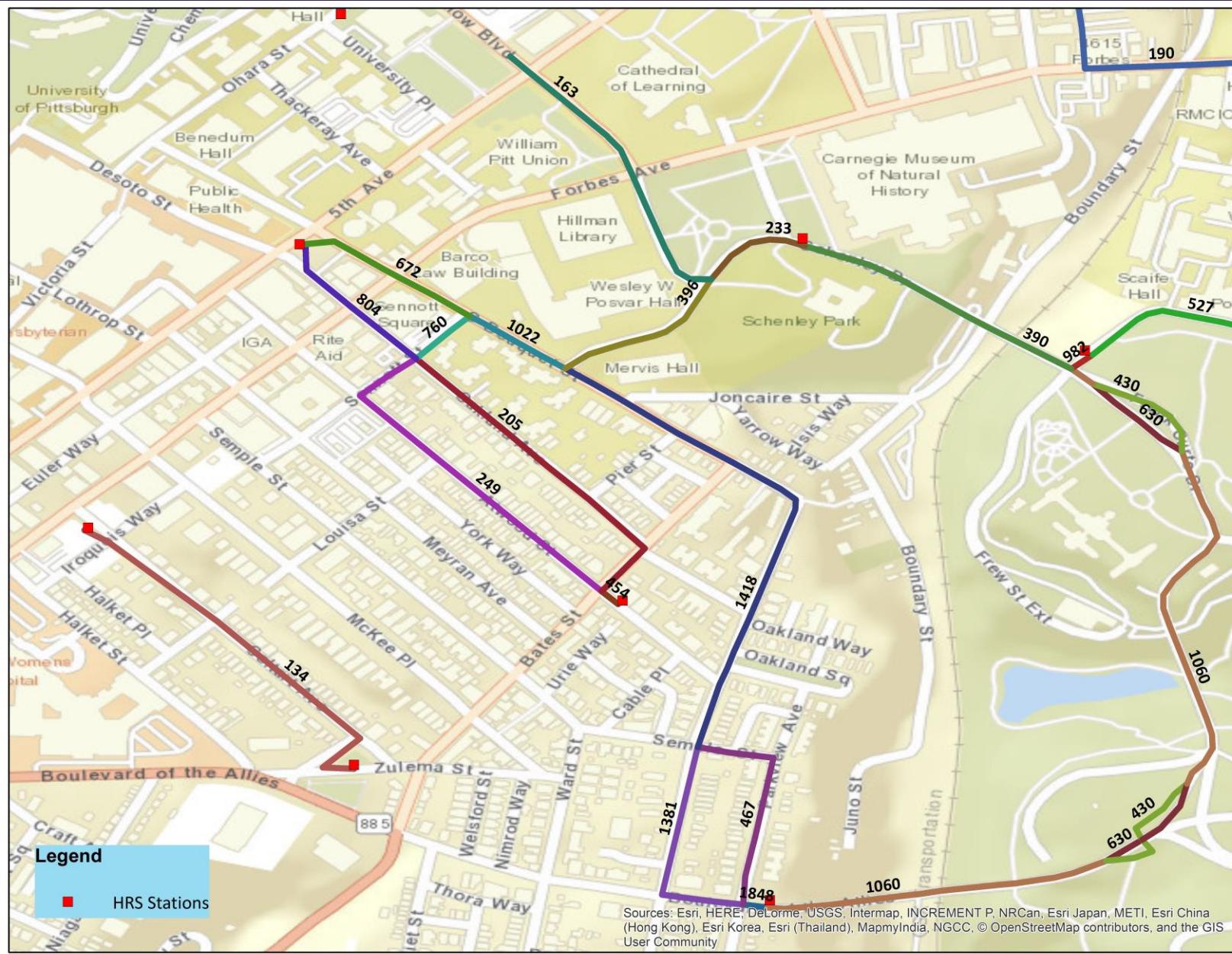


## **Creating a GIS Base Map for the Study Area**

- Find O/D bike routes on google maps based on the HRS average trip time
- Plot the routes on the GIS ArcMap and import the annual bike trips number per trips
- Divide the routes by several links
- Find total annual trip volumes by links (sum of annual bike trips for all frequencies/overlapped routes in the links)



