Asphalt Art Safety Study

Historical Crash Analysis and Observational Behavior Assessment at Asphalt Art Sites

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Executive Summary

Transportation infrastructure is perhaps the most visible aspect of a city's public realm—the sidewalks and roadways we depend on daily are often as recognizable as the buildings, destinations, and people within it. As cities transform to meet evolving needs of the future, there is an increasing opportunity for streets to not only be safe and efficient, but a unique and inspiring part of the urban experience. Among other strategies to achieve that goal, public art projects coupled with improvements to transportation infrastructure, often known as "asphalt art," offer many benefits. They can create safer, more desirable streets and public spaces. They are typically inexpensive and quickly implementable, while helping cities test long-term roadway redesigns. And they help local governments engage with residents to reshape their communities.

These projects, including intersection murals, crosswalk art, and painted plazas or sidewalk extensions, have existed for years and are growing in popularity in communities across the world. Though asphalt art projects frequently include specific roadway safety improvements, the art itself is often also intended to improve safety by increasing visibility of pedestrian spaces and crosswalks, promoting a more walkable public realm, and encouraging drivers to slow down and be more alert for pedestrians and cyclists, the most vulnerable users of the road.

There has been considerable public feedback, anecdotal evidence, and analyses of individual locations indicating that asphalt art can have these traffic-calming benefits and encourage safer behavior. However, despite broad support from people who use and design streets, art within the public roadway network has faced regulatory hurdles in the United States and elsewhere because of concerns about compliance with current design standards and guidance that governs roadway markings. These concerns have persisted in the absence of much rigorous evaluation or published literature on safety performance of asphalt art projects.

This study was conducted to address the need for impact analysis by comparing crash rates and real-time behavior of pedestrians and motorists at an array of asphalt art sites before and after the projects were installed. There are two main components to the study: first is a Historical Crash Analysis that compares crash data prior to and after the introduction of asphalt art at 17 diverse study sites with at least two years of data. The second is an Observational Behavior Assessment that compares before and after video footage of motorist and pedestrian behavior at five U.S. locations with asphalt art projects installed in 2021 as part of the Bloomberg Philanthropies' Asphalt Art Initiative. **The analysis found significantly improved safety performance across a variety of measures during periods when asphalt art was installed.**

Comparing the average of crash rates for before-after analysis periods, results from the Historical Crash Analysis include:

- 50% decrease in the rate of crashes involving pedestrians or other vulnerable road users
- 37% decrease in the rate of crashes leading to injuries
- 17% decrease in the total crash rate

Similarly, the Observational Behavior Assessment indicates:

- 25% decrease in pedestrian crossings involving a conflict with drivers
- 27% increase in frequency of drivers immediately yielding to pedestrians with the right of way
- 38% decrease in pedestrians crossing against the walk signal

The promising findings from this study will inform ongoing discussions on how to revise U.S. roadway engineering guidance to improve safety for the most vulnerable road users. The study also provides data-driven evidence cities can use to make the case for their own arts-driven transportation projects.

The following report details the background, methodology, and results of the Historical Crash Analysis and the Behavioral Observation Assessment.

1. Introduction

There is arguably no more important goal for the transportation profession than ensuring safe travel for everyone on the road, especially pedestrians, cyclists, and other vulnerable road users. In recent years, though, this goal has proven elusive. According to the National Highway Traffic Safety Administration (NHTSA), in 2020, a total of 38,824 people died in motor vehicle crashes in the U.S., the most since 2007 and an increase of 6.8% over 2019.[1] Considering an 11% reduction in vehicle miles traveled (VMT) in 2020 during the pandemic, the fatality rate adjusted for miles traveled increased by 21% and the adjusted pedestrian fatality rate increased by an unprecedented 21%. Clearly, innovative, proven street design tactics need to be more broadly embraced in order to improve safety and mobility on our roadways.

Cities across the globe have been installing asphalt art treatments at intersections and pedestrian crossings for some time now with a goal of improving safety and the quality of life for all roadway users. Such projects have been used in a variety of applications, including within the crosswalk, within the center of an intersection, or in place of or in addition to traditional roadway features such as islands or curb extensions. The art is intended to create a highly visible crossing and suggest a walkable, active, shared use environment. Additionally, art in the crosswalk or at curb extensions makes the pedestrian crossing location more conspicuous to drivers.

