Appendix 3 Content:

- Appendix 3 - Columbus HIN Maps
- Appendix 3 - Crash Data Summary 2014-2018
- Appendix 3 - Communities of Interest Map
- Appendix 3 - Walk Bike Ohio Need and Demand Maps
- Appendix 3 - Areas of Persistent Poverty Map
- Appendix 3 - CEJST Map
- Appendix 3 - HOLC Map
- Appendix 3 - Stakeholder Involvement List
- Appendix 3 - Comments from Residents
- Appendix 3 - RAP Pilot Presentation
- Appendix 3 - PlusTi information
- Appendix 3 - Limestone Concrete Information

Vision Zero Columbus - Crash Data

https://columbus.maps.arcgis.com/apps/MapSeries/index.html?appid=0ff6f8f1fa134b848959ba4fc3c35bbb

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes

Low — High

Crash Density Intensity

High Injury Network

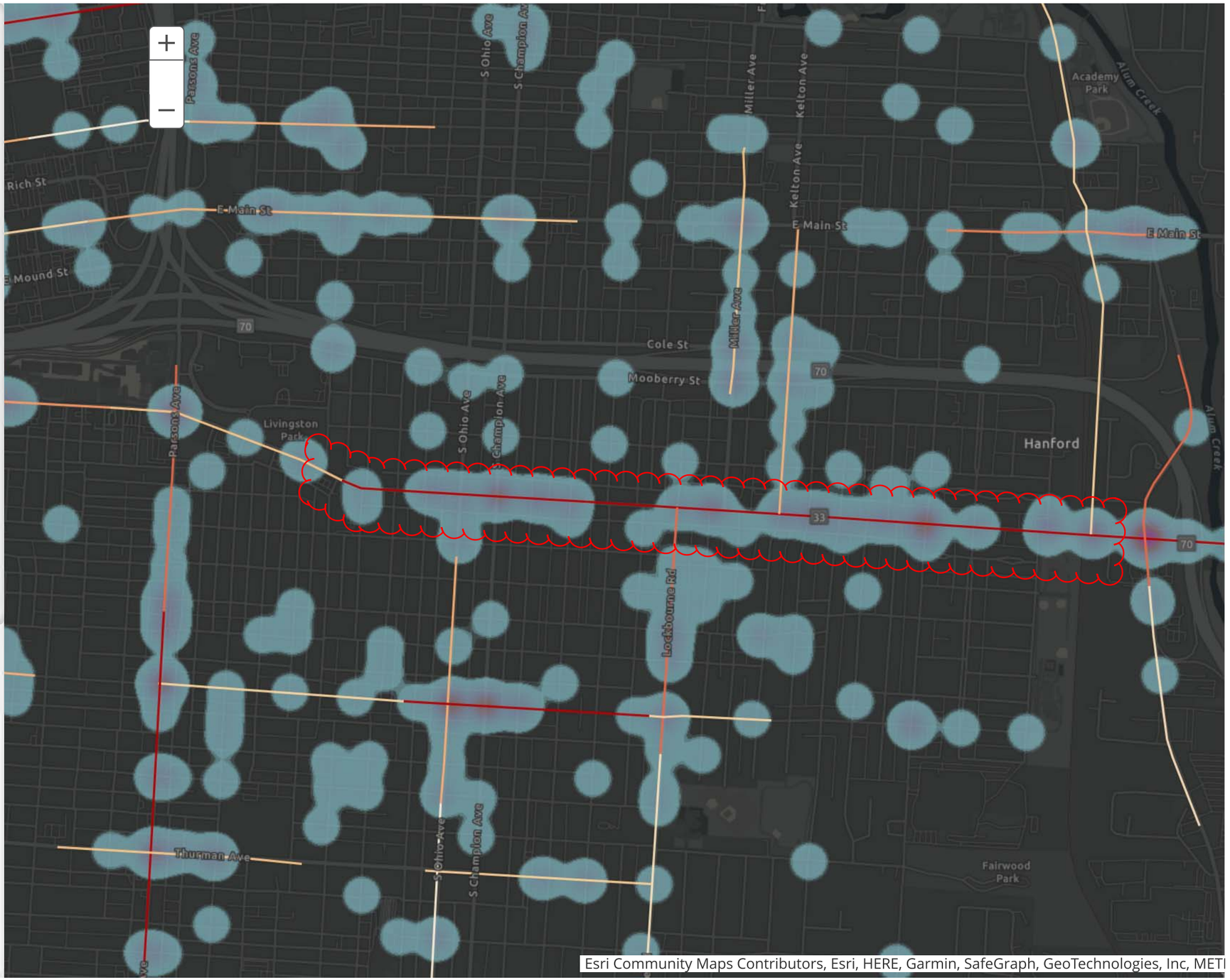
Columbus Vision Zero Definitions:

High Injury Network - Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

Vulnerable Road Users – pedestrians, bicyclists or motorcyclists – individuals who are inherently more at risk of injury when involved in any traffic crash

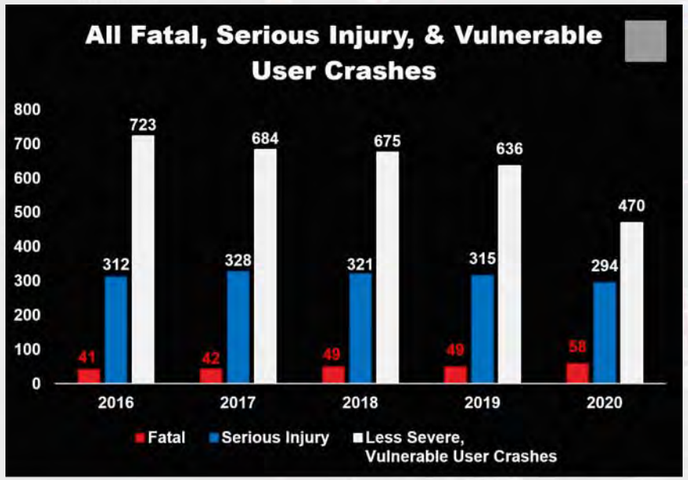
Columbus Vision Zero Crash Data:

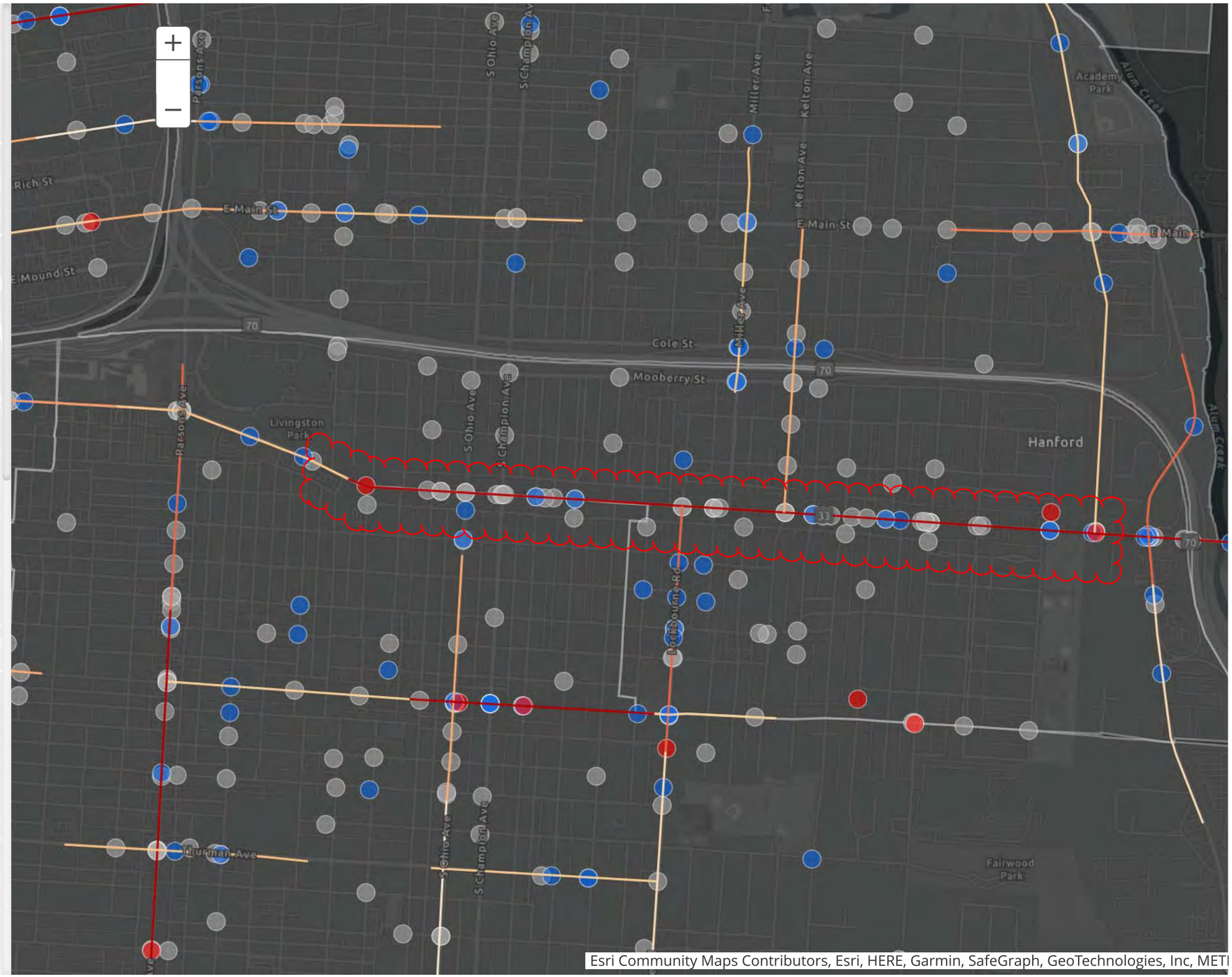
- currently includes data from 2016-2020
- does not include freeways or crashes outside the City corporation limits where the City has limited authority to make any changes
- includes all fatal or serious injury crashes
- includes all Vulnerable User Crashes of any severity



Vision Zero Columbus - Crash Data

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes





Columbus Vision Zero Definitions:

High Injury Network – Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

Fatal Crash – one or more people were killed as a result of this crash

Serious Injury Crash –one or more people needing emergency medical attention as a result of this crash

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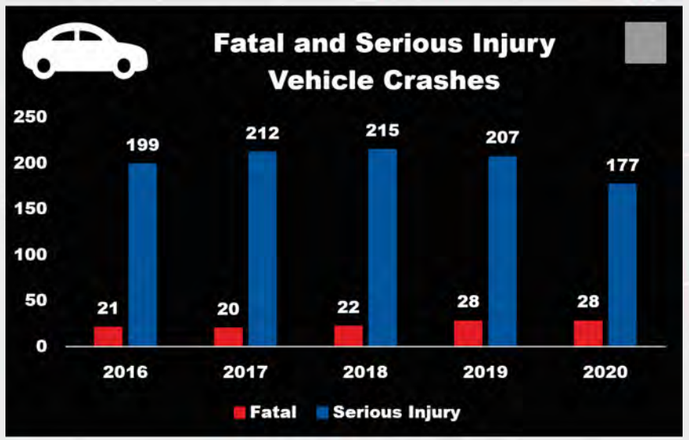
Columbus Vision Zero Crash Data:

- currently includes data from 2016-2020
- does not include freeways or crashes outside the City corporation limits where the City has limited authority to make any changes
- includes all fatal or serious injury crashes
- includes all Vulnerable User Crashes of any severity

Vision Zero Columbus - Crash Data

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes



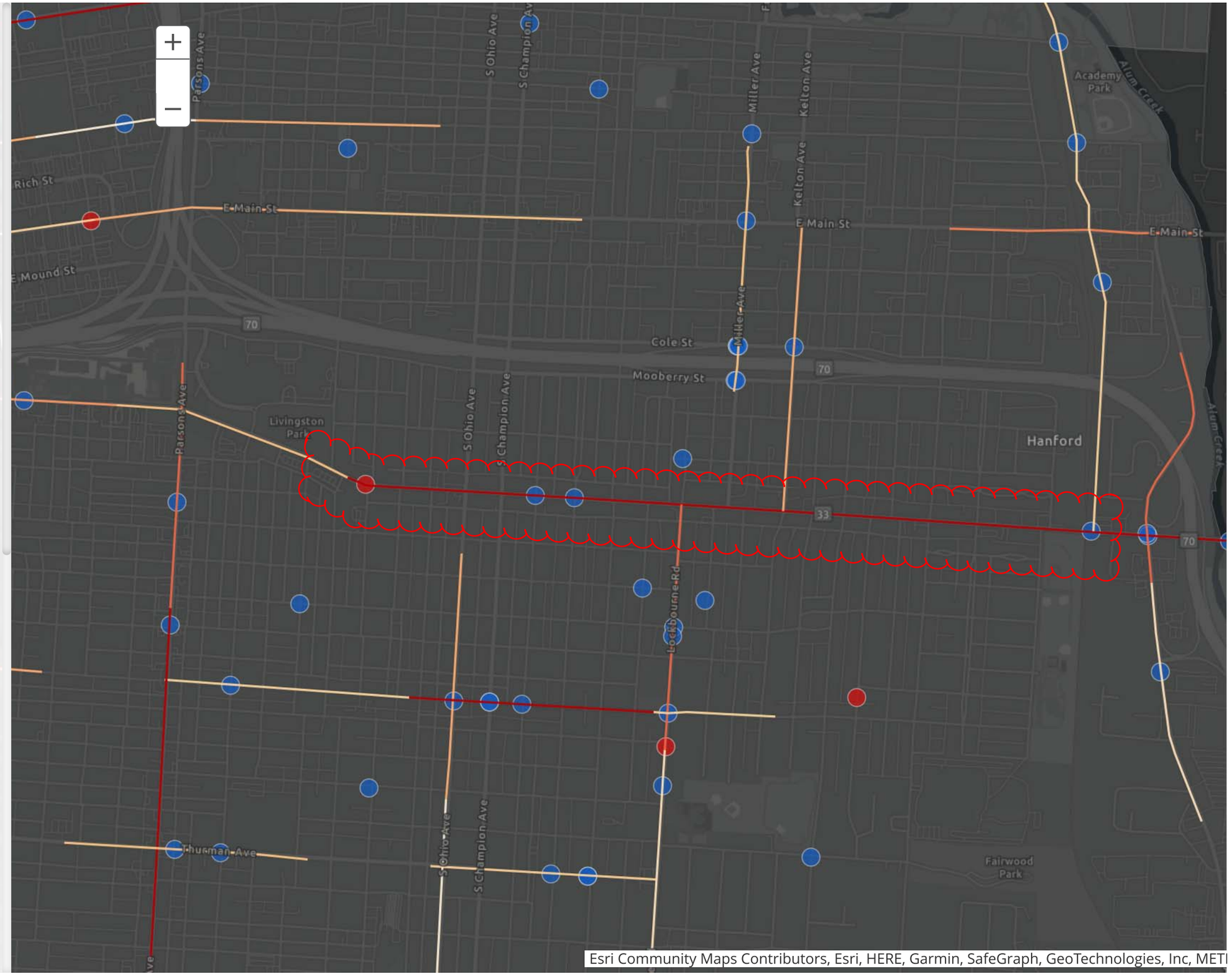
Columbus Vision Zero Definitions:

Vehicle Crash – any vehicle crash that does *not* involve a vulnerable user

High Injury Network – Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

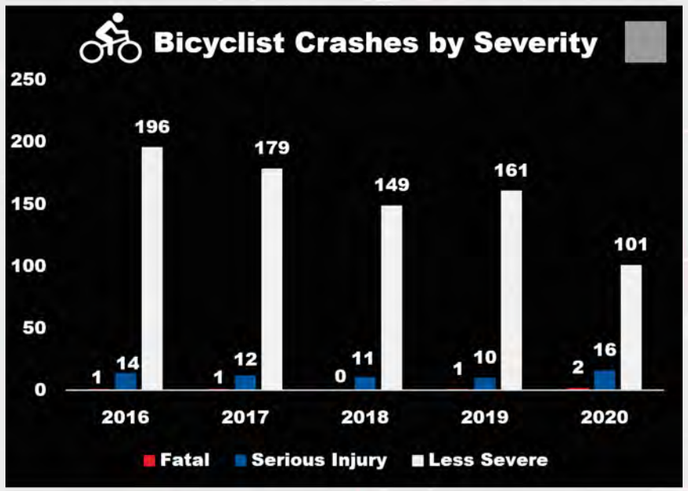
Fatal Crash – one or more people were killed as a result of this crash