**Total annual trip volumes  
by links – Oakland to  
Shadyside (Part 1)**



**Total annual trip volumes by links – Oakland to Shadyside  
(Part 2)**

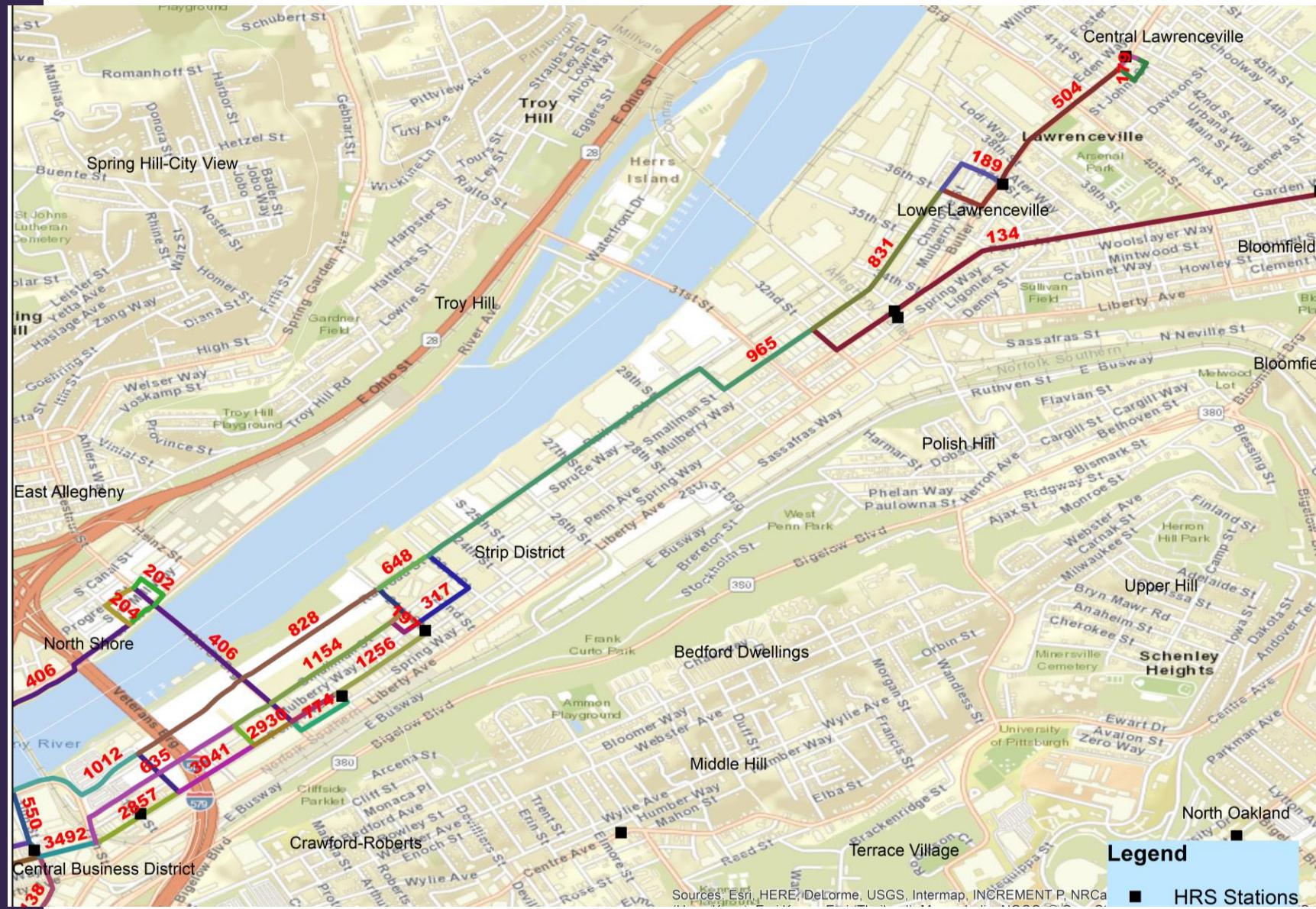
# Spatial and Volume Distribution of HRS Bicycle Trips – Oakland Shadyside