However, some in the transportation community find that such projects on portions of roads open to motor vehicles are typically not compliant with official interpretations of the 2009 version of the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD), which provides standards and guidance for markings on public roadways in the United States. This interpretation of the standard—which pre-dates the availability of modern colored pavement materials—has limited the number

[1] National Highway Traffic Safety Administration 2020 Annual Crash Data

of communities who can, as a practical matter, use asphalt art in crosswalks and other parts of the street. Recently, such interpretations have been challenged by organizations like the National Association of City Transportation Officials (NACTO) and individual public agencies seeking to improve roadway safety by focusing more on the most vulnerable road users, and less on the rapid movement of motor vehicles on city streets. Both NACTO and the Institute of Traffic Engineers (ITE) have proposed that asphalt art in crosswalks be permitted in the forthcoming revision to the MUTCD; however, the status of asphalt art in the ongoing revisions will likely not be known until 2023.

Given this divide between existing policy and the growing movement of practitioners and community residents who see the potential benefit of asphalt art, some local authorities have been willing to approve asphalt art projects while those in other jurisdictions have been more reluctant to do so. The resulting patchwork approach makes approval processes difficult for community organizations seeking to install asphalt art projects and leads to time-consuming, redundant efforts by local engineers seeking to assess such proposals. This study was designed to address this need and provide a quantitative assessment of multiple asphalt art projects to determine their impact on roadway safety.

1.1 Study Goals and Objectives

The goal of this study is to assess the effectiveness of asphalt art as a safety improvement through quantification and analysis of crash and behavior performance metrics before and after installation at study sites. There are two independent components to the study:

- **Historical Crash Analysis** – Site characteristics, traffic volumes, and crash data were obtained for 17 asphalt art sites in five states (seven unsignalized intersections, seven signalized intersections and three mid-block crossings). A before-after comparison group study design was used to evaluate the safety effectiveness of the projects.
- **Observational Behavior Assessment** – Performance metrics were developed for pedestrian and driver behavior and recordings were assessed to identify occurrences of the behavior during before and after comparison periods. This methodology was applied to five asphalt art intersection locations (two signalized and three unsignalized).

The objective of the study is to quantify the change in the following metrics for before and after comparison periods:

- Crash Rates
    - Total Crashes
    - Vulnerable user crashes
    - Fatal and injury crashes
- Driver and Pedestrian Behavior Metrics
    - Pedestrian-Vehicle conflicts with crash potential (near-miss)
    - Driver yielding/stopping behavior
    - Compliance with traffic control devices

These components were combined because crash rates should not be used as a lone factor in determining the safety effectiveness of roadway treatments, as crashes often have numerous contributing factors. By also assessing quantifiable behavioral metrics such as rate of pedestrian-vehicle conflicts and rates of drivers yielding to pedestrians, the intention is for the study to provide a more holistic measure of the effectiveness of treatments at installation sites.

1.2 Literature Review

In addition to the analysis itself, a literature review was performed and interviews with transportation officials from over three dozen cities were conducted, inquiring about their experience with asphalt art projects related to safety. Aside from a small number of internal studies generated by municipal staff, the study team found no all-encompassing analysis that created a standardized set of metrics by which to compare safety across different asphalt art improvement types, facility types, settings, and geographic regions, or that considered the long-term safety impacts of asphalt art, further demonstrating the need for the analysis in this document. Findings from the literature review and interviews are summarized in **Appendix A**.

2. Historical Crash Analysis

2.1. Background and Scope

To quantify the safety performance of a site, road safety practitioners use metrics called crash modification factors (CMF). CMFs are multiplicative factors used to compute the expected number of crashes after implementing a given countermeasure or roadway modification at a specific site. FHWA has developed a living database called the CMF Clearinghouse, which includes a list of recognized CMFs and provides references to studies from which they were developed. CMFs listed in the CMF Clearinghouse are developed as a product of robust published research studies. CMFs included are rated based on the thoroughness of the associated research study, which is predicated on criteria such as study design, sample size, statistical methodology, statistical significance, etc.