Serious Injury Crash –one or more people needing emergency medical attention as a result of this crash



Vision Zero Columbus - Crash Data

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes



Columbus Vision Zero Definitions:

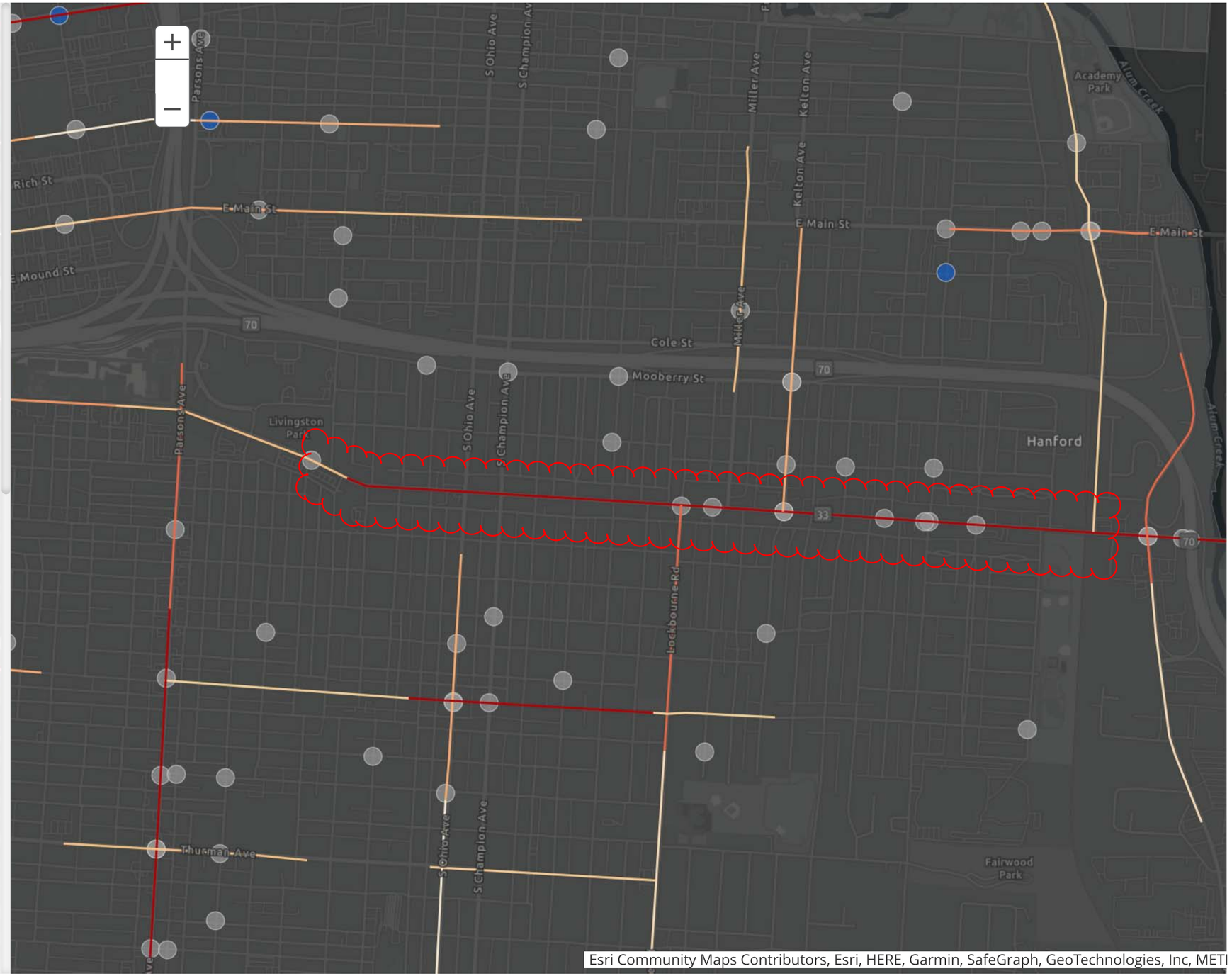
Bicycle Crash –when a vehicle strikes a bicyclist or scooter

High Injury Network – Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

Fatal Crash – one or more people were killed as a result of this crash

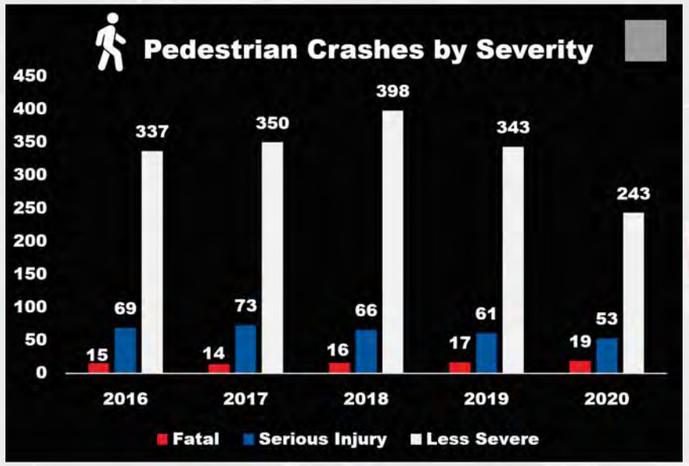
Serious Injury Crash –one or more people needing emergency medical attention as a result of this crash

Vulnerable Road Users – pedestrians, bicyclists or motorcyclists – individuals who are inherently more at risk of injury when involved in any traffic crash



Vision Zero Columbus - Crash Data

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes



Columbus Vision Zero Definitions:

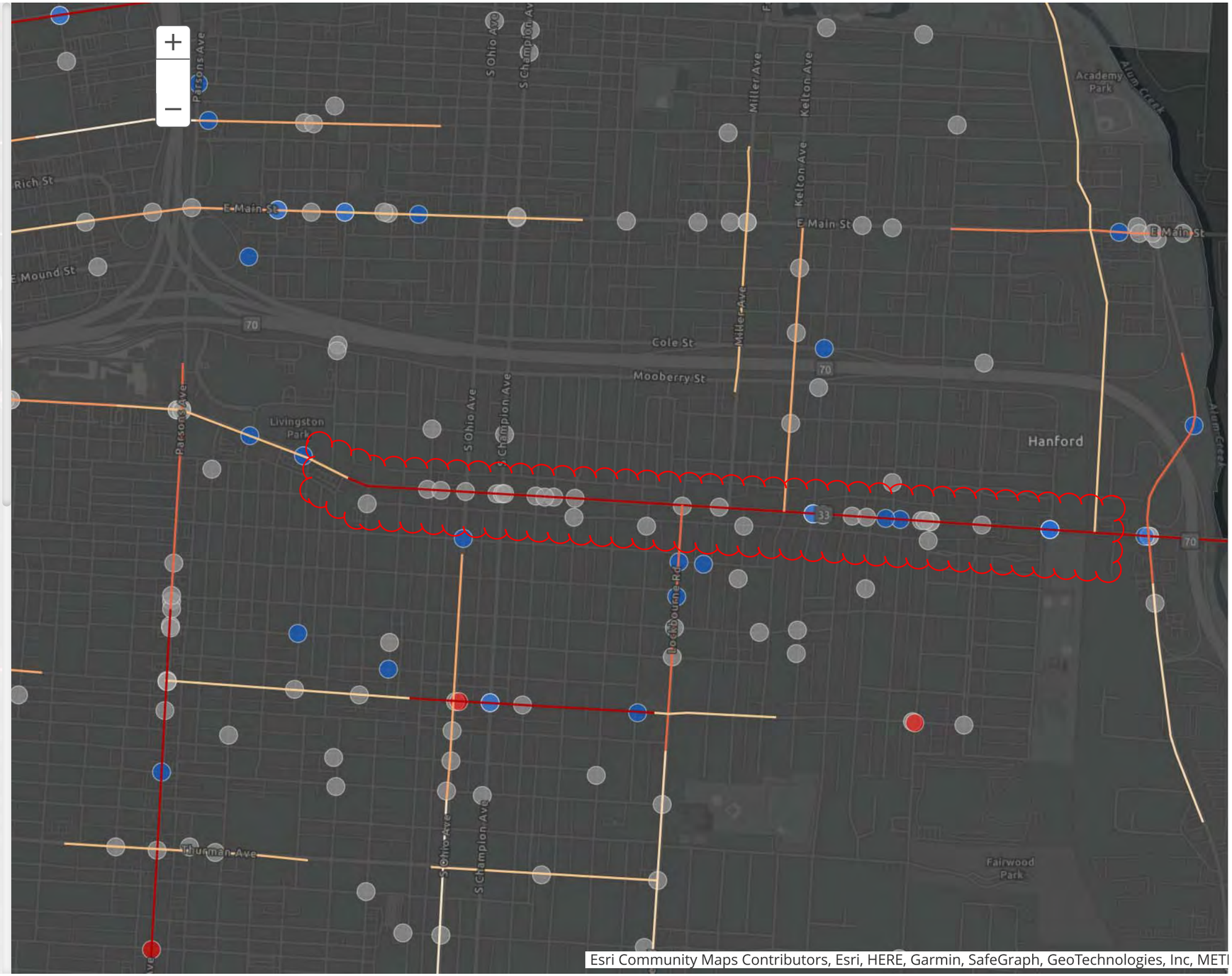
Pedestrian Crash – when a vehicle strikes a pedestrian

High Injury Network – Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

Fatal Crash – one or more people were killed as a result of this crash

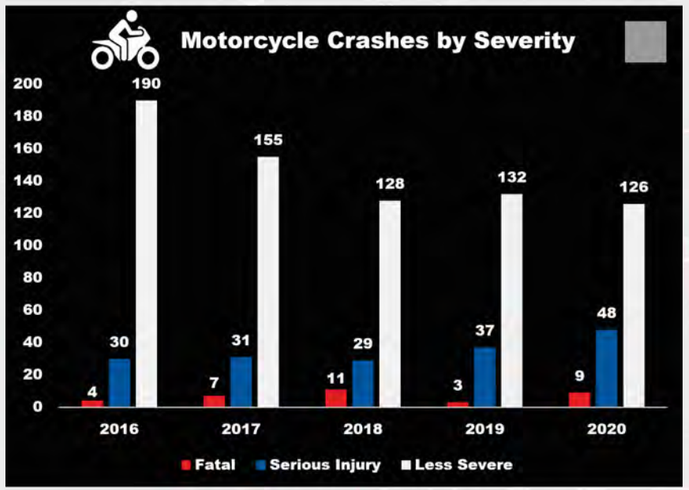
Serious Injury Crash –one or more people needing emergency medical attention as a result of this crash

Vulnerable Road Users – pedestrians, bicyclists or motorcyclists – individuals who are inherently more at risk of injury when involved in any traffic crash



Vision Zero Columbus - Crash Data

High Injury Network | All Crashes | Vehicle Crashes | Bicycle Crashes | Pedestrian Crashes | Motorcycle Crashes



Columbus Vision Zero Definitions:

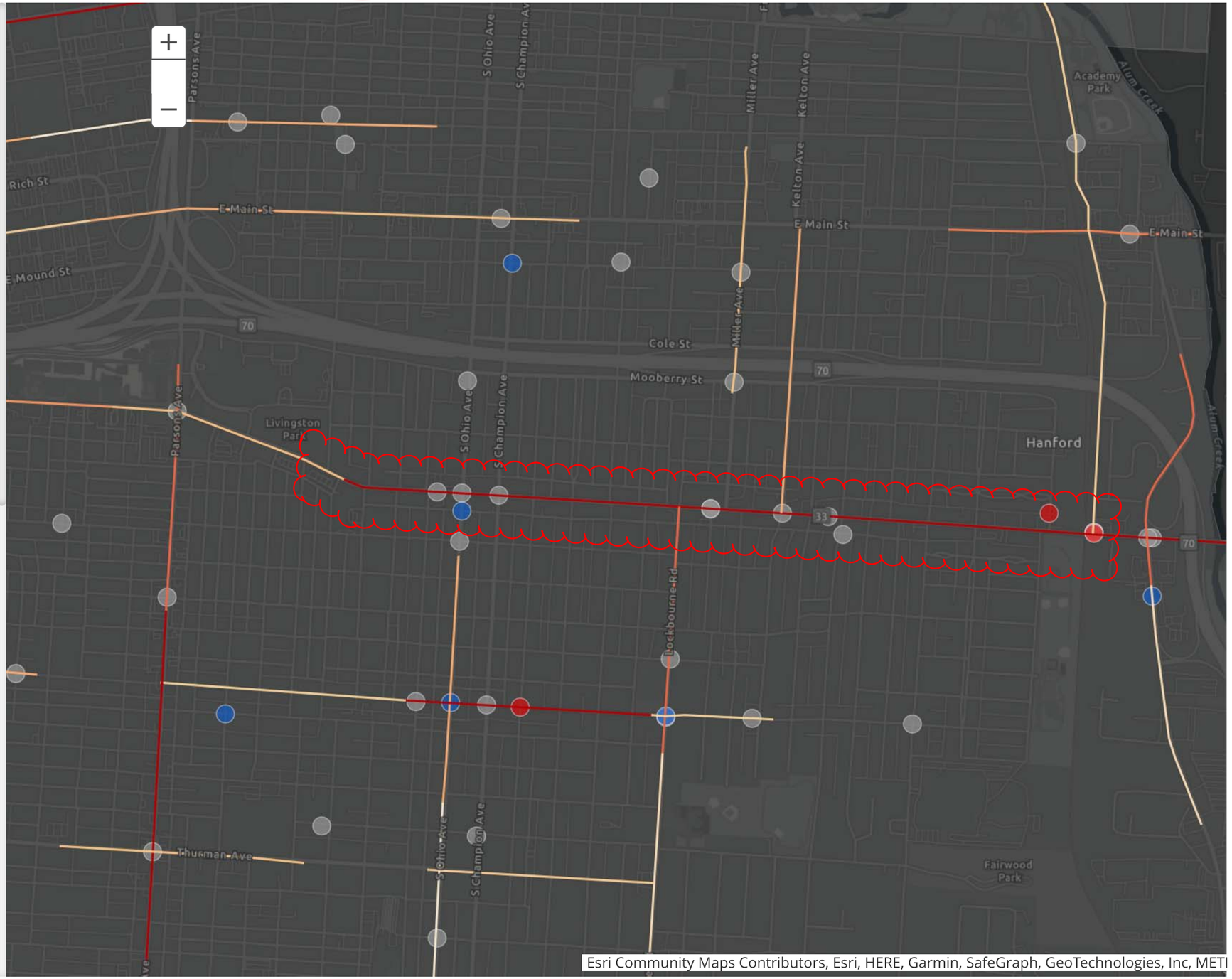
Motorcycle Crash – any crash involving a motorcycle

High Injury Network – Corridors in the City of Columbus that have had the greatest number of fatal, serious injury and/or vulnerable user crashes per half mile segment. Does not include freeways.