Link No.	Route Name	Route Frequency	Sum of Annual Bike Trips for all frequencies
1	Dawson St	5	1848
2	Schenley Drive and Boulevard of the Allies	3	1060
3	Schenley Drive and Boulevard of the Allies	2	630
4	Boulevard of the Allies	1	430
5	Boulevard of the Allies	1	430
6	Schenley Drive and Boulevard of the Allies	2	630
7	Dawson St	4	1381
8	S Bouquet St and Dawson St	1	467
9	Atwood St and Oakland Ave	2	454
10	Coltart Ave	1	134
11	Schenley Drive and Boulevard of the Allies	3	1060
12	Schenley Drive and Boulevard of the Allies	2	630
13	Boulevard of the Allies	1	430
14	Schenley Drive and Boulevard of the Allies	3	1060
15	Dawson St	4	1418
16	Atwood St and Oakland Ave	1	249
17	Oakland Ave	1	205
18	Ellsworth Ave	3	982

Link No.	Route Name	Route Frequency	Sum of Annual Bike Trips for all frequencies
19	Dawson St and S Bouquet St	2	760
20	Dawson St and S Bouquet St	2	1022
21	Dawson St	2	396
22	Ellsworth Ave	2	390
23	Dawson St and S Bouquet St	2	804
24	S Bouquet St and Dawson St	2	672
25	Dawson St	1	233
26	Dawson St	1	163
27	Ellsworth Ave	3	527
28	Forbes Ave	1	190
29	Ellsworth Ave	2	328
30	Ellsworth Ave	2	337
31	Ellsworth Ave	2	303
32	Ellsworth Ave	1	147
33	Marchand St	2	748
34	Walnut St	1	472
35	Marchand St	1	276
36	Marchand St	2	748
37	Ellsworth Ave	1	156