While the intent of this historical crash analysis is not to develop a CMF (as it lacks the scale and complexity of FHWA-reviewed research studies), elements of research studies used to develop CMFs were used as a model for this analysis. Similar to FHWA research studies, the goal of this study is to observe and compare long-term crash trends over a range of sites with similar characteristics. In addition to comparing crash quantity/frequency, trends in crash attributes and contributors such as severity, vulnerable user involvement, lighting condition, and crash type were also assessed.

2.2. Crash Data Sources

Many states and cities actively maintain open-source crash databases with historical crash data available at differing levels of granularity and comprehensiveness. While in certain states/jurisdictions, comprehensive data is relatively easy to obtain, others do not allow the public to search for crash data at a single site, only by municipality or neighborhood. Additionally, some public databases only have crash data available for a limited number of years, often excluding the current and most recent complete year (for this study 2020 and 2021) and/or data older than five years.

Further, while a range of roadway data (volume, speed, multimodal, user behavior) is also becoming more widely available and easier to obtain, it is usually not granular enough for quantifying performance at a specific site without dedicated, often costly, monitoring programs.

This lack of comprehensive crash and road user behavior data ultimately impacted both the study site selection and the methodology itself. A list of crash data sources for each study site including years of data obtained is included in the Appendix B.

2.3. Site Selection Criteria

While asphalt art sites are prevalent throughout the country, the study team sought the most rigorous understanding of asphalt art impacts and initially reviewed 150 locations. Of those, 17 sites were selected that met all of the below criteria while offering a diverse array of project types, geographic locations, and neighborhood contexts.

» Known installation dates and dates of deterioration/repainting within 3 months (confirmed through NearMap or Google Maps historical imagery)

» Facility type is a marked mid-block crossing, stop-controlled intersection, or signalized intersection within (or formerly within) public ROW and open to vehicle traffic (excludes art in driveways, trails, approaches to controlled access highways, private developments, etc.)

» State or municipality has publicly available historical crash data through an online resource or open-source data portal

» Historical crash data available on a location-based scale (i.e., more than just county-wide or municipal-wide data)

» At least 12 months of pre- and post-implementation (“before” and “after”) crash data available (as many states delay crash data for the current and previous year or only keep recent crash records for the last 5 years, many recently implemented asphalt art sites or those implemented longer than 6 years ago did not have 12 months of data)

» Robust crash data including (at a minimum) crash date, time of day, severity, vulnerable user involvement, lighting condition, crash type/circumstances

2.4. Summary of Study Sites Selected

The 17 sites selected for this study are included in Table 1 below. Sites from five states were included in high-density urban (central business district, downtown, or mixed-use areas), medium/low density urban (mostly residential), and suburban settings. Sites included mid-block crossings, stop-controlled intersections, and signalized intersections. Tables 2–4 below include a disaggregation of the 17 study sites by state, region, setting, and facility type.

Table 1: **Study Site Location Information**

#	City	State	Intersection	Site Setting	Facility Type
1	St Petersburg	FL	Central Ave & 5th St	Urban Core	Intersection-Signal
2	Miami	FL	Northeast 98th St & Northeast 2nd Ave	Neighborhood Commercial	Mid-Block
3	Ft Lauderdale	FL	Terramar St & Breakers Ave	Neighborhood Residential	Intersection-Stop
4	Ft Lauderdale	FL	Riomore St & Breakers Ave	Neighborhood Residential	Intersection-Stop
5	Pinecrest	FL	Killian Dr & SW 67th Ave	Suburban	Intersection-Signal
6	Pinecrest	FL	Killian Dr & SW 62nd Ave	Suburban	Intersection-Stop
7	Atlanta	GA	Piedmont Ave & 10th St	Urban Core	Intersection-Signal
8	Decatur	GA	Ponce de Leon Ave & Fairview Ave	Neighborhood Residential	Intersection-Stop
9	Decatur	GA	Ponce de Leon Ave & Clairemont Ave	Urban Core	Intersection-Signal
10	Decatur	GA	Ponce de Leon Ave & E Court Square	Urban Core	Mid-Block
11	Cambridge	MA	Massachusetts Avenue & Inman Street	Urban Core	Intersection-Signal
12	Rahway	NJ	E Cherry St & Irving St	Neighborhood Residential	Intersection-Stop
13	Maplewood	NJ	Valley St & Oakview Ave	Suburban	Intersection-Signal
14	NYC (Brooklyn)	NY	Hooper St & Division Ave	Urban Core	Intersection-Stop
15	NYC (Manhattan)	NY	7th Ave & Christopher St	Urban Core	Intersection-Signal
16	Tampa	FL	N River Blvd & W Louisiana Ave	Suburban	Intersection-Stop
17	New Brunswick	NJ	Livingston Ave	Urban Core	Mid-Block