Fatal Crash – one or more people were killed as a result of this crash

Serious Injury Crash –one or more people needing emergency medical attention as a result of this crash

Vulnerable Road Users – pedestrians, bicyclists or motorcyclists – individuals who are inherently more at risk of injury when involved in any traffic crash



Livingston Avenue, 18th Street to Nelson Road

Crash Summary Sheet

Fatalities	2
Serious Injuries	12
Other Injuries	359

Crashes Per Year	162.20
Fatal and All Injury Crashes	249
Percent Injury	30.7%
Equivalent PDO Index Value	3.06

Crash Severity	Crashes	%
(1) Fatal	2	0.25%
(2) Serious Injury Suspected	11	1.36%
(3) Minor Injury Suspected	135	16.65%
(4) Injury Possible	101	12.45%
(5) PDO/No Injury	562	69.30%
Grand Total	811	100.00%

Year	Crashes	%
2014	140	17.26%
2015	177	21.82%
2016	180	22.19%
2017	162	19.98%
2018	152	18.74%
Grand Total	811	100.00%

Day of Week	Crashes	%
(1) Sunday	93	11.47%
(2) Monday	107	13.19%
(3) Tuesday	98	12.08%
(4) Wednesday	133	16.40%
(5) Thursday	127	15.66%
(6) Friday	144	17.76%
(7) Saturday	109	13.44%
Grand Total	811	100.00%

Hour of Day	Crashes	%
0	19	2.34%
1	13	1.60%
2	12	1.48%
3	9	1.11%
4	4	0.49%
5	4	0.49%
6	12	1.48%
7	19	2.34%
8	30	3.70%
9	41	5.06%
10	33	4.07%
11	51	6.29%
12	48	5.92%
13	49	6.04%
14	41	5.06%
15	73	9.00%
16	71	8.75%
17	59	7.27%
18	56	6.91%
19	46	5.67%
20	35	4.32%
21	33	4.07%
22	35	4.32%
23	18	2.22%
Grand Total	811	100.00%

Crash Type	Crashes	%
Angle	171	21.09%
Rear End	166	20.47%
Sideswipe - Passing	163	20.10%
Left Turn	96	11.84%
Parked Vehicle	49	6.04%
Fixed Object	46	5.67%
Right Turn	36	4.44%
Pedestrian	35	4.32%
Backing	21	2.59%
Pedalcycles	9	1.11%
Head On	7	0.86%
Other Non-Collision	6	0.74%
Sideswipe - Meeting	3	0.37%
Unknown	2	0.25%
Overturning	1	0.12%
Grand Total	811	100.00%

Month	Crashes	%
1	62	7.64%
2	66	8.14%
3	61	7.52%
4	73	9.00%
5	76	9.37%
6	84	10.36%
7	58	7.15%
8	72	8.88%
9	64	7.89%
10	74	9.12%
11	60	7.40%
12	61	7.52%
Grand Total	811	100.00%

Livingston Avenue, 18th Street to Nelson Road

Crash Summary Sheet

Weather Condition	Crashes	%
Clear	549	67.69%
Cloudy	143	17.63%
Rain	94	11.59%
Snow	13	1.60%
Unknown	6	0.74%
Sleet, Hail	4	0.49%
Fog, Smog, Smoke	2	0.25%
Grand Total	811	100.00%

Road Condition	Crashes	%
Dry	639	78.79%
Wet	136	16.77%
Snow	16	1.97%
Ice	9	1.11%
Other / Unknown	7	0.86%
Slush	2	0.25%
Sand, Mud, Dirt, Oil, Gravel	2	0.25%
Grand Total	811	100.00%

Light Condition	Crashes	%
Daylight	549	67.69%
Dark - Lighted Roadway	219	27.00%
Dawn/Dusk	24	2.96%
Dark - Roadway Not Lighted	13	1.60%
Other / Unknown	6	0.74%
Grand Total	811	100.00%

Number of Units	Crashes	%
2	703	86.68%
1	57	7.03%
3	36	4.44%
4	13	1.60%
5	2	0.25%
Grand Total	811	100.00%

ODOT Location	Crashes	%
Not An Intersection	322	39.70%
Four-Way Intersection	313	38.59%
T-Intersection	161	19.85%
Driveway/Alley Access	12	1.48%
Unknown	1	0.12%
Y-Intersection	1	0.12%
Shared-Use Paths Or Trails	1	0.12%
Grand Total	811	100.00%

Work Zone Related	Crashes	%
No	809	99.75%
Yes	2	0.25%
Grand Total	811	100.00%

Alcohol Related	Crashes	%
No	780	96.18%
Yes	31	3.82%
Grand Total	811	100.00%

Drug Related (Inc. Marijuana)	Crashes	%
No	807	99.51%
Yes	4	0.49%
Grand Total	811	100.00%

Contour	Crashes	%
Curve Grade	1	0.12%
Curve Level	9	1.11%
Straight Grade	6	0.74%
Straight Level	795	98.03%
Grand Total	811	100.00%

Marijuana Related	Crashes	%
No	811	100.00%
Grand Total	811	100.00%

Roadway Departure	Crashes	%
No	703	86.68%
Yes	108	13.32%
Grand Total	811	100.00%

Older Driver (65+)	Crashes	%
No	727	89.64%
Yes	84	10.36%
Grand Total	811	100.00%

Intersection Related	Crashes	%
Yes	532	65.60%
No	279	34.40%
Grand Total	811	100.00%

Young Driver (15-25)	Crashes	%
No	555	68.43%
Yes	256	31.57%
Grand Total	811	100.00%

Speed Related	Crashes	%
No	742	91.49%
Yes	69	8.51%
Grand Total	811	100.00%

Motorcycle Involved	Crashes	%
No	802	98.89%
Yes	9	1.11%
Grand Total	811	100.00%

Livingston Avenue, 18th Street to Nelson Road

Crash Summary Sheet

Unit 1 Summary

Unit 1 Pre-Crash Action	Crashes	%
Straight Ahead	401	49.45%
Making Left Turn	148	18.25%
Changing Lanes	72	8.88%
Data Not Valid or Not Provided	42	5.18%
Making Right Turn	40	4.93%
Backing	21	2.59%
Slowing or Stopped In Traffic	19	2.34%
Other / Unknown	15	1.85%
Entering Traffic Lane	14	1.73%
Walking, Running, Jogging, Playing	12	1.48%
Leaving Traffic Lane	9	1.11%
Overtaking/Passing	6	0.74%
Entering or Crossing Specified Location	4	0.49%
Parked	3	0.37%
Standing	2	0.25%
Negotiating a Curve	2	0.25%
Making U-Turn	1	0.12%
Grand Total	811	100.00%

Unit 1 Contributing Factor	Crashes	%
Other Improper Action	224	27.62%
Failure to Yield	168	20.72%
Following Too Closely/ACDA	152	18.74%
Improper Lane Change	75	9.25%
Ran Red Light	65	8.01%
None	44	5.43%
Improper Turn	18	2.22%
Ran Stop Sign	17	2.10%
Improper Backing	15	1.85%
Improper Crossing	12	1.48%
Left of Center	8	0.99%
Wrong Way	4	0.49%
Swerving to Avoid	3	0.37%
Lying in Roadway	3	0.37%
Stopped or Parked Illegally	1	0.12%
Operating Defective Equipment	1	0.12%
Improper Start From a Parked Position	1	0.12%
Grand Total	811	100.00%

Unit 1 Object Struck	Crashes	%
Nothing Struck	742	91.49%
Utility Pole	26	3.21%
Curb	8	0.99%
Wall	7	0.86%
Other Fixed Object	7	0.86%
Other Post, Pole Or Support	5	0.62%
Traffic Sign Post	4	0.49%
Tree	4	0.49%
Other / Unknown	3	0.37%
Embankment	2	0.25%
Fire Hydrant	1	0.12%
Light/Luminaries Support	1	0.12%
Fence	1	0.12%
Grand Total	811	100.00%

Unit 1 Traffic Control	Crashes	%
No Control	474	58.45%
Signal	260	32.06%
Stop Sign	77	9.49%
Grand Total	811	100.00%

Unit 1 Posted Speed	Crashes	%
0	119	14.67%
5	3	0.37%
10	2	0.25%
15	9	1.11%
20	2	0.25%
25	117	14.43%
30	5	0.62%
35	546	67.32%
40	2	0.25%
45	4	0.49%
50	1	0.12%
65	1	0.12%
Grand Total	811	100.00%

Unit 1 Direction From	Crashes	%
West	302	37.24%
East	253	31.20%
South	125	15.41%
North	120	14.80%
Unknown	9	1.11%
Northeast	1	0.12%
Southeast	1	0.12%
Grand Total	811	100.00%

Unit 1 Direction To	Crashes	%
East	269	33.17%
West	211	26.02%
South	158	19.48%
North	144	17.76%
Northwest	9	1.11%
Unknown	9	1.11%
Southeast	5	0.62%
Southwest	4	0.49%
Northeast	2	0.25%
Grand Total	811	100.00%

Livingston Avenue, 18th Street to Nelson Road

Crash Summary Sheet

Unit 1 Summary

Unit 1 Type	Crashes	%
Passenger Car	436	53.76%
Sport Utility Vehicle	163	20.10%
Pick up	58	7.15%
Unknown or Hit/Skip	42	5.18%
Passenger Van (minivan)	33	4.07%
Pedestrian/Skater	20	2.47%
Cargo Van	18	2.22%
Bus (16+ Passengers)	13	1.60%
Heavy Equipment	7	0.86%
Single Unit Truck	7	0.86%
Bicycle	5	0.62%
Semi-Tractor	4	0.49%
Other Vehicle	2	0.25%
Motorcycle 2 Wheeled	2	0.25%
Van (9-15 Seats)	1	0.12%
Grand Total	811	100.00%

Unit 1 Special Function	Crashes	%
None	776	95.68%
Police	9	1.11%
School Transport	6	0.74%
Taxi	5	0.62%
Bus – Transit/Commuter	5	0.62%
Fire	4	0.49%
Public Utility	2	0.25%
Other / Unknown	2	0.25%
Bus – Other	1	0.12%
Ambulance	1	0.12%
Grand Total	811	100.00%

Livingston Avenue, 18th Street to Nelson Road
Crash Summary Sheet

Unit 2 Summary

Unit 2 Pre-Crash Action	Crashes	%
Straight Ahead	428	52.77%
Slowing or Stopped In Traffic	165	20.35%
Parked	73	9.00%
	59	7.27%
Making Left Turn	39	4.81%
Walking, Running, Jogging, Playing	10	1.23%
Making Right Turn	10	1.23%
Changing Lanes	7	0.86%
Other / Unknown	7	0.86%
Backing	4	0.49%
Overtaking/Passing	3	0.37%
Entering or Crossing Specified Location	3	0.37%
Entering Traffic Lane	2	0.25%
Negotiating a Curve	1	0.12%
Grand Total	811	100.00%

Unit 2 Contributing Factor	Crashes	%
None	695	85.70%
	57	7.03%
Other Improper Action	40	4.93%
Failure to Yield	5	0.62%
Following Too Closely/ACDA	5	0.62%
Ran Red Light	3	0.37%
Improper Crossing	2	0.25%
Vision Obstruction	1	0.12%
Ran Stop Sign	1	0.12%
Improper Start From a Parked Position	1	0.12%
Lying in Roadway	1	0.12%
Grand Total	811	100.00%

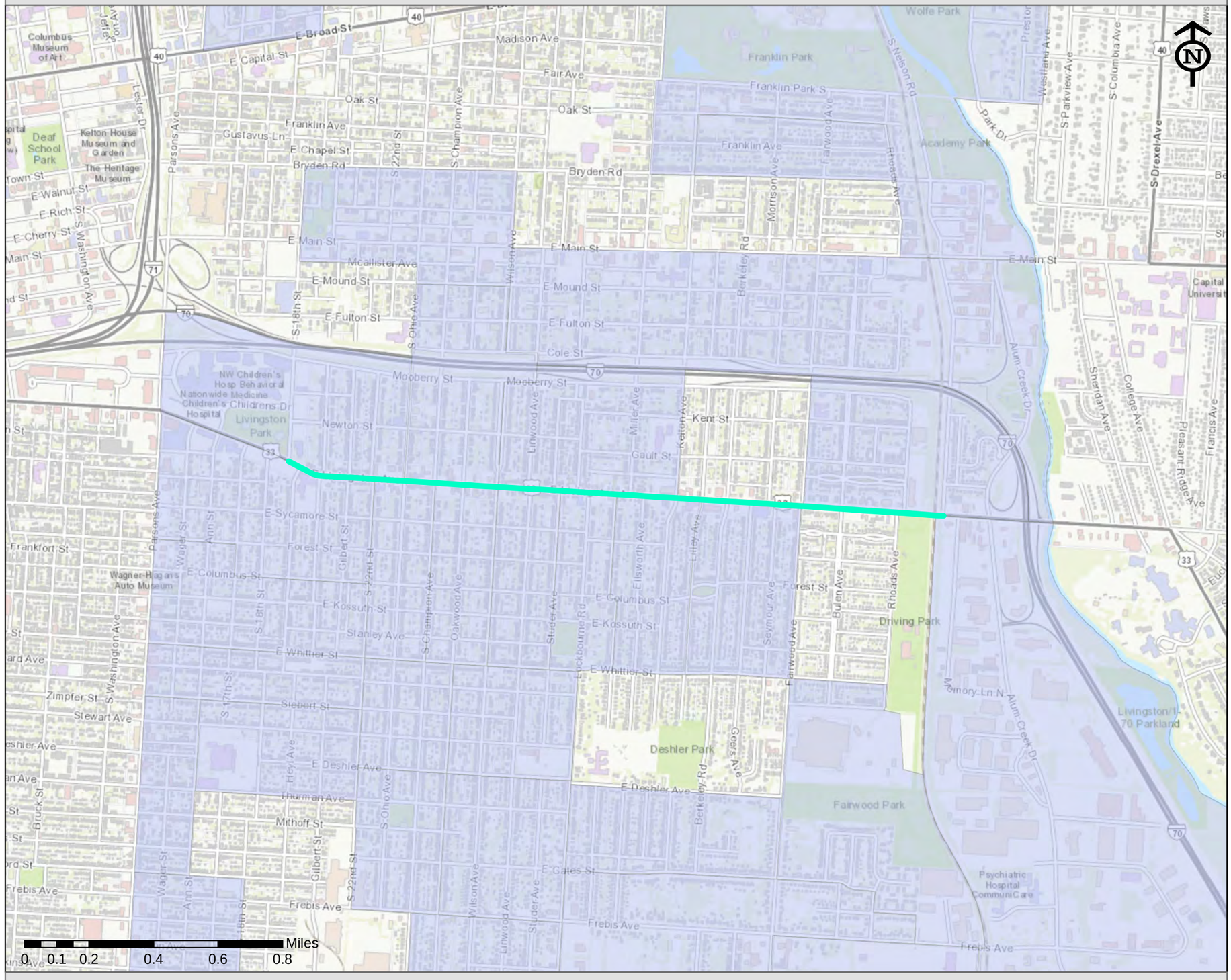
Unit 2 Direction From	Crashes	%
	57	7.03%
East	252	31.07%
North	91	11.22%
South	83	10.23%
Southwest	1	0.12%
Unknown	5	0.62%
West	322	39.70%
Grand Total	811	100.00%

Unit 2 Direction To	Crashes	%
	57	7.03%
East	320	39.46%
North	98	12.08%
South	83	10.23%
Southeast	1	0.12%
Unknown	4	0.49%
West	248	30.58%
Grand Total	811	100.00%

Unit 2 Type	Crashes	%
Passenger Car	441	54.38%
Sport Utility Vehicle	162	19.98%
	57	7.03%
Pick up	39	4.81%
Passenger Van (minivan)	24	2.96%
Bus (16+ Passengers)	21	2.59%
Cargo Van	17	2.10%
Pedestrian/Skater	15	1.85%
Single Unit Truck	8	0.99%
Heavy Equipment	7	0.86%
Motorcycle 2 Wheeled	6	0.74%
Bicycle	4	0.49%
Other Vehicle	3	0.37%
Van (9-15 Seats)	3	0.37%
Unknown or Hit/Skip	2	0.25%
Semi-Tractor	2	0.25%
Grand Total	811	100.00%

Unit 2 Special Function	Crashes	%
None	703	86.68%
	57	7.03%
Bus – Transit/Commuter	14	1.73%
Police	6	0.74%
Ambulance	6	0.74%
School Transport	6	0.74%
Public Utility	5	0.62%
Other / Unknown	5	0.62%
Taxi	4	0.49%
Fire	3	0.37%
Construction Equipment	2	0.25%
Grand Total	811	100.00%

Livingston Avenue West: Communities of Interest



Disclaimer: Distances are approximate. This map has been provided as reference material and does not constitute a legally binding document. Use at your own discretion.