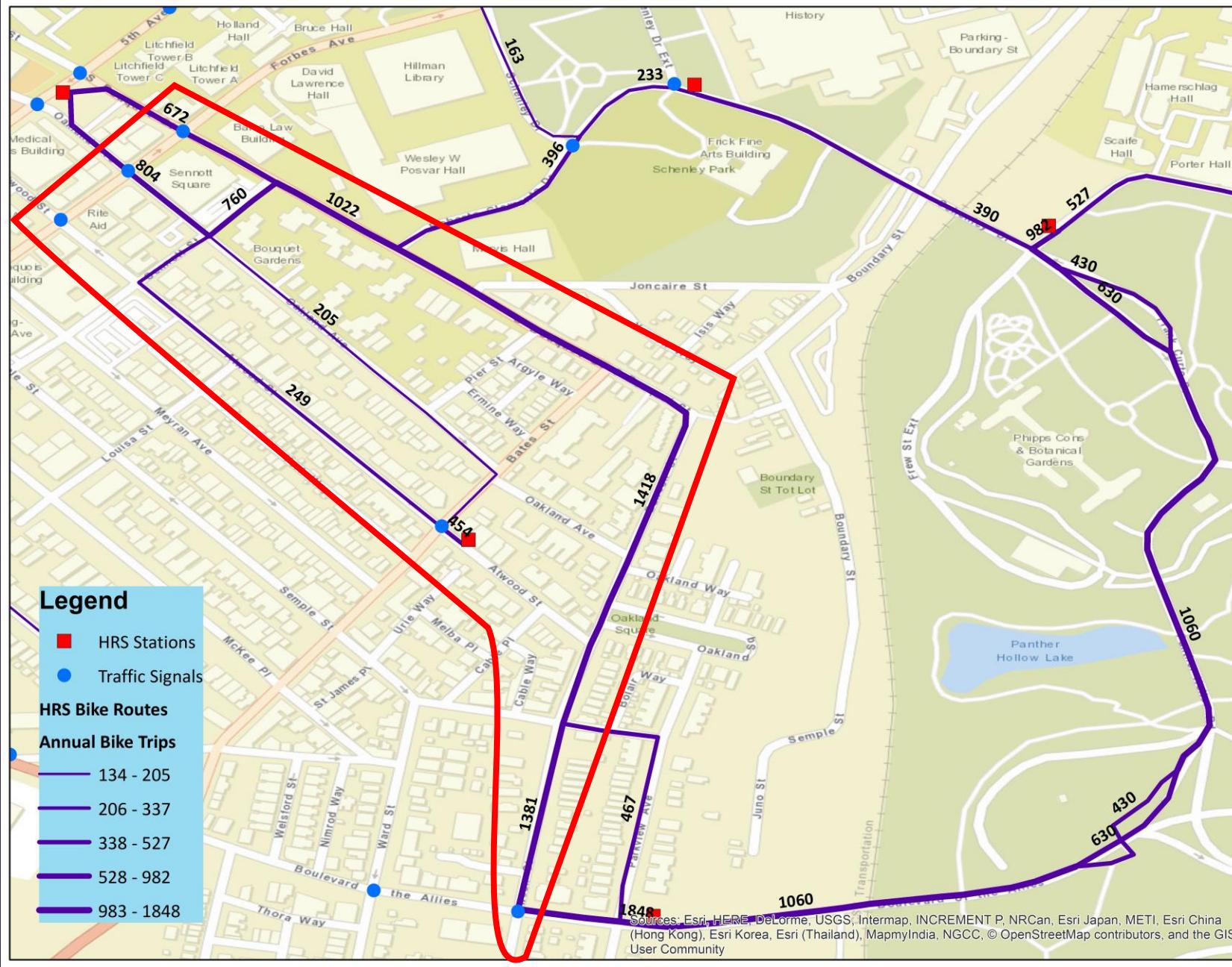


**Total annual trip volumes by links – Downtown Lawrenceville (Part 1)**



## Spatial and Volume Distribution of HRS Bicycle Trips – Downtown Lawrenceville

Link No	Route Name	Route Frequency	Sum of Annual Bike Trips for all frequencies
39	Three Rivers Heritage Trail and Penn Ave	12	3492
55	Forbes Ave	11	3041
58	Forbes Ave	11	2930
44	Three Rivers Heritage Trail	10	2857
33	Three Rivers Heritage Trail and Penn Ave	8	2484
15	Forbes Ave	11	2481
13	Forbes Ave	10	2337
62	North Shore Trail/Three Rivers Heritage Trail	8	2154
10	Forbes Ave	9	2088
17	Three Rivers Heritage Trail and Penn Ave	8	1955
1	Forbes Ave	8	1820
70	Penn Ave	7	1770
6	Penn Ave	7	1612
72	Three Rivers Heritage Trail and Penn Ave	6	1481
71	Three Rivers Heritage Trail and Penn Ave	5	1351
38	Three Rivers Heritage Trail and Penn Ave	6	1329
67	Penn Ave	4	1256
27	Penn Ave and Smallman St	5	1176
59	Three Rivers Heritage Trail and Penn Ave	4	1154
68	Three Rivers Heritage Trail and Penn Ave	4	1154



**Study Area: Oakland  
(Outlined in red)**

## Recommended Study Area – Oakland Shadyside

Link No.	Route Name	Route Frequency	Sum of Annual Bike Trips for all frequencies
7	Dawson St	4	1381
9	Atwood St and Oakland Ave	2	454
15	Dawson St	4	1418
16	Atwood St and Oakland Ave	1	249
17	Oakland Ave	1	205
19	Dawson St and S Bouquet St	2	760
20	Dawson St and S Bouquet St	2	1022
23	Dawson St and S Bouquet St	2	804
24	S Bouquet St and Dawson St	2	672

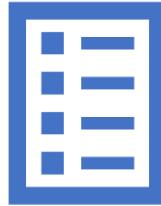
# Next Steps> Task 2: Analysis of Data

- Evaluate potential reduction in emissions and traffic congestion associated with this mode shift in region - SPC
- Calculate the resulting reduction in CO<sub>2</sub>, HC, NOx and other emissions measures using Synchro for Oakland Study Area



# Project Schedule

- Task 1 Report Summary 5/1/18
- The analysis results for local and regional air quality impacts 9/1/18
- Final Report 11/7/18



# Thank you