Table 2: **Study Sites by Region**

Region	#	%
Northeast	6	35%
Southeast	11	65%
TOTAL	**17**	**100%**

Table 3: **Study Sites by Setting**

Setting	#	%
Urban Core	8	47%
Neighborhood Residential/Commercial	5	29%
Suburban	4	24%
TOTAL	**17**	**100%**

Table 4: **Study Sites by Facility Type**

Facility Type	#	%
Intersection (Signal Controlled)	7	41%
Intersection (Stop Controlled)	7	41%
Mid-Block	3	18%
TOTAL	**17**	**100%**

2.5. Improvements at Study Sites

Asphalt art sites included in the study were classified based on type of improvement. Improvements related directly to installation of art include crosswalk art, intersection art serving a functional traffic control/calming purpose and meeting the definition of a traffic control device or traffic calming treatment device (e.g., curb extension, painted chicane, incorporation of traffic control elements), and roadway art serving only as an aesthetic improvement and not meeting the definition of a traffic control device (e.g., within the center of an intersection or along an approach). At some sites, in addition to asphalt art, other roadway/roadside improvements were implemented at the same time (e.g., raised crosswalks, pedestrian signal improvements, traffic control device modifications). Table 5 provides a matrix of improvements at each study site. Pre- and post-implementation aerial photos and links to locations in Google Maps are provided in Appendix C.

Table 5: **Site Locations by Improvement Type**

#	City	State	Crosswalk Art	Roadway Art (Center of intersection or intersection approach)	Other Improvements/Notes
1	St Petersburg	FL		✓	
2	Miami	FL		✓	
3	Ft Lauderdale	FL	✓	✓	Sidewalk improvements
4	Ft Lauderdale	FL	✓	✓	Sidewalk improvements
5	Pinecrest	FL		✓	
6	Pinecrest	FL		✓	
7	Atlanta	GA	✓		Rapid development, nearby bike network expansion, bike & pedestrian volume growth
8	Decatur	GA	✓		Raised crosswalks
9	Decatur	GA	✓		Bollards/sidewalk improvements
10	Decatur	GA	✓		Raised crosswalks
11	Cambridge	MA	✓		
12	Rahway	NJ	✓		
13	Maplewood	NJ	✓		
14	NYC (Brooklyn)	NY		✓	Restricted turning movement, intersection leg closure
15	NYC (Manhattan)	NY	✓		
16	Tampa	FL		✓	
17	New Brunswick	NJ	✓		Art within marked parking spaces
COMBINED SITES		#	11	8	8
		%	65%	47%	29%

2.6. Historical Crash Data Analysis Methodology

Historical crash data was obtained from state and municipal transportation agencies for each of the 17 study sites. As mentioned above, sites were selected based on a set of criteria identified to support a sound analysis methodology. In many jurisdictions, there are limitations on data available through open-source data portals. This required extracting data for thousands of crashes, and then manually parsing data to obtain the desired datasets at individual locations.

NearMap, an online resource for regularly updated historical aerial imagery, was used to obtain art installation dates as interviews with each municipality were not conducted. Using this imagery, the last confirmed date of the condition prior to asphalt art implementation, date of art installation, and dates of deterioration/repainting/removal were obtained. Months between the confirmed prior condition and implementation and months after art had deteriorated beyond recognition were excluded from both analysis periods. At some locations, the exact date(s) of installation are known and were used when available.