Legend

Livingston Avenue West

Livingston Avenue, from 18th ST to Nelson RD

Vision Zero Communities of Interest

COI block groups

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR

DEPARTMENT OF PUBLIC SERVICE

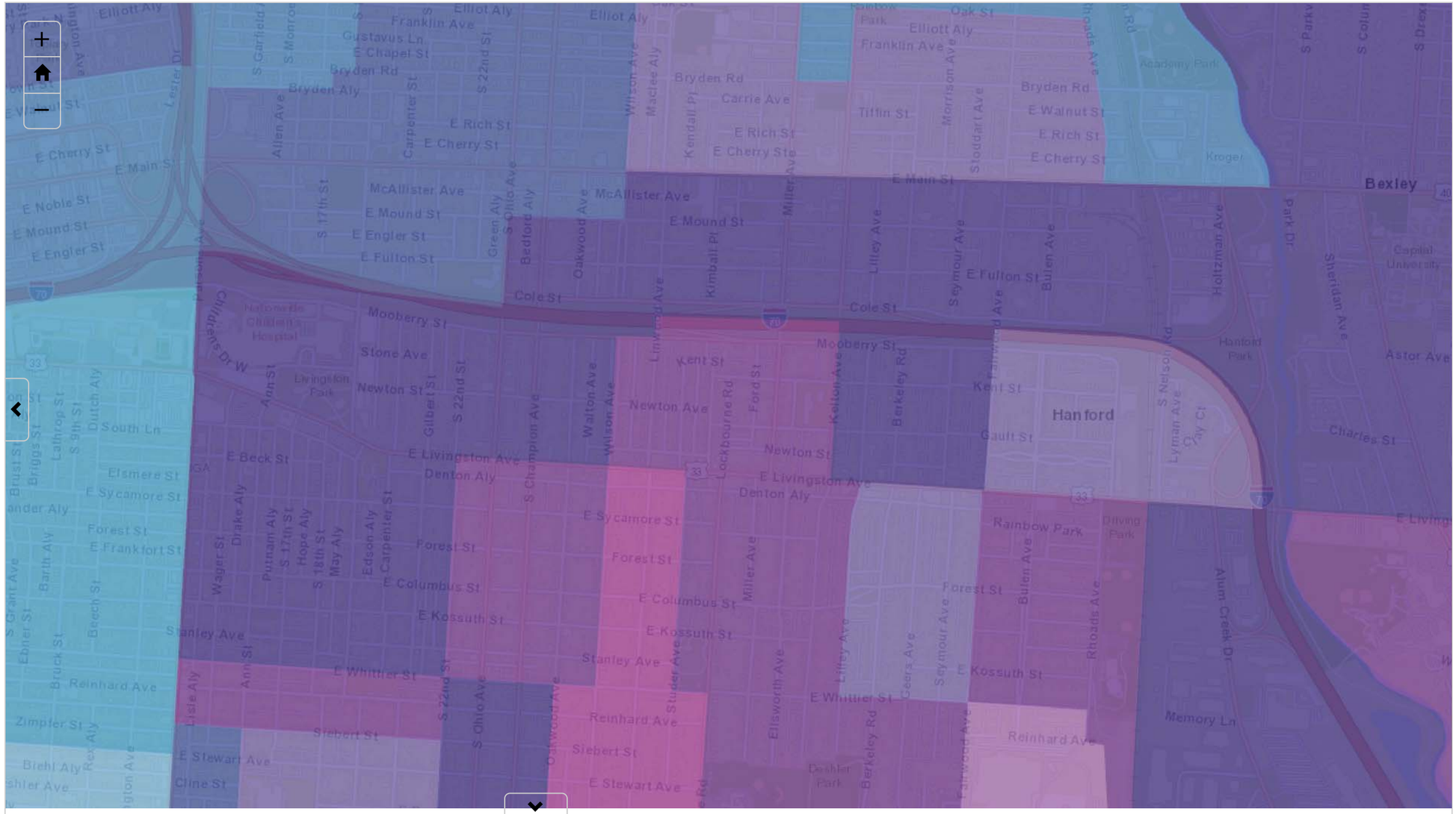
Composite AT Demand & Need - https://gis.dot.state.oh.us/tims/Map/ActiveTransportation

Legend

AT Demand and Need Analysis

AT Composite Analysis

- *D1 N1*
- *D1 N2*
- *D1 N3*
- *D1 N4*
- *D2 N1*
- *D2 N2*
- *D2 N3*
- *D2 N4*
- *D3 N1*
- *D3 N2*
- *D3 N3*
- *D3 N4*
- *D4 N1*
- *D4 N2*
- *D4 N3*
- *D4 N4*



Results

10 records per page

Search:

Show / Hide columns | Zoom to results | Export data

No data available in table

Showing 0 to 0 of 0 entries

First | Previous | Next | Last

AT Need - https://gis.dot.state.oh.us/tims/Map/ActiveTransportation

Layers

Layers | Legend

Legend

AT Demand and Need Analysis

AT Need

- *1 - Low*
- *2 - Moderate*
- *3 - High*
- *4 - Very High*

Results

10 records per page

Search:

Show / Hide columns | Zoom to results | Export data

No data available in table

Showing 0 to 0 of 0 entries

First | Previous | Next | Last

AT Demand - https://gis.dot.state.oh.us/tims/Map/ActiveTransportation

Layers

Layers | Legend

Legend

AT Demand and Need Analysis

AT Demand

- *1 - Low*
- *2 - Moderate*
- *3 - High*
- *4 - Very High*

Results

10 records per page

Search:

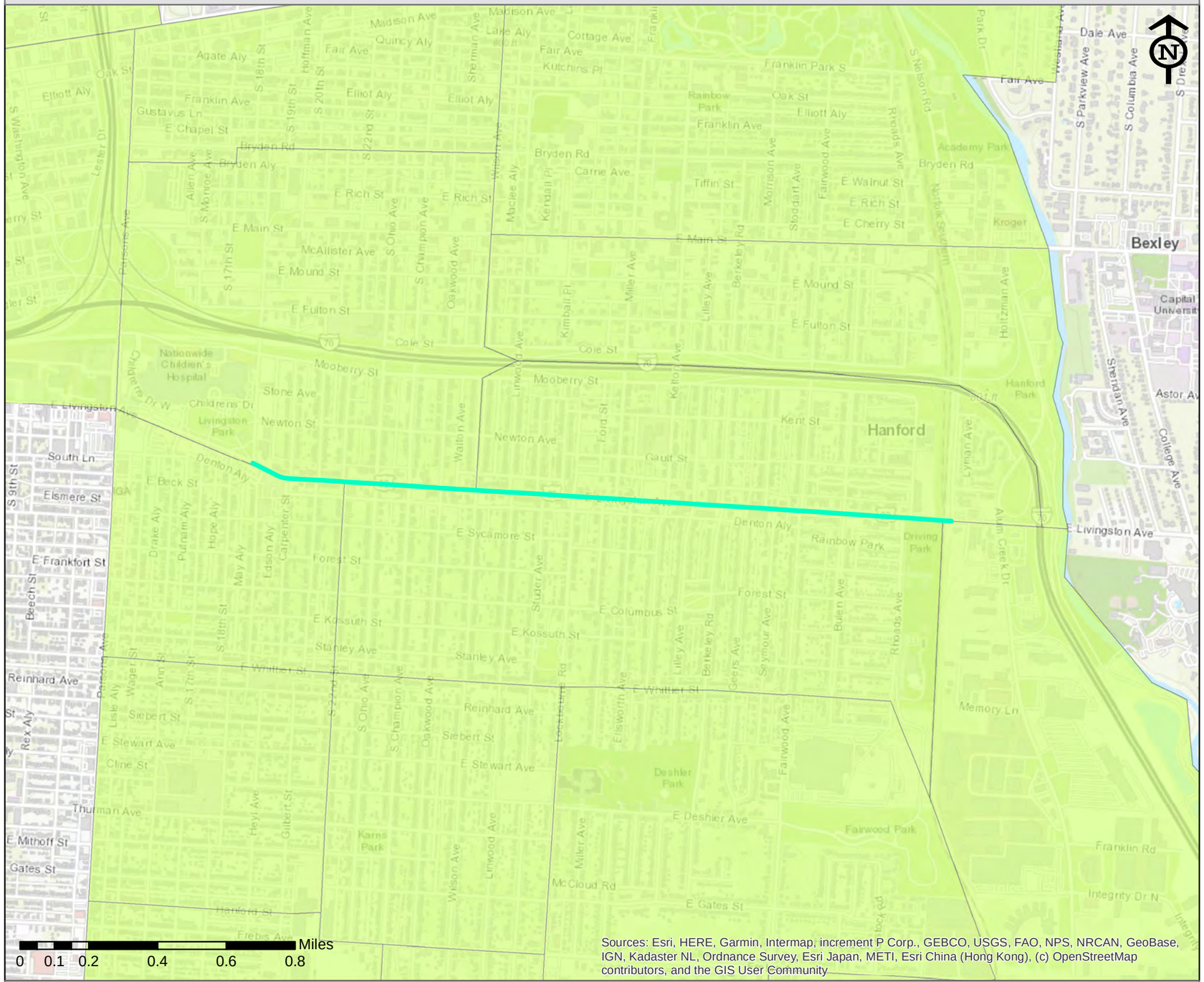
Show / Hide columns | Zoom to results | Export data

No data available in table

Showing 0 to 0 of 0 entries

First | Previous | Next | Last

Livingston Avenue West: Areas of Persistent Poverty



Disclaimer: Distances are approximate. This map has been provided as reference material and does not constitute a legally binding document. Use at your own discretion.

Legend

Livingston Avenue West

Livingston Avenue West

Areas of Persistent Poverty

Census Tracts identified as Areas of Persistent Poverty

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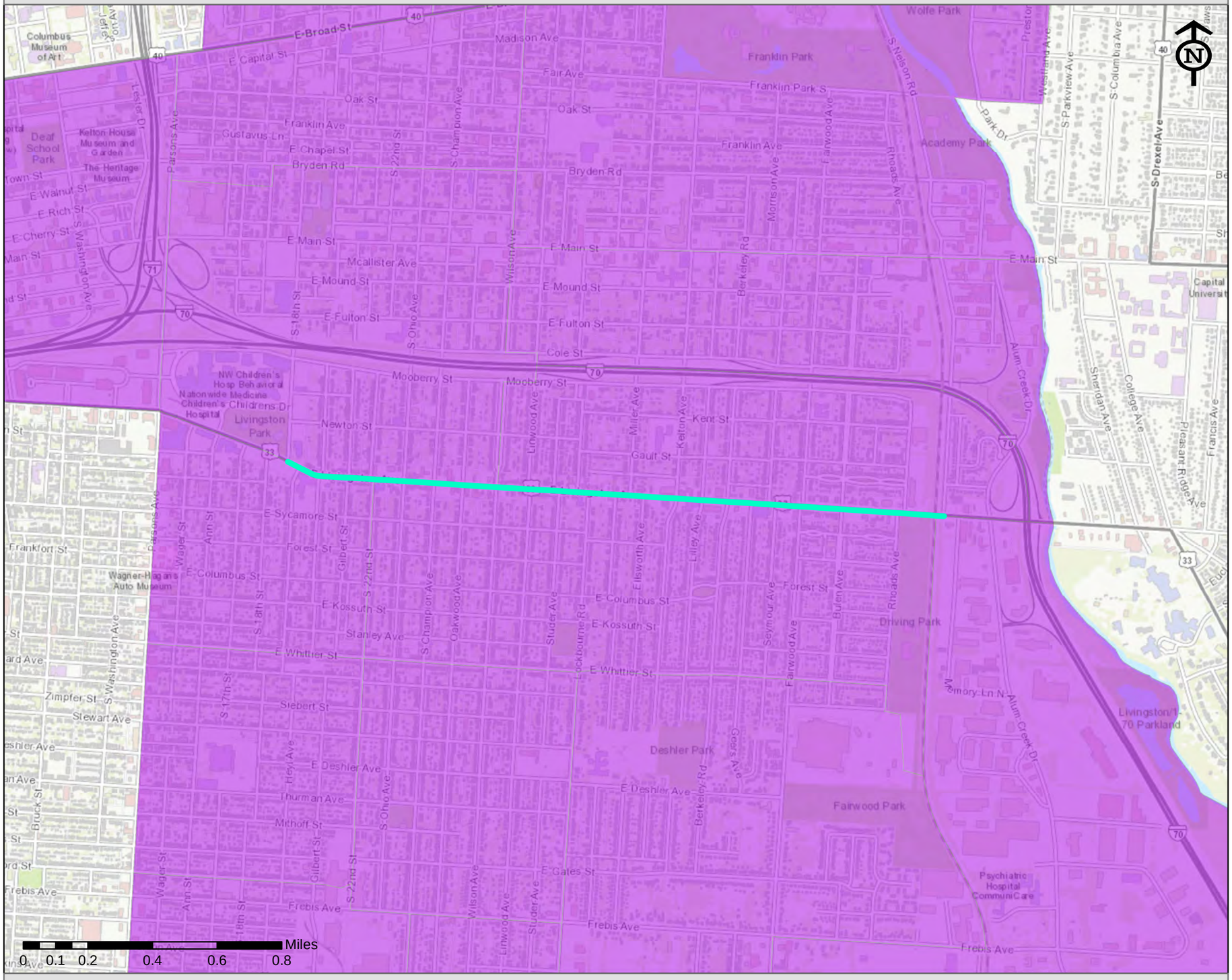
ANDREW J. GINTHER, MAYOR

DEPARTMENT OF PUBLIC SERVICE

Livingston Avenue West: Climate and Economic Justice Screening Tool



Disclaimer: Distances are approximate. This map has been provided as reference material and does not constitute a legally binding document. Use at your own discretion.

Legend

Livingston Avenue West

Livingston Avenue, from 18th ST to Nelson RD

Climate and Economic Justice Screening Tool

Disadvantaged Census Tracts

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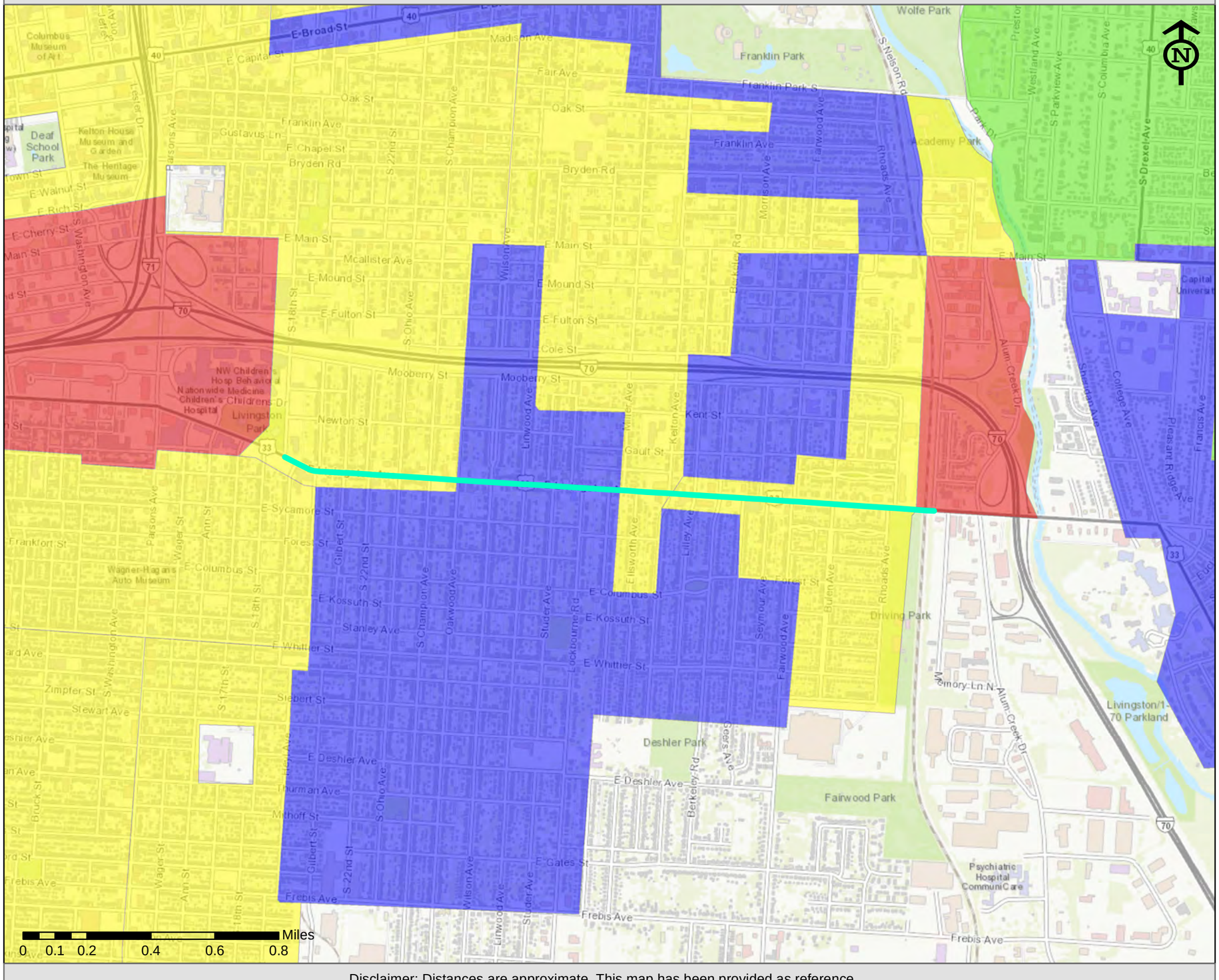
Livingston Avenue West: 1930's Home Owners' Loan Corporation Map



Disclaimer: Distances are approximate. This map has been provided as reference material and does not constitute a legally binding document. Use at your own discretion.

Legend

Livingston Avenue West

Livingston Avenue, from 18th ST to Nelson RD

Residential Security Map

- A - First Grade
- B - Second Grade
- C - Third Grade
- D - Fourth Grade

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I. Stakeholder Involvement List

- Africentric Personal Development Shop (APDS)
- Bethany Baptist Church
- Central Ohio Transit Authority (COTA)
- Columbus City Schools
- Columbus Metropolitan Library
- Columbus South Side Area Commission
- Driving Park Civic Association
- Gertrude Wood Community Foundation
- Healthy Neighborhoods, Healthy Families
- Livingston Avenue Area Commission
- Livingston Avenue Columbus Ohio Safety Group
- Nationwide Children's Hospital
- Ohio Department of Transportation (ODOT)
- Old Oaks Civic Association
- Rickenbacker Woods Community Foundation
- South Side Thrive Collaborative
- Southern Orchards Civic Association
- City of Columbus, Department of Development
- City of Columbus, Department of Neighborhoods
- City of Columbus, Department of Public Safety, Division of Fire
- City of Columbus, Department of Public Safety, Division of Police
- City of Columbus, Department of Public Service
- City of Columbus, Department of Recreation and Parks
- City of Columbus, Mayor's Office
- Columbus City Council

Community comments from some of the 30 letters of support received from residents:

"As a homeowner who has lived on Livingston Avenue for 6 years, the lack of safety on this street is horrible. I've witnessed an unbearable amount of car accidents on this street, car accidents right outside of my home, car crashes that have jumped the curb and damaged the stone retaining wall on my property, children almost getting hit by cars, adults almost getting hit by cars, and the list goes on. For anyone who has spent time on Livingston Avenue, it's clear that this corridor needs attention and change."

~ P.W.

"I have become all too familiar with the dangers of this neglected part of the city. My friends and neighbors have had multiple cars totalled while being parked on a residential street at the corner of Livingston. As this neighborhood continues to grow I see families moving in, with children playing on sidewalks which should be safe, but instead have many signs of damage where accidents have resulted in vehicles forced off the street. I know progress can be made. I've seen examples of dangerous streets made safe and feel Livingston is worthy of the same care and attention."

~ R.R.

"As a three-year homeowner in Old Oaks, this would greatly improve our neighborhood by making it feel safer. We previously lived in German Village and would eventually like to feel the same safety walking around and exploring. Hoping that this paves the way for more businesses to also move into the area."

~ L.P.

"Our neighborhood has been ignored long enough on any improvements to help better the peoples lives along Livingston Ave. It is a very busy corridor that deserves the financial support to better the area and hopefully promote new businesses to join the community."

~ K.M.

"This money will undoubtably help my community and improve transportation. It is an up-and-coming area with such a vibrant and diverse population. I want to continue to see The Livingston Avenue Area grow and prosper. We have made great progress on our own the past 10 years, but we need outside help to continue this momentum."

~ E.O.

"The Livingston Avenue project would greatly increase the overall sense of community, where there is currently none. In Historic Old Oaks, where I live, (adjacent to Livingston Ave) we have no easy access to supermarkets (or even mini-markets) and our residents have only two options: drive miles to a supermarket, or eat unhealthy, quick snacks like chips and ramen noodles, from the oh-so-underwhelming and crime-ridden corner stores nearby."

~ C.G.

"As a demonstration of my commitment to the area, I currently serve on the Livingston Avenue Area Commission as one of nine commissioners (although I speak only for myself in this letter)."

~ A.V.

"As a neighborhood that is directly impacted by everything that happens on Livingston Avenue, as Livingston has declined, so has Old Oaks. Conversely, with active participation in community efforts and as Livingston improves, so does the Old Oaks neighborhood. We moved to the near-east side because of our passion for historic preservation and a desire to enjoy walkability and greenspace near

the urban center of Columbus. However, we now find ourselves avoiding Livingston due to the pedestrian fatalities, reckless driving, abundance of trash and litter, and general lack of upkeep. We understand the city is working to rectify many of these issues but funding is of course always limited."
~ K.J.S.

High Recycled Content Asphalt Pavement

THE CITY OF
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ANDREW J. GINTHER, MAYOR

DEPARTMENT OF
PUBLIC SERVICE

City of Columbus Supplemental Specification 1505
High Recycled Asphalt Pavement Content

Supplemental Specification 1505 appends the following sections of the City of Columbus, Construction and Material Specifications to provide for the incorporation of Recycled Asphalt Pavement materials exceeding twenty-five percent (25%) in Type I Surface, forty percent (40%) in Type II Intermediate and fifty-five percent (55%) in 301 Base in the job mix formulas for City of Columbus projects where this Supplemental Specification is provided.

Revised RAP by Dry Weight of Mix, (Max) = 60%

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ROAD
WORK
AHEAD

Standard Paving Year- RAP Usage

It's a little less tonnage than previous years since 18-2/18-3 did not get all the paving completed.

Type	Tons	% RAP	RAP Tons
301 Base	18415.58	50.00%	9207.79
64-22 (Medium)	25210.02	20.00%	5042.004
70-22M (Medium)	19703.65	20.00%	3940.73
70-22M (Heavy)	4723.80	10.00%	472.38
	68053.05		18662.904

It comes out to about 27% RAP average for the entire year's asphalt on 2018 Resurfacing Projects.

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Extended RAP Timeline

- April 2016 Received Proposals via ORIL for "*Optimizing the Effective Use of RAP in Local Roadways*"
- September 2018 Placed extended RAP test sections on Hall Road 2018-P3
- October 2018 Presented ORIL extended RAP to OTEC
- November 2018 Contacted by RAP Management and provided tour of new asphalt plant on Fifth Avenue
- December 2018 Presentation to Public Service Management
- May 2019 ORIL Report Issued "*Optimizing the Effective Use of RAP in Local Roadways*"
- June 2020 Received and approved first High RAP asphalt mix design from RAP Management
- July 2020 High RAP asphalt placed on Wright Road
- February 2021 RAP Management Presentation to City NPPC

ORIL Summary

Optimizing the Effective Use of RAP in Local Roadways

This presentation will provide an update on an Ohio's Research Initiative for Locals (ORIL) research study aimed at assessing the feasibility of using higher percentage of reclaimed asphalt pavement (RAP) in surface course mixtures of local roadways. Phase 1 of this study included conducting a comprehensive laboratory testing program to identify the factors that affect the performance asphalt mixtures with RAP. To this end, several mixtures were designed with different RAP contents: 0%, 20%, 30%, 40, and 50% RAP. Two RAP materials that have binders with different rheological properties were selected. The laboratory testing program also evaluated the effect of using recycling agents on the performance of asphalt mixtures with high RAP content. Three different types of recycling agents (rejuvenators) were used, namely, Hyrolene, Sylvaroad, and soybean. Laboratory tests were conducted to evaluate the propensity of the designed asphalt mixtures to fatigue cracking, low-temperature cracking, moisture-induced damage, and rutting. This presentation will discuss the results of the comprehensive testing program conducted in Phase 1 of this study. In addition, the presentation will highlight the method that was developed to design and construct cost-effective, well-performing, and durable asphalt mixtures with higher RAP contents to be used in the surface course of local roadways in Ohio.

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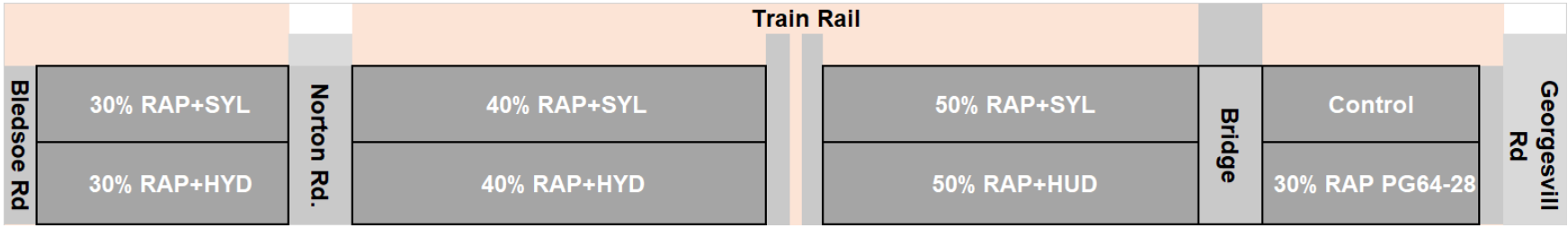
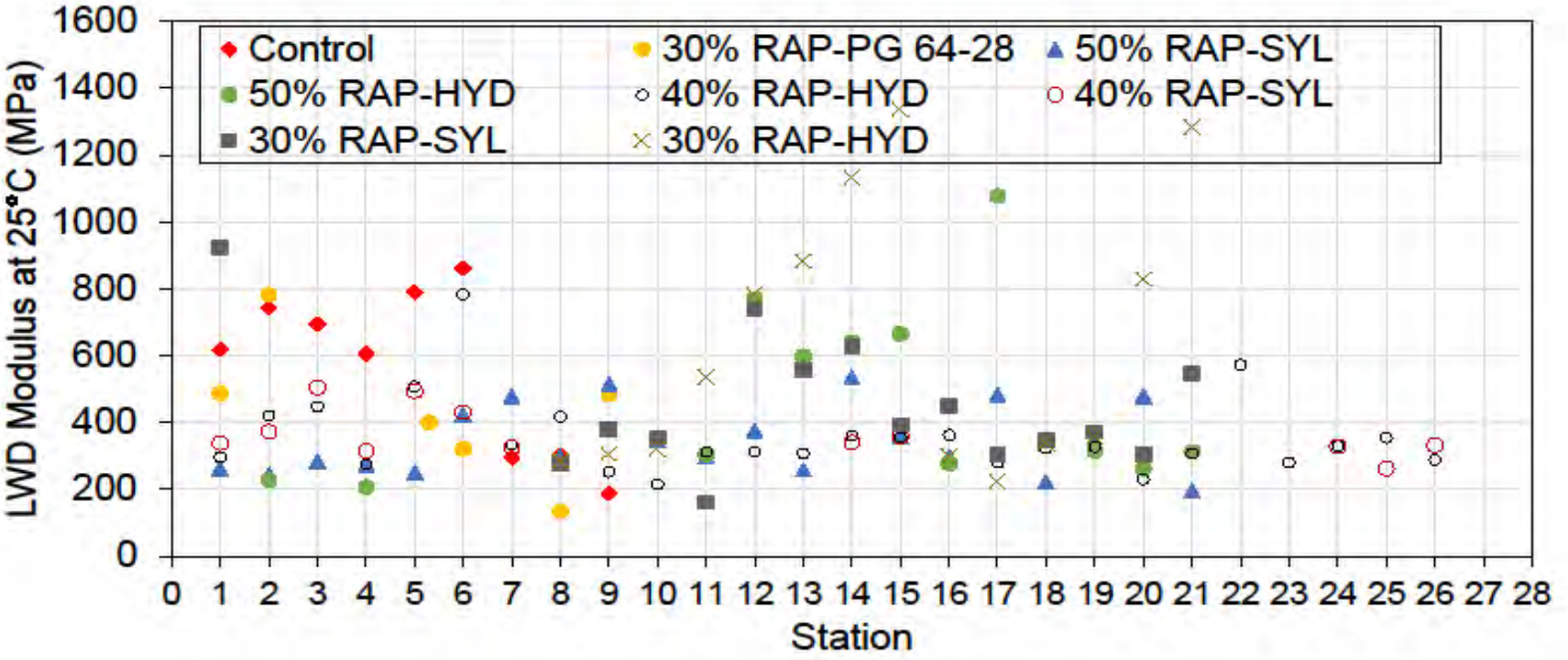
Hall Road Test Sections via ORIL



Hall Road Test Sections via ORIL

Sections Pre-Construction Evaluation



OHIO UNIVERSITY

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DEPARTMENT OF PUBLIC SERVICE

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PUBLIC SERVICE

2018 Resurfacing Project 3

				KOKOSING		ENG EST
Item #	Desctription	Quantity	Unit	2018 Price	2018 Extended	
46	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, (1.5")	95.00	CY	$ 310.00	$ 29,450.00	$ 128.00	$ 12,160.00
47	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 30% RAP w/Rejuvenator Type A (1.5"), APP	181.00	CY	$ 255.00	$ 46,155.00	$ 136.00	$ 24,616.00
48	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 30% RAP w/Rejuvenator Type B (1.5"), APP	158.00	CY	$ 255.00	$ 40,290.00	$ 136.00	$ 21,488.00
49	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 40% RAP w/Rejuvenator Type A (1.5"), APP	174.00	CY	$ 227.00	$ 39,498.00	$ 136.00	$ 23,664.00
50	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 40% RAP w/Rejuvenator Type B (1.5"), APP	235.00	CY	$ 227.00	$ 53,345.00	$ 136.00	$ 31,960.00
51	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 50% RAP w/Rejuvenator Type A (1.5"), APP	162.00	CY	$ 223.00	$ 36,126.00	$ 136.00	$ 22,032.00
52	Asphalt Concrete Surface Course, Type 1, (448), PG64-22, 50% RAP w/Rejuvenator Type B (1.5"), APP	211.00	CY	$ 223.00	$ 47,053.00	$ 136.00	$ 28,696.00
53	Asphalt Concrete Surface Course, Type 1, (448), PG64-28, 30% RAP (1.5")	112.00	CY	$ 308.00	$ 34,496.00	$ 136.00	$ 15,232.00
54	Contractor Mix Design, Recycled Asphalt Pavement, APP	1.00	LS	$ 50,000.00	$ 50,000.00	$ 8,500.00	$ 8,500.00
			TOTAL		$ 376,413.00		$ 188,348.00
						DIFFERENCE	$ (188,065.00)

**This price inlcudes design & placing surface course on Hall Rd
-Note that the rejuvenators were donated to KMI for this research project

2020 Resurfacing Project 1

- SPECIAL ASPHALT CONCRETE SURFACE COURSE, TYPE 1, (448), 60% RAP w/ REJUVENATOR, (1.5"), AS PER PLAN CU YD 1,792.00

- Performed on six streets:
  - HAZELMERE DR
  - CROSSBROOK BLVD
  - GLENWILLOW BLVD
  - JOHNSON RD
  - WRIGHT RD
  - BIG RUN SOUTH RD

RAP MANAGEMENT

SUSTAINABLE ASPHALT MATERIALS

Paving Ohio's future.

4647 E 5th Ave
Columbus, OH 43219

ABOUT US

RAP Management is a Columbus, OH paving materials plant producing durable, precisely manufactured asphalt products made from Recycled Asphalt Product. We lower the environmental footprint of infrastructure, at a cost savings to the end user.

WHY CHOOSE US ??

- **High quality.** Recycling means precision manufacturing and the highest quality pavement materials.
- **Save money.** We can recycle and lower our cost to manufacture while still providing industry leading pavement materials.
- **Convenience.** The first asphalt plant of its kind in North America located *right down the road.*

OUR PRODUCTS

No job is too big or small. Whether you are patching a parking lot or paving an interstate, we have the best materials & mix designs ...