To account for differences in sites with different analysis periods, crash rates (crashes/year) were used as a metric instead of raw number of crashes. The average pre-implementation/before period for all sites was 48.2 months while the post-implementation/after period averaged 32.9 months. Analysis periods for each site are presented in Table 6 on page 21.

The combined pre- and post-implementation analysis periods for the 17 study sites included a total of 390 reported crash records. Crash records were first reviewed and analyzed for all 17 sites combined in the following categories: total reported crashes, crashes involving vulnerable users (e.g., bicyclists, pedestrians, scooter users), crashes resulting in an injury, crash type, contributing circumstance, and time of day/lighting condition. Contributing circumstances and crash types were not available for every site and breakdown of crash types were summarized for combined sites with that information available. Lighting condition data was incomplete for many states and varied widely from state to state, resulting in inclusive data that was not included in the analysis.

Table 6: **Analysis Periods**

#	City	State	Pre-Implementation "Before" (Months)	Post-Implementation "After" (Months)	Implementation Year
1	St Petersburg	FL	52	39	2016
2	Miami	FL	54	25	2017
3	Ft Lauderdale	FL	49	42	2016
4	Ft Lauderdale	FL	49	42	2016
5	Pinecrest	FL	59	14	2018
6	Pinecrest	FL	59	14	2018
7	Atlanta	GA	54	42	2017
8	Decatur	GA	47	46	2016
9	Decatur	GA	48	47	2017
10	Decatur	GA	48	47	2017
11	Cambridge	MA	60	28	2016
12	Rahway	NJ	39	18	2019
13	Maplewood	NJ	40	31	2018
14	NYC (Brooklyn)	NY	30	35	2018
15	NYC (Manhattan)	NY	16	42	2017
16	Tampa	FL	60	32	2017
17	New Brunswick	NJ	57	16	2019
AVERAGE			48.3	32.9	-

Crash rate metrics for combined study sites were calculated using two separate methods. The average of crash rates is the average of the individual crash rate values of each site within an analysis period and is calculated by dividing the sum of crash rates for each site by the quantity of sites. The average rate is the aggregated crash rate of all sites/analysis periods and is calculated by dividing the total number crashes that occurred divided by the total amount of time analyzed. It should be noted that several after periods overlapped with periods of reduced volumes due to the COVID-19 pandemic.

2.7. Historical Crash Analysis Results

Comparisons of crash types are presented in the following tables and further detailed by site in Appendix D. The percent differences between analysis periods were calculated as the difference in crash rates of the after and before period divided by the crash rate of the before period. Positive values for percent difference between the crash rates in the before and after condition indicate a reduction in the crash rate, while negative values indicate an increase.

Study Sites - Combined

Results indicate that, at the 17 study sites, the average of crash rates was 17.3% lower in the analysis periods after art installation than the average of crash rates for the before analysis periods. Similarly, the average of vulnerable user and injury crash rates were 49.6% and 36.5% lower in analysis periods after art was installed.

It should be noted that sites with a comparatively large number of crashes in both the before and after analysis periods heavily influenced averages of crash rates. As such, the average of crash rates was calculated for the entire 17 site sample and separately, excluding the sites with the highest and lowest number of total crashes statistical outliers. For this study, Site 7 (Atlanta, GA) experienced the highest number of crashes (70 and 77 crashes in before and after periods respectively) and both Site 16 (Tampa, FL) and Site 17 (New Brunswick, NJ) had no crash occurrences either analysis period. For purposes of performing calculations excluding statistical outliers, Site 17 was excluded as opposed to Site 16 because the before and after analysis periods were longer.

The following points summarize key findings from an analysis of crashes of all types (total crashes), crashes involving vulnerable users, and crashes involving an injury, holistically for all 17 study sites combined. Reported crashes, analysis periods intervals, and crash rates for before and after periods are presented by site and as an average in Tables 7–9 below. Table 10 presents the average (aggregate) crash rate of crashes and analysis periods of the 17 study sites combined.

Table 7: **Total Crash Rate by Site and Average of Rates (Crashes/Year)**

#	City	State	Analysis Period (Months)		Total Crash Quantity		Total Crash Rate (Crashes/Year)		
			Before	After	Before	After	Before	After	Difference
1	St Petersburg	FL	52	39	18	13	4.2	4.0	-4%
2	Miami	FL	54	25	3	0	0.7	0.0	-100%
3	Ft Lauderdale	FL	49	42	2	1	0.5	0.3	-42%
4	Ft Lauderdale	FL	49	42	4	3	1.0	0.9	-13%
5	Pinecrest	FL	59	14	28	1	5.7	0.9	-85%
6	Pinecrest	FL	59	14	3	0	0.6	0.0	-100%
7	Atlanta	GA	54	42	70	77	15.6	22.0	+41%
8	Decatur	GA	47	46	11	4	2.8	1.0	-63%
9	Decatur	GA	48	47	12	15	3.0	3.8	+28%
10	Decatur	GA	48	47	11	8	2.8	2.0	-26%
11	Cambridge	MA	60	28	31	7	6.2	3.0	-52%
12	Rahway	NJ	39	18	6	2	1.8	1.3	-28%
13	Maplewood	NJ	40	31	17	9	5.1	3.5	-32%
14	NYC (Brooklyn)	NY	30	35	12	12	4.8	4.1	-14%
15	NYC (Manhattan)	NY	16	42	5	5	3.8	1.4	-62%
16	Tampa	FL	60	32	0	0	0.0	0.0	0%
17	New Brunswick	NJ	57	16	0	0	0.0	0.0	0%
AVERAGE SITE			48.3	32.9	13.7	9.2			
AVERAGE OF TOTAL CRASH RATES (ALL SITES)							3.44	2.84	-17.3%
AVERAGE OF TOTAL CRASH RATES (EXCLUDING HIGH AND LOW SITES)							2.86	1.75	-38.7%

Table 8: **Vulnerable User Crash Rate by Site and Average of Rates (Crashes/Year)**

#	City	State	Analysis Period (Months)		Vulnerable User Crash Quantity		Vulnerable User Crash Rate (Crashes/Year)		
			Before	After	Before	After	Before	After	Difference
1	St Petersburg	FL	52	39	1	0	0.00	0.00	-100%
2	Miami	FL	54	25	0	0	0.00	0.00	0%
3	Ft Lauderdale	FL	49	42	0	0	0.00	0.00	0%
4	Ft Lauderdale	FL	49	42	0	0	0.00	0.00	0%
5	Pinecrest	FL	59	14	0	0	0.00	0.00	0%
6	Pinecrest	FL	59	14	0	0	0.00	0.00	0%
7	Atlanta	GA	54	42	4	3	0.89	0.86	-4%
8	Decatur	GA	47	46	0	0	0.00	0.00	0%
9	Decatur	GA	48	47	0	0	0.00	0.00	0%
10	Decatur	GA	48	47	0	0	0.00	0.00	0%
11	Cambridge	MA	60	28	1	0	0.20	0.00	-100%
12	Rahway	NJ	39	18	0	1	0.00	0.67	0%
13	Maplewood	NJ	40	31	0	1	0.00	0.39	0%
14	NYC (Brooklyn)	NY	30	35	6	1	2.40	0.34	-86%
15	NYC (Manhattan)	NY	16	42	1	0	0.75	0.00	-100%
16	Tampa	FL	60	32	0	0	0.00	0.00	0%
17	New Brunswick	NJ	57	16	0	0	0.00	0.00	0%
AVERAGE SITE			48.3	32.9	13.7	9.2			
AVERAGE OF VULNERABLE USER CRASH RATES (ALL SITES)							0.26	0.13	-49.6%
AVERAGE OF VULNERABLE USER CRASH RATE (EXCLUDING HIGH AND LOW SITES)							0.24	0.09	-61.0%