HMA - HOT MIX ASPHALT

- 448 Type 1 Asphalt Concrete
- Commercial Surface Asphalt Concrete
- 448 Type 2 Asphalt Concrete
- 402 Surface Mix Asphalt Concrete
- 302 Bituminous Aggregate Base
- 301 Bituminous Aggregate Base

FSB - FOAM STABLIZED BASE

Heavy duty pavement base material or construction working surface.

CMA - COLD MIX ASPHALT

Temporary asphalt patching material. An asphalt repair product used for patching of potholes, cracks and other defects in asphalt and concrete.

1-614-484-7120 info@RAPmanagement.com RAPmanagement.com

RAP MANAGEMENT

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CALL US TODAY
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HMA
HOT MIX ASPHALT

Highest quality pavement materials, for roads engineered to last.

4647 E 5th Ave
Columbus, OH 43219

HMA MATERIALS AVAILABLE:

- 448 Type 1 Asphalt Concrete
- Commercial Surface Asphalt Concrete
- 448 Type 2 Asphalt Concrete
- 402 Surface Mix Asphalt Concrete
- 302 Bituminous Aggregate Base
- 301 Bituminous Aggregate Base

PROVEN PLANT TECHNOLOGY

Utilizing new technology we can lower the environmental cost while still providing industry leading pavement materials.

QUALITY IS OUR MISSION
PRICE IS YOUR VALUE

We create the most rigorously tested precision engineered asphalt on the market, using up to 70% Recycled Asphalt Product (RAP).

ASSURANCE YOU CAN TRUST

Our regular testing ensures compliance with a*ny specification.*

- *Aggregate Gradation*
- *Binder Volume*
- *Binder Performance Grade*
  - *Resistant to rutting*
  - *Resitant to cracking*
- *Workablity*

1-614-484-7120 | info@RAPmanagement.com | RAPmanagement.com

2020 Resurfacing Project 1

- Add'l Quality Control requirements in Lab and field
- Requirement of using Asphalt Concrete Rejuvenating Agent
- Method 3 shall be produced from a High Recycle Technology (HRT) plant
- HRT plant is comprised of a batch tower to heat, dry and reclassify the virgin aggregate and a gravimetrically fed continuous parallel flow dryer to heat and dry the recycling aggregate materials.
- SS 1505 will eventually transition into 441 Method 3 (High RAP);
  (Method 1 = Standard RAP and Method 2= Extended RAP)

RAP MANAGEMENT

2019 CONSTRUCTION SEASON SUSTAINABILITY REPORT

AVERAGED 56% RECYCLED CONTENT

THAT'S ALMOST 3X THE INDUSTRY AVERAGE IN THE UNITED STATES. **3X**

86,300 TONS
OF *RAP DISPLACED FROM LANDFILLS
*Recycled Asphalt Product

Equal To
9 LANE MILES OF ROAD
15' road 1.5" deep

Or
4,795 DUMP TRUCK LOADS
The average dump truck holds up to 18 tons!

All statistics listed are volume calculations

Additional Sustainability Items

- 2015 Resurfacing Project 1-Reclaimed Shingle Asphalt (RAS)

Additional Sustainability Items

- 2017 ORIL study Analysis of Ground Tire Rubber in Mix Design on Local Roadways Ground Tire Rubber Asphalt (GTR)

PROJECT SUMMARY

GTR is a recycled product produced from old vehicle tires. It can be used as an additive to asphalt mixtures, in place of polymers, to improve the durability, longevity and performance of pavements. While GTR has the potential for positive environmental impacts, historically the initial cost of using GTR in asphalt mixes can be so high that many city, townships and counties simply cannot afford to use it. However, over time, advances in technology have increased the options available in regards to products and application methods. This research was initiated to assess the true life-cycle cost of GTR mixes and identify opportunities for GTR to be more affordable and cost-competitive with traditional polymer modified mixes without compromising performance.

Researchers identified three GTR modified binders that, based on lab tests, can be used to promote performance equal to or better than that of traditional polymer modified asphalt mixes at a comparable cost. Each of the binders tested were compared to a PG 70-22 polymer modified binder. A draft specification, designed specifically for use on local roads, was developed along with supplemental QC/QA testing and acceptance criteria. Test sections were constructed in Columbus, OH and Akron, OH for long-term evaluation of their performance.

Additional Sustainability Items

- 2018 Recycled Glass Aggregate worked with Tom Bolon of Novotec

Additional Sustainability Items

- 2020 Resurfacing Project 1- Cold in Place Recycling (CIR) PARTIAL DEPTH ASPHALT PAVEMENT COLD IN PLACE RECYCLING (CIR) SQ YD 52,570.00

Questions?

CLEVELAND, OH – 12/22/2020 – FOR IMMEDIATE RELEASE

Pavement Technology, Inc. Becomes Sustaining Partner in GCCA's Newly Launched "Cool Roadways Partnership"

Westlake Ohio-based Pavement Technology, Inc. (PTI) is proud to be a sustaining partner of the newly launched "Cool Roadways Partnership," which includes major municipalities in AZ, CA, KY, MO, MS, NC, NM, PA, and TX. This initiative, launched on December 8, 2020, is an offshoot of the Global Cool Cities Alliance (GCCA), which is a consortium of foundations and corporations committed to accelerating a world-wide transition to cooler, healthier cities. The "Cool Roadways Partnership" consists of 20 jurisdictions, non-profits and industry representatives actively engaged in accelerating the development and scaled deployment of pavement-related materials that reduce surface and air temperatures and build resilience to rising heat.

For nearly have a century, PTI executives have been deeply engaged with environmentally responsible pavement preservation solutions, sitting on the board of The National Center for Pavement Preservation (NCPP) at Michigan State University, and holding memberships in U.S. Green Building Council (USGBC) and the Institute for Sustainable Infrastructure (ISI). Colin Durante, PTI founder and president reports, "We saw the need nearly half a century ago for public agencies and the pavement industry to come together to promote best practices in order to ensure superior roadway maintenance and long-term sustainability while extending scarce municipal and county capital resources and reducing society's carbon footprint. This newest initiative is consistent with our long-term commitment to improving the quality of life of the communities we serve."

Although pavements make-up nearly one-third of urban land surfaces, society has historically lacked a vehicle that integrates government and industrial efforts nationwide in an effort to combat rising urban temperatures commonly referred to as the Urban Heat Island (UHI) effect. Excessive heat adversely affects the health and well-being of our communities, reduces the quality of air and water, increases dependence on the fossil fuels needed to cool our buildings, and damages pavements and related infrastructure. In addition, the health and economic burdens of excess heat are borne disproportionately by "at risk" communities, jeopardizing the equity goals of America's societal compact.

As a Silver Partner of the newly formed "Cool Roadways Partnership," PTI reports that the partnership anticipates investing $4.75 billion to add, maintain, replace or upgrade as many as 70,000 lane-miles over the next ten years to engage in this critical fight. The company's innovative **P**lus**Ti**™ family of photocatalytic pavement solutions, specifically targeted at reducing mobile-sourced pollution and mitigating UHI, is one of the many toolsets government agencies and transportation authorities will be deploying in this effort.

The newest **P**lus**Ti** product line has been successfully applied and tested in the field for more than three years now with startling results, demonstrating NOx emission reductions as high as 50 percent, and more than tripling pavement solar reflectivity, meeting USGBC, LEED and APWA/ASCE Envision standards. PTI's vice president of strategic planning, Michael Durante, concludes: "This exciting technology will enable our public agency partners to cost-effectively attack climate change one road at a time, providing a scalable and sustainable solution to improve the quality of life in our communities and the sustainability and resilience of our urban infrastructure."

For more information, visit www.smogeatingroads.com, call Michael Durante at 972-974-6037 mdurante@pavetechinc.com or visit https://globalcoolcities.org.

Pavement Technology, Inc.

24144 Detroit Rd.
Westlake, Ohio 44145
Phone: 800-333-6309

Cincinnati - TiO2-Bearing Pavement Field Results

To: **Chris M. Ertel, P.E.,**
Principal Transportation Design Engineer

Jennifer Russell, P.E., P.S., Supervising Engineer
Joe Flading, P.E., Senior Engineer

Department of Transportation and Engineering
City of Cincinnati
801 Plum Street, Suite 450
Cincinnati, Ohio 45202

Dave Helm, Technical Representative
Colin Durante, President

From: **Michael Durante, Vice President Finance & Strategic Planning**

Re: **Test Results: Photocatalytic Pavements – Pollution Remediation; Heat (Absorption) Reduction; and Hydrophilic Improvement**

Date: **30 July 2020**

Pavement Technology's (PTI) photocatalytic pavement solutions for pollution removal, pavement preservation, Heat Island (UHI) mitigation and other photo-induced properties beneficial to air quality, pavement life-cycle extension and heat sink management now are into scale piloting.

On May 11, 2020, PTI completed a pilot application of **A.R.A.-1 Ti®** TiO_2 enhanced Maltene Asphalt Rejuvenator on a newly paved section of Montgomery Road. The test section was three lanes of new

pavement approximating 62,000 sq/yds and 16,000 linear feet. The application rate was 0.05 gallons per square yard with 3.5% photocatalytic grade TiO_2 [1] by volume concentrate.

A.R.A.-1 Ti® - Trial
Montgomery Road, Cincinnati, Ohio
May 11, 2020

A.R.A.-1 Ti® is a specialized version of a **Maltene Replacement Technology (MRT)** product enhanced to impart both the **regenerative properties** of a maltene rejuvenator and the beneficial sustainability and environmental properties of imbedded photocatalytic grade **Titanium Dioxide (TiO_2)**.

As a photocatalyst material (semiconductor), TiO_2 is a multifaceted photo-responsive material [2] rapidly gaining increased scientific and commercial interest for near-roadway microenvironments as it advances a host of preservation and environmental benefits, including:

- **Depolluting** near-pavement air (or water) cleaning applications, where TiO_2 reacted surfaces are able to oxidize a variety of pollutants and contaminants such as those emitted by vehicles, especially NO_x and VOCs, and even worn tire residue (microplastic) reducing ozone pollution and mitigating acid rain formation

- **"Cool Pavement"** applications where TiO_2 treated surfaces provide a solar-reflective top boundary, which lessens pavement related radiative forcing (RF) by reducing the convective re-release or

[1] n-type semiconductor containing >99.5% TiO_2 content comprised of no less than 80% anatase crystallite by weight (plus or minus 5%) in a particle size averaging 21nm (plus or minus 5nm) with a small portion of rutile crystalline content.

[2] *Polymers, Light and the Science of TiO2*, DuPont™ Ti-Pure® Titanium Dioxide, DowDuPont, www.dow-dupont.com.

emissivity of solar radiation that leads to the undesired UHI effects and enhances the life-cycle assessment of pavements by slowing-down oxidation [3]

- **Super-Hydrophilic** surfaces, which provide a rapid **water-desorbing pavement**, which is self-cleaning to remove contaminants (e.g., mold) and staining; protects against water intrusion; and is indicated for inclement weather-related safety (rain displacing; ice inhibiting) improvements for roadways [4]

As a radiant heat mitigator, photocatalytic grade TiO_2 simultaneously absorbs solar radiation away from the pavement substrate and efficiently redirects the energy back into the atmosphere, thereby protecting the pavement from oxidative deterioration and eliminating excess pavement emissivity (especially in asphalts), creating a so-called – **"cool pavement"** which greatly slows-down oxidative damage while improving air quality.[5]

TiO_2-bearing pavements also exhibit a **Photoinduced Superhydrophilicity State** when exposed to sunlight (UV radiation), which enables water to more efficiently disperse and desorb across a TiO_2-treated surface.[6] [7] This not only protects the substrate from damaging water intrusion, it holds significant highway safety improvement implications including reduced hydroplaning, less windshield visibility impairment, and possibly ice formation mitigation. A PSH is why TiO_2 treated surfaces are mechanically "self-cleaning" and both anti-mold and antimicrobial. [8]

Cincinnati Test Results:

Core samples (2 = 1 treated and 1 untreated) from the Montgomery Road test site were sent to the Texas A&M Transportation Institute to complete laboratory testing of these field samples for photocatalytic oxidation for pollution removal (NO_x Reduction %); solar reflectance index for heat absorption or Urban Heat Island effect mitigation; water contact angle for hydrophilic analysis; and X-ray Fluorescence for TiO_2 load and dispersion efficiency under:

[3] Gopalakrishnan K, et al.

[4] Arainpour F and Farzaneh M, On Hydrophobic and Icephobic Properties of TiO2-Doped Silicon Rubber Coatings, Department of Applied Sciences, Universite du Quebec, *International Journal of Theoretical and Applied Nanotechnology*, 2012.

[5] EPA, *Reducing Urban Heat Islands: Compendium of Strategies, Urban Heat Island Basics*, www.epa.org.

[6] Mechanism of Photoinduced Superhydrophilicity on the Photocatalyst Surface, *The Journal of Physical Chemistry*, American Chemistry Society, 2005, Masato T, et al.

[7] Vassilia Z, *Hydrophilic TiO2 Surface Without Photocatalytic Activation*, Lawrence Berkeley National Laboratory, University of California at Berkeley.

[8] Kubacka A, Suarez Diez M, et al., Understanding the Antimicrobial Mechanism of TiO2- based Nanocomposite Films in a Pathogenic Bacterium, *Nature Journal,* 2014.

JIS TR Z 0018 *Photocatalytic Materials – Air Purification Test Procedure;*

ASTM E1980 - 11 *Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces;*

ASTM C1549-16 *Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer.*

ASTM D7334 - 08(2013) *Standard Practice for Surface Wettability of Coatings, Substrates and Pigments by Advancing Contact Angle Measurement*

Cincinnati Cores Results – Photocatalytic Properties

Date	Sample ID #	Treatment	NO Reduction (%)	Titanium Concentration (ppm)	SRI Values	Water Contact Angle (WCA)	Specification
6/9/20	1	A.R.A.-1Ti	30.21	3205	0.1442	56.34	6325 Montgomery Rd. (Center Lane) | South of untreated test
	2	A.R.A.-1Ti	31.55	3104	0.1345	66.17	6325 Montgomery Rd. (Center Lane) | South-west of untreated test
	Control	Untreated	9.18	-	0.0821	76.86	6325 Montgomery Rd. (Center Lane)

Source: Texas A&M Transportation Institute (TTI)

The Montgomery Road **A.R.A.-1 Ti®** trial results were successful; exceeded PTI performance specifications; and were consistent with PTI's expected results. All photocatalytic properties tested were validated. Based on the field test results, PTI recommends the City of Cincinnati expand **A.R.A.-1 Ti®** to full use.

X-ray Fluorescence (TiO_2 Delivery)

The Montgomery Road TiO_2 concentrations were observed at efficient photo-reactivity levels (e.g., >2000 parts per million and a dielectric constant reading ≥5) through wearing-course depth, producing the expected PCO activity. The Montgomery Road TiO_2 loads averaged **150% of PTI's performance specifications**, which call for:

TiO_2 Penetration Test: A non-destructive analytical procedure shall be used to determine the percent of Titanium Dioxide nanoparticles present in each two-millimeter (2mm) layer of the field core sample matrix for a total depth of six millimeters (6mm) from the top of the treated sample core. The method of measurement shall be by fluorescent X-ray emitted from the surface when excited by a principal X-ray source that is exceptional for the given element. A hand-held XRF analyzer is acceptable for this testing.

The minimum required concentration of Titanium Dioxide nanoparticles per each two-millimeter (2mm) section shall be 2000 parts per million (ppm).

Photocatalytic Oxidation (PCO) of NO_x

The PCO rate reflected the initial test protocol TiO_2 delivery and impregnation consistent with the XRF results. **NO (nitric oxide) reduction effectiveness was 30%-32%** which correlated to the photocatalyst material concentration and **A.R.A.-1 Ti®** application rate. The pollution reduction rate was **125% of PTI's performance specifications**, which call for:

NOx Reduction Effectiveness: Verification of the effectiveness of the air pollution remediation of the Titanium Dioxide nano-particle portion of the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

NOx Reduction Test: A photo reactor test chamber shall be employed that allow for the evaluation of the efficient photocatalytic reduction of introduced NO_x gas of a known and controlled concentration within the chambers volume. The chamber light source shall be a UV lamp having a wavelength of 375 nanometers. The interior chamber environment shall be at 77ºF with a constant humidity of 55% ±5%. The test total duration shall be five hours. The analysis test system shall be based on a Japanese Industrial Standard (JIS) TR Z0018 "Photocatalytic Materials-Air purification test procedure". NO removal efficiency shall be measured using a Model 42i Chemiluminescence NO-NO_2-NO_x Analyzer (Thermo Fisher Scientific Inc.).

The minimum NO reduction following the heretofore outlined test procedure evaluating field core samples shall average 25% for all cores tested.

Solar Reflectance

The SRI value also reflected the impact of the TiO_2 penetration and dispersion consistent with the XRF results. The **solar reflectance index readings were 0.13-0.14** which were a 70% improvement to the untreated test section and correlated to the photocatalyst material concentration and material application rate of 0.05 gallons per sq/yd. The Montgomery Road pilot area met the US Green Building Council (USGBC) minimum threshold of 50% x 0.29 for LEED credits as well as American Public Works Association (APWA) ISI Envision credits.

PTI's performance specifications call for:

Solar Reflectance Effectiveness: Verification of the effectiveness of the solar reflectivity the Titanium Dioxide nano-particle portion of the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

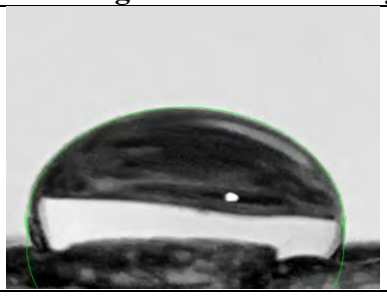
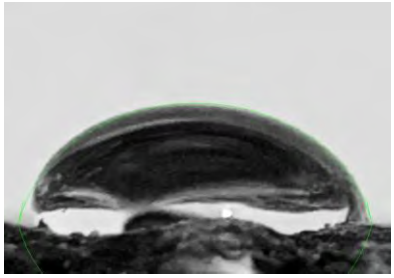
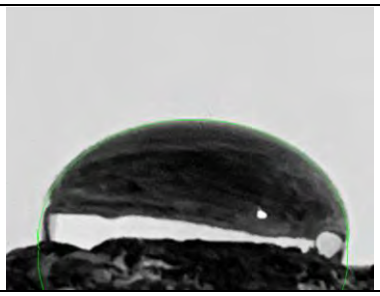
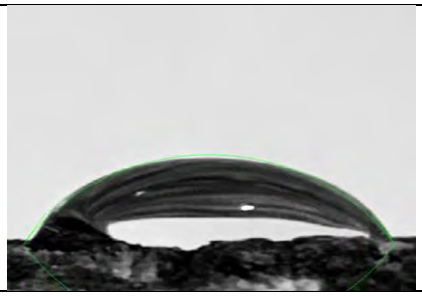
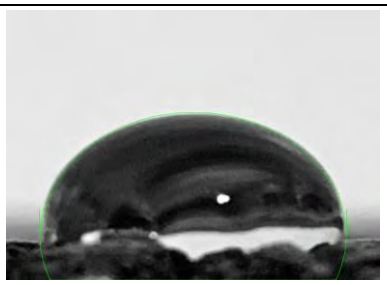
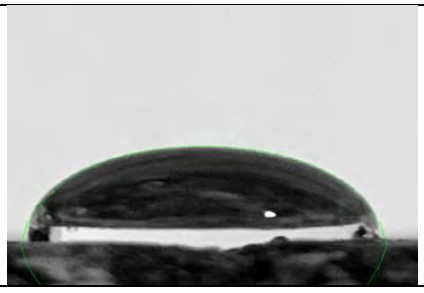
Solar Reflectance Test(s): Solar reflectivity shall be determined by measuring the treated core samples for a Solar Reflectance Index (SRI) value. SRI is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100.

The minimum SRI value following the heretofore outlined test procedure(s) evaluating field core samples shall average 0.29 for all cores tested, which meet the minimum standard (≥50% 0.29 SRI) for the U.S. Green Building Council (USGBC) hardscape threshold for Leadership in Energy and Environmental Design (LEED) credit or the minimum standard for the American Public Works Association (APWA) / Institute for Sustainable Infrastructure (ISI) Envision Superior (≥60% 0.29 SRI) level of achievement credit.

Hydrophilic Improvement

The WCA observed on the **A.R.A.-1 Ti®** pilot section cores reflected the impact of the TiO_2 penetration and dispersion consistent with the XRF results as well. The **water contact angle improved to 56 º-66º** which correlated to the photocatalyst material concentration and 0.05 gallons per sq/yd application rate. The untreated (control) section of asphalt recorded a 77º WCA or 30%-40% higher than the TiO_2 treated section. At a higher TiO_2 content of 4.0% to 4.5% by volume concentrate (at an 0.05 rate), the Montgomery Road test area would see as much as 50% or more improvement in WCA, approaching technical superhydrophilicity (≤25º).

Water Contact Angle of Core Samples

#	Contact Angle under Visible Light	Contact Angle under UV Irradiation
C		
	θ=86.65º	θ=76.86º
#1		
	θ=87.31º	θ=59.34º
#2		
	θ=89.22º	θ=66.17º

Source: Texas A&M Transportation Institute (TTI)

PTI's performance specifications call for:

Hydrophilic Improvement: Verification of the improvement in hydrophilic property of the Titanium Dioxide nano-particle portion of the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

Wettability Test: Hydrophilic improvement shall be determined by measuring the treated core samples for Water Contact Angle (WCA). WCA is a common measurement of a constructed surface's ability to improve wettability or the ability of water to develop a stronger boundary (less resistance) with the surface as shown by a decline in water contact angle. A WCA of $> 90^0$ is considered hydrophobic or high resistance while a WCA $<90^0$ is considered hydrophilic or low resistance.

The minimum WCA reduction following the heretofore outlined test procedure evaluating field core samples shall average 20% for all cores tested.

Rheological Improvement

Rheology tests on the **A.R.A.-1 Ti®** pilot section on Montgomery Road was completed by APART. Those reports are available separately **(table provided is an abstract)**.

Summary of Testing:

The top 3/8-inch of each core was removed for testing. The asphalt from each core was extracted and recovered as prescribed by California Test Method 365. Viscosities, phase angles, and moduli were determined on the recovered asphalt binder of each sample using a DSR as prescribed by AASHTO T315. Test data are as follows:

Sample	Viscosity 60°C, P	Phase Angle, °	MODULUS, 60°C, Pa		
			Complex	Elastic	Viscous
6325 Montgomery Road					
Untreated	19983	68.2	20226	7420	18555
Treated	10592	70.8	10677	4919	9651

Source: APART

A.R.A.-1 Ti® binder rejuvenation efficacy was validated. The test section showed a 47% reduction in viscosity; an improvement in phase angle; and improvement in modulus, all meeting or exceeding specification.

Conclusion and Recommendation

Based on the validation of the Montgomery Road **A.R.A.-1 Ti®** photocatalytic property field tests for the City of Cincinnati, PTI recommends the city consider **A.R.A.-1 Ti®** for scale deployment citywide for the indicated beneficial regenerative, preservation and environmental impacts of photocatalytic pavement retrofits.

Included as an addendum is the full **A.R.A.-1 Ti®** performance specification for additional reference.

Pollution-Remediating Polymerized Maltene Asphalt Rejuvenator

Description: TiO_2 Enhanced Asphalt Rejuvenating Agent

The work specified in this section shall consist of furnishing all labor, material, and equipment necessary to perform all operations for the application of a penetrating polymerized asphalt rejuvenating agent to asphaltic concrete surface courses. The asphalt binder rejuvenation shall be affected through the petroleum Maltene Replacement Technology method. In addition, and with the same penetrating carrier liquid, apply photocatalytic-grade titanium dioxide (TiO_2) to create a pollution reducing pavement microenvironment. The rejuvenation of surface courses shall be by spray application of a polymerized maltene based cationic rejuvenating agent composed of petroleum oils and resins emulsified with water and containing photocatalytic titanium dioxide in a minimum parts per million at a minimum depth as hereafter specified.

All work shall be in accordance with the specifications, the applicable drawings, and subject to the terms and conditions of this contract.

Figure 2.1 A.R.A.-1 Ti® Application

Source: Pavement Technology, Inc.; Cary, NC 2019

1 Materials and Performance: TiO_2 Enhanced Asphalt Rejuvenating Agent

The TiO_2 Enhanced Asphalt Rejuvenating Agent shall be a cationic emulsion composed of a petroleum resin oil base uniformly emulsified with water. Each bidder must submit a bid with a certified statement from the TiO_2 enhanced asphalt rejuvenating agent manufacturer showing that the asphalt rejuvenating emulsion conforms to the required physical and chemical requirements.

Table 1 Test of Emulsion and on Residue

	Test Methods		Requirements	
	ASTM	AASHTO	Min	Max
Tests on Emulsion				
Viscosity @ 25°C, SFS	D-244	T-59	15	40
Residue, %W[1]	D-244(Mod.)	T-59(Mod)	60	65
Miscibility Test[2]	D-244(Mod.)	T-59(Mod)	No Coagulation	
Sieve Test, %W[3]	D-244(Mod.)	T-59(Mod)		0.1
Particle Charge Test	D-244	T-59	Positive	
Percent Light Transmittance[4]				80
Tests on Residue from Distillation:				
Flash Point, COC, °C	D-92	T-48	196	
Viscosity @ 60°C, cSt	D-445	-	100	200
Asphaltenes, %w	D-2006-70	-		1.00
Maltene Dist. Ratio[5]	D-2006-70	-	0.3	0.6
PC/S Ratio[5]	D-2006-70	-	0.5	
Saturated Hydrocarbons, S[5]	D-2006-70	-	21	28

[1] ASTM D-244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 149°C (300°F) until foaming ceases, then cool immediately and calculate results.

[2] Test procedure identical with ASTM D-244-60 except that .02 Normal Calcium Chloride solution shall be used in place of distilled water.

[3] Test procedure identical with ASTM D-244 except that distilled water shall be used in place of two percent sodium oleate solution.

[4] Procedure for Determining Percent Light Transmittance on Asphalt Rejuvenating Agent:

a. Scope: This procedure covers the determination of percent light transmittance of the asphalt rejuvenating agent.

b. Apparatus:

1. Container may be glass, plastic or metal having a capacity of 6,000 ml.

2. Graduated cylinder, 1,000 ml, or greater

3. Light transmittance measuring apparatus, such as Bausch and Lomb or Lumberton spectrophotometer

4. Graduated pipette having 1 ml capacity to 0.01 ml accuracy

5. Suction bulb for use with pipette

6. Test tubes compatible with spectrophotometer, 3/4" X 6, Bausch and Lomb, Catalog No. 33-17- 81, (B&L)

c. Calibration of spectrophotometer:

1. Calibrate spectrophotometer as follows:

a. Set wavelength at 580 mu,

b. Allow spectrophotometer to warm-up thirty minutes,

c. Zero percent light transmittance (%LT) scale,

d. Rinse test tube three times with tap water and fill to top of circle marking on B&L test tube or approximately 2/3 full,

e. Place tube in spectrophotometer and set %LT scale at 100, and,

f. Repeat steps (c) (e) two times or until no further adjustments necessary.

d. Procedure:

1. Shake, stir or otherwise thoroughly mix emulsion to be tested. Place sample of emulsion in beaker and allow to stand one minute.

2. Place 2,000 ml tap water in container.

3. Suck 1.00 ml emulsion into pipette using suction bulb. Wipe off outside of pipette.

4. Using suction bulb, blow emulsion into container.

5. Rinse pipette by sucking in diluted emulsion solution and blowing out.

6. Clean pipette with soap or solvent and water. Rinse with acetone.

7. Stir diluted emulsion thoroughly.

8. Rinse out tube to be used with the diluted emulsion three times and fill to top of circle.

9. Calibrate spectrophotometer.

10. Place diluted emulsion sample tube in spectrophotometer, cover and read %LT to nearest tenth.

11. Repeat steps 9 and 10 until three identical consecutive readings are achieved.

12. The elapsed time between addition of emulsion to dilution of water and final %LT reading should not exceed 5 minutes.

[5] Chemical Composition by ASTM Method D-2006-70 -- (Free) Maltene Distribution Ratio (MDR) can be defined as:

$$\frac{PC + A_1}{S + A_2}$$

Where:

PC = Polar Compounds A_1 = First Acidaffins

A_2 = Second Acidaffins S = Saturated Hydrocarbons

2 Maltene Replacement ("Rejuvenation") Test

The TiO_2 Enhanced Asphalt Rejuvenating Agent shall have the capability to penetrate the asphalt pavement surface and shall be absorbed and incorporated into the asphalt binder. Verification that said incorporation of the TiO_2 Enhanced Asphalt Rejuvenating Agent into the asphalt binder has been effected shall be by the petroleum maltene fraction replacement method and analysis of the chemical properties of said asphalt binder therein i.e., viscosity shall be reduced by said method.

For pavements less than two-years old and receiving the original application of TiO_2 Enhanced Asphalt Rejuvenating Agent, the viscosity shall be reduced by a minimum of twenty (20%) percent as determined by the dynamic shear rheometer (DSR) method for asphalt testing in accord with AASHTO T315-05. For treatments of pavements older than two-years and/or after an initial treatment with a petroleum maltene asphalt rejuvenator, the viscosity shall be reduced by petroleum maltene replacement method a minimum of thirty percent (30%) in accord with same. This analysis shall apply to extracted asphalt binder, taken from cores extracted fifteen to thirty days following application, in the upper 3/8" of pavement. The treated areas shall be densified or resistant in depth to the intrusion of air and water.

The TiO_2 Enhanced Asphalt Rejuvenating Agent shall have a record of at least two years of satisfactory service as a TiO_2 enhanced petroleum maltene based emulsion asphalt rejuvenating agent and in-depth densifier. Satisfactory service shall be based on the capability of the material to decrease the viscosity of the asphalt binder by the petroleum maltene replacement method and provide an in-depth seal. **A.R.A.-1 Ti®**, a Pavement Technology, Inc. product manufactured by D&D Emulsions, Inc., Mansfield, Ohio, is a product of know quality and accepted performance.

The bidder must submit with his bid the manufacturer's certification that the material proposed for use is in compliance with the specification requirements. The bidder must submit with his bid previous use documentation and test data conclusively demonstrating that; the TiO_2 Enhanced Asphalt Rejuvenating Agent has been used successfully for a period of two years by government agencies such as state, county and municipal governments or "SCMs", etc.; and that the enhanced rejuvenating agent has been proven to perform, as heretofore required, through field testing by government agencies as to the required change in asphalt binder rheology and photocatalytic properties as hereinafter detailed. Testing data shall be submitted indicating such product performance on a sufficient number of projects to insure product consistency. In addition, field testing data shall be submitted to indicate said product performance over a minimum testing period of two years to insure reasonable sustainability.

The Engineer may require that untreated and treated core samples, a minimum of four inches in diameter, be removed by the Contractor at locations indicated by the Engineer. The treated core sample shall be taken in the same lane in close proximity to each untreated sample. A minimum of one untreated and treated core sample shall be taken for each pavement group or one per 50,000 square yards of treated pavement in each pavement group.

3 Photocatalytic Properties Testing

3.1 TiO_2 Penetration Test: The TiO_2 Enhanced Asphalt Rejuvenating Agent shall have a non-destructive analytical procedure applied to determine the percent of Titanium Dioxide nanoparticles present in each two-millimeter (2mm) layer of the field core sample matrix for a minimum depth of six millimeters (6mm) from the top of the treated sample core. The method of measurement shall be by fluorescent X-ray emitted from the surface when excited by a principal X-ray source that is exceptional for the given element. A hand-held XRF analyzer is acceptable for this testing.

The minimum required concentration of Titanium Dioxide nanoparticles per each two-millimeter (2mm) section up to the minimum depth of 6mm shall average 2000 parts per million (ppm).

3.2 NO_2 Reduction Effectiveness: The TiO_2 Enhanced Asphalt Rejuvenating Agent shall be verified for the effectiveness of the air pollution remediation of the Titanium Dioxide nanoparticle portion by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

3.3 NO_2 Reduction Test: A photo reactor test chamber shall be employed that allow for the evaluation of the efficient photocatalytic reduction of introduced NO_x gas of a known and controlled concentration within the

chambers volume. The chamber light source shall be a UV lamp having a wavelength of 375 nanometers. The interior chamber environment shall be at 77ºF with a constant humidity of 55% ±5%. The test total duration shall be five hours. The analysis test system shall be based on a Japanese Industrial Standard (JIS) TR Z0018 "Photocatalytic Materials-Air purification test procedure". NO removal efficiency shall be measured using a Model 42i Chemiluminescence NO-NO_2-NO_x Analyzer (Thermo Fisher Scientific Inc.).

The minimum NO reduction following the heretofore outlined test procedure evaluating field core samples shall average 25% for all cores tested.

3.4 Solar Reflectance Effectiveness: Verification of the effectiveness of the solar reflectivity the Titanium Dioxide nano-particle portion of the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

3.5 Solar Reflectance Test(s): Solar reflectivity shall be determined by measuring the treated core samples for a Solar Reflectance Index (SRI) value. SRI is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100. The relevant standards for measuring solar reflectance are:

Table 2 Test of Solar Reflectance

Value	Test Method
Solar Reflectance	**ASTM C1549 – Standard Test Method for Determination of Solar Reflectance**
Solar Reflectance Index	**ASTM E 1980 – Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces**

Based on these standards, the SRI is a measure of the relative steady-state temperature of a surface with respect to a standard white surface (SRI=100) and a standard black surface (SRI=0) under standard solar and ambient conditions.

Under normal ambient conditions, the steady-state temperature for the black and white reference surfaces is 355.61 kelvin (K) or 180°F and 317.76 K (110°F), respectively.

A Solar Reflectance Index (SRI) can be defined as:

$$SRI = \frac{T_b - T_s}{T_b - T_w}$$

Where:

- Steady-state Surface Temperature (Ts)—the temperature of the surface, in K, under the standard solar conditions. The surface temperature Ts (°C)=Ts (K)-273

- Reference Black Surface Temperature (Tb)—the steady-state temperature of a black surface with a solar reflectance of 0.05 and infrared emittance of 0.9, under the standard solar and ambient conditions
- Reference White Surface Temperature (Tw)—the steady-state temperature of a white surface with a solar reflectance of 0.80 and infrared emittance of 0.9, under the standard solar and ambient conditions
- Sky Temperature (Tsky)—the temperature of a black body that would radiate the same power in the thermal infrared spectrum (5 to 40 nm) toward the earth as does the sky

The minimum SRI value following the heretofore outlined test procedure(s) evaluating field core samples shall average 29 (or 0.29) for all cores tested, which meet the minimum standard (≥50% 29 SRI) for the U.S. Green Building Council (USGBC) hardscape threshold for Leadership in Energy and Environmental Design (LEED) credit or the minimum standard for the American Public Works Association (APWA) / Institute for Sustainable Infrastructure (ISI) Envision Superior (≥60% 29 SRI) level of achievement credit.

3.6 Hydrophilic Improvement: Verification of the improvement in hydrophilic property of the Titanium Dioxide nano-particle portion of the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be by laboratory analysis of core samples extracted from the treated pavement as directed and required by the Engineer. The cores shall be a minimum of four inches (4") in diameter and in pairs at each location directed by the Engineer. The cores shall be tested by an accredited laboratory or university with the equipment and capability to perform the following test procedures.

3.7 Wettability Test: Hydrophilic improvement shall be determined by measuring the treated core samples for Water Contact Angle (WCA). WCA is a common measurement of a constructed surface's ability to improve wettability or the ability of water to develop a stronger boundary (less resistance) with the surface as shown by a decline in water contact angle. A WCA of $> 90^0$ is considered hydrophobic or high resistance while a WCA $<90^0$ is considered hydrophilic or low resistance. The relevant standard for measuring WCA is:

Table 3 Test of Water Contact Angle

Value	Test Method
Water Contact Angle	ASTM D7334 - 08(2013) Standard Practice for Surface Wettability of Coatings, Substrates and Pigments by Advancing Contact Angle Measurement

The minimum WCA reduction following the heretofore outlined test procedure evaluating field core samples shall average 20% for all cores tested.

2 Equipment

2.1 Distributor: The distributor for spreading the emulsion shall be self-propelled and shall have pneumatic tires. The distributor shall be designed and equipped to distribute the asphalt rejuvenating agent uniformly on variable widths of surface at readily determined and controlled rates from 0.04 to 0.10 gallons per square yard of surface, and with an allowable variation from any specified rate not to exceed 5% of the specified rate.

Distributor equipment shall include full circulation spray bars, pump tachometer, volume measuring device and a hand hose attachment suitable for application of the emulsion manually to cover areas inaccessible to the distributor. The distributor shall be equipped to circulate and agitate the emulsion within the tank.

The rate of application shall be controlled by an onboard computer control system designed to control the selected application rate uniformly and consistently in gallons per square yard regardless of the forward speed of the distributor truck.

A check of distributor equipment as well as application rate accuracy and uniformity of distribution shall be made when directed by the Engineer.

2.2 Aggregate Cover Truck: The truck used for cover aggregate application shall be equipped with a spreader that allows the aggregate to be uniformly distributed onto the pavement. The spreader shall be able to apply 1/2 pound to 3 pounds of cover aggregate per square yard in a single pass. The spreader shall be adjustable so as not to broadcast cover aggregate onto driveways or to lawns.

The cover aggregate to be used shall be free flowing, without any leaves, dirt, stones, etc. Any wet aggregate shall be rejected from the job site.

Any equipment that is not maintained in full working order, or is proven inadequate to obtain the results prescribed, shall be repaired, or replaced at the direction of the Engineer.

2.3 Calibration: Distributor- prior to construction, calibrate the distributor in accordance with ASTM D2995-99 in the presence of the Engineer. The distributor shall be moving forward at the proper application speed at the time the spray bar is opened. If at any time a nozzle becomes clogged or not spraying a proper pattern, the operation shall be immediately halted until repairs are made.

3 Construction

3.1 Layout: The Contractor will be responsible for the lay out of the roadway and project planning and sequencing to meet traffic control requirements prior to paving.

3.2 Weather and Seasonal Limitations: The TiO_2 Enhanced Asphalt Rejuvenating Agent shall not be applied to a wet surface or when rain is occurring, or the threat of rain is present immediately before placement. The surface treatment shall not be applied when the temperature is less than 40° in the shade. When applying emulsions, the temperature of the surface shall be a minimum of 45°F, and no more than 150°F.

If unexpected rain occurs prior to material penetration and cover aggregate application, the agent shall be reapplied at no cost to the agency. Further, the contractor's traffic control and project monitoring shall continue until the application has penetrated, area has been sanded and the resultant surface is acceptable to the Engineer for vehicular travel.

3.3 Preparation of Surface: The contractor will be responsible for blowing or sweeping the road immediately ahead of the application operation to make sure the road is free of standing water, dirt, loose aggregate, and other debris. The surface shall be clean and dry prior to the application.

3.4 Application of TiO_2 Enhanced Asphalt Rejuvenating Agent: The TiO_2 Enhanced Asphalt Rejuvenating Agent shall be applied by a distributor truck at the temperature recommended by the manufacturer and at the pressure

required for the proper distribution. The emulsion shall be so applied that uniform distribution is obtained at all points of the areas to be treated. Distribution shall be commenced with a running start to ensure full rate of spread over the entire area to be treated. Areas inadvertently missed shall receive additional treatment as may be required by hand sprayer application.

3.5 Material Placement of TiO_2 Enhanced Asphalt Rejuvenating Agent: Application of TiO_2 Enhanced Asphalt Rejuvenating Agent shall be on one-half width of the pavement at a time. When the second half of the surface is treated, the distributor nozzle nearest the center of the road shall overlap the previous application by at least one-half the width of the nozzle spray. In any event the centerline construction joint of the pavement shall be treated in both application passes of the distributor truck.

Before spreading, the TiO_2 Enhanced Asphalt Rejuvenating Agent shall be blended with water at the rate of two parts rejuvenating agent to one-part water, by volume or as specified by the manufacturer. The combined mixture of asphalt rejuvenating agent and water shall be spread at the rate of 0.04 to 0.10 gallons per square yard, or as approved by the Engineer following field testing.

Where more than one application is to be made, succeeding applications shall be made as soon as penetration of the preceding application has been completed and the Engineer grants approval for additional applications. Grades or super elevations of surfaces that may cause excessive runoff, in the opinion of the Engineer, shall have the required amounts applied in two or more applications as directed.

The Contractor shall furnish a quality inspection report showing the source, manufacturer, and the date shipped, for each load of TiO_2 Enhanced Asphalt Rejuvenating Agent. When directed by the Engineer, the Contractor shall take representative samples of material for testing.

3.6 Test Strip for Application Rate: Prior to start of the project, the contractor shall perform test strip applications as directed by the engineer. Test strips shall be performed for each pavement group of similar age and type within the project area.

The test strips shall be applied at a minimum width of 6 feet and for a length of 50 feet. A total of three test strips shall be applied at application rates of 0.04, 0.08 and 0.10 gallons per square yard, respectively. The time, in minutes, for essentially complete absorption of the asphalt rejuvenating emulsion shall be recorded for each test strip. The optimal rate to be used in a given area shall be that rate essentially absorbed within 20 minutes.

In the event that all three of the standard test rates are absorbed completely within the 20-minute timeframe, then the Contractor and the Engineer shall agree on a fourth test strip application rate.

Upon completion of the test strips for each pavement group, the Engineer will determine the final application rate to be applied to each pavement group.

3.7 Cover Aggregate Application: After the TiO_2 Enhanced Asphalt Rejuvenating Agent emulsion has penetrated, and when recommended by the Contractor and approved by the Engineer, a coating of dry cover aggregate shall be applied to the surface in sufficient amount to protect the traveling public as required.

All cover aggregate used during the treatment must be removed no later than 24 hours after treatment of a roadway. This shall be accomplished by a combination of hand and mechanical sweeping. All turnouts, cul-de-sacs, etc. must be cleaned of any material to the satisfaction of the Engineer. Street sweeping will be included in the price bid per square yard for asphalt rejuvenating emulsion.

If, after the cover aggregate is swept and in the opinion of the Engineer a hazardous condition exists on the roadway, the contractor must apply additional cover aggregate and sweep same no later than 24 hours following reapplication. No additional compensation will be allowed for reapplication and removal of materials.

3.8 Handling of TiO_2 Enhanced Asphalt Rejuvenating Agent: Contents in tank cars or storage tanks shall be circulated at least 45 minutes before withdrawing any material for application. The distributor truck will be cleaned of all of its asphalt materials and washed out to the extent that no discoloration of the emulsion may be perceptible. Cleanliness of the spreading equipment shall be subject to the approval of the Engineer.

3.9 Street Sweeping: The Contractor shall be responsible for sweeping and cleaning the streets after treatment. All cover aggregate used during the treatment must be removed no later than 24 hours after treatment of the street. This shall be accomplished by a combination of hand and mechanical sweeping. All turnouts, cul-de-sacs, etc. must be cleaned of any material to the satisfaction of the Engineer.

If, after cover aggregate is swept and in the opinion of the Engineer a hazardous condition exists on the roadway, the contractor must apply additional cover aggregate and sweep same no later than 24 hours following reapplication. No additional compensation will be allowed for reapplication and removal of cover aggregate.

3.10 Resident Notification: The contractor shall distribute by hand, a typed notice to all residences and businesses on the street to be treated. The notice will be delivered no more than 24 hours prior to the treatment of the road. The notice will have a local phone number that residents may call to ask questions. The notice shall be of the door hanger type, which secures to the door handle of each dwelling. Unsecured notices will not be allowed. The contractor shall also place the notice on the windshield of any parked cars on the street. Hand distribution of this notice will be considered incidental to the contract.

3.11 Traffic Control: The Contractor shall furnish all necessary traffic control, barricades, signs, and flagmen, to ensure the safety of the traveling public and to all working personnel. Traffic shall not travel on fresh TiO_2 Enhanced Asphalt Rejuvenating Agent until penetration, in the opinion of the Engineer, has become complete and the area is suitable for traffic. The Contractor shall submit an M.O.T plan indicating all facets of traffic control for the project area. The M.O.T. plan must be approved in writing by the Engineer prior to commencing any work. All traffic control shall be in accordance with the DOT Roadway Design Standards (most current edition). Traffic control devices shall be checked daily and periodically throughout the project for compliance; and where adjustments or corrections are needed, prompt revisions shall be made.

3.12 Method of Measurement: The TiO_2 Enhanced Asphalt Rejuvenating Agent emulsion shall be paid at the Contract bid unit prices for the actual square yards of pavement treated as field measured. Said payment is compensation in full for all costs of furnishing and applying the material as specified, including cleaning the existing pavement, purchase of cover aggregate, delivery of cover aggregate, all labor, equipment, and materials necessary for the placement of the TiO_2 Enhanced Asphalt Rejuvenating Agent emulsion, sweeping of any loose material after construction and other requirements as specified. Traffic control for maintaining traffic for constructing TiO_2 Enhanced Asphalt Rejuvenating Agent emulsion shall be considered incidental.

Payment for removal of untreated and treated cores shall be paid for as each at the unit price bid for Test Core Removal.

3.13 Basis of Payment:

Pay Item	**Unit**
• TiO_2 Enhanced Asphalt Rejuvenating Agent	Per Sq/Yd
• Field Core Removal*	Each
• Field Core Laboratory Analysis – Viscosity*	Each
• Field Core Laboratory Analysis -Titanium Dioxide Penetration*	Each
• Field Core Laboratory Analysis - Titanium Dioxide NO_2 Reduction*	Each
• Field Core Laboratory Analysis - Titanium Dioxide Solar Reflectance Index (SRI)*	Each
• Field Core Laboratory Analysis - Titanium Dioxide Water Contact Angle (WCA)*	Each
• Mobilization	Per Project

*When required by the Engineer

ANDERSON CONCRETE CORPORATION
400 FRANK ROAD, COLUMBUS, OHIO 43207
(614) 443-0123

February 16, 2022

To: Anderson Concrete Customers

Re: Portland Limestone Cement

This letter is regarding the Central Ohio ready-mix concrete market switch from Portland Cement (PC) to Portland Limestone Cement (PLC). In order to reduce carbon emissions, cement producers across the United States have been switching from PC to PLC, resulting in around a 10% reduction in carbon emissions. PC allows for up to 5% ground limestone while PLC allows for a range of 5% to 15% ground limestone. This change will inevitably occur in every market across our country and has already resulted in the reduction of CO2 emissions by hundreds of thousands of tons. Cement producers have completed extensive testing and their PLCs are able to replace PCs at a 1:1 ratio. PLCs are recognized in the ACI 301 and ACI 318 building codes. ASTM C595 and AASHTO M240 standards allow for the use and specification of PLCs.
More information on this can be found at www.greenercement.com.

Anderson Concrete Corp. (ACC) has led the Central Ohio ready-mix concrete market in quality mixes and innovation for decades. ACC is fully committed to our mixes exceeding project requirements for every performance requirement specified. The ACC quality control department is the largest and most experienced in the market, and our team has been extensively testing thousands of our mix designs using PLC. This testing will continue until all our design data has been tested using PLCs. To date, our testing has shown that performance with PLC equals that of PC.

ACC is a proud partner in reducing carbon emissions and we assure you that the performance of our products will not change. To allow for the seamless transition to PLC on your projects, our ownership, sales, production and quality control groups are available to assist you in any way possible (#614-443-0123). We are fully committed to working with our customers, general contractors and specifiers as we begin this transition. It is important to stress that, in the near future, there will no longer be the option to purchase PC in the Central Ohio market. ACC lab testing has led us to concur with the cement industry that ongoing projects should accept PLC as an equivalent to PC. The failure of our industry to adopt this approach could lead to widespread construction delays across our market. It is crucial for all parties involved in the Central Ohio concrete market to understand this and take steps to ease the period of transition. Many markets around the world have accomplished this change without disruption, and we should strive to achieve the same results.

Respectfully,

Anderson Concrete Corp.

Rod Jenkins
Vice President of Production
National Ready Mix Concrete Association Concrete Technologist Level 3
American Concrete Institute Concrete Quality Technical Manager