Table 9: **Injury Crash Rate by Site and Average of Rates (Crashes/Year)**

#	City	State	Analysis Period (Months)		Injury Crash Quantity		Injury Crash Rate (Crashes/Year)		
			Before	After	Before	After	Before	After	Difference
1	St Petersburg	FL	52	39	5	0	1.15	0.00	-100%
2	Miami	FL	54	25	1	0	0.22	0.00	-100%
3	Ft Lauderdale	FL	49	42	0	0	0.00	0.00	0%
4	Ft Lauderdale	FL	49	42	6	0	1.47	0.00	-100%
5	Pinecrest	FL	59	14	3	1	0.61	0.86	+40%
6	Pinecrest	FL	59	14	0	0	0.00	0.00	0%
7	Atlanta	GA	54	42	14	9	3.11	2.57	-17%
8	Decatur	GA	47	46	4	2	1.02	0.52	-49%
9	Decatur	GA	48	47	1	4	0.25	1.02	+309%
10	Decatur	GA	48	47	1	1	0.25	0.26	+2%
11	Cambridge	MA	60	28	14	0	2.80	0.00	-100%
12	Rahway	NJ	39	18	0	1	0.00	0.67	0%
13	Maplewood	NJ	40	31	6	5	1.80	1.94	+8%
14	NYC (Brooklyn)	NY	30	35	4	5	1.60	1.71	+7%
15	NYC (Manhattan)	NY	16	42	1	0	0.75	0.00	-100%
16	Tampa	FL	60	32	0	0	0.00	0.00	0%
17	New Brunswick	NJ	57	16	0	0	0.00	0.00	0%
AVERAGE SITE			48.3	32.9	13.7	9.2			
AVERAGE OF INJURY CRASH RATES (ALL SITES)							0.88	0.56	-36.5%
AVERAGE OF INJURY CRASH RATE (EXCLUDING HIGH AND LOW SITES)							0.80	0.46	-41.5%

Table 10: **Average (Aggregate) Crash Rate (Crashes/Year)**

Sites	Crash Type	Analysis Period (Months)		Quantity		Crash Rate (Crashes/Year)		
		Before	After	Before	After	Before	After	Difference
Average Crash Rate (All Sites Aggregated)	**Total**	**821**	**560**	**233**	**157**	**3.41**	**3.36**	**-1.2%**
	Vulnerable Users	821	560	13	6	0.7	0.0	-32.3%
	Injury	821	560	60	28	0.5	0.3	-31.6%
Average Crash Rate (Aggregated, Excluding High and Low sites)	**Total**	**710**	**502**	**163**	**80**	**2.75**	**1.91**	**-30.6%**
	Vulnerable Users	710	502	9	3	0.15	0.07	-52.9%
	Injury	710	502	46	19	0.78	0.45	-41.6%

- Using the average of rates method, between the before and after analysis periods, the average of total, vulnerable user, and injury crash rates decreased by 17.3%, 49.6%, 36.5%, respectively. Excluding the statistical outliers (Sites 7 and 17), the average of total, vulnerable user, and injury crash rates decreased by 38.7%, 61.0%, 41.5%, respectively.
- Using the average (aggregate) rate method, between the before and after analysis periods, the average (aggregate) total, vulnerable user, and injury crash rates decreased by 1.2%, 32.3%, and 31.6%, respectively. Excluding the statistical outliers (Sites 7 and 17), the average (aggregate) total, vulnerable user, and injury crash rates decreased by 30.6%, 52.9%, and 41.6%, respectively.
- Change in crash rates at sites ranged from a decrease of 100% (two FL locations) to an increase of 41% (Atlanta, GA).
- 13 (76%) sites had a decreased total crash rate, 2 (12%) had an increased total crash rate, 2 (12%) had no crashes in either period.
- No crashes resulted in a fatality during before or after analysis periods at each of the 17 study sites.
- No crashes were reported during one or both analysis periods at 4 (24%) sites and both analysis periods at 2 (12%) sites.
- No vulnerable user crashes were reported during one or both analysis periods at 15 (88%) sites and both analysis period at 10 (59%) sites.
- No injury crashes were reported during one or both analysis periods at 10 (59%) sites and both analysis period at 4 (24%) sites.
- Crashes at one site (Atlanta, GA) accounted for 38% of total crashes (30% in the before period, 49% in the after period).

Study Sites – Disaggregated by Site Characteristics

A disaggregate analysis was completed to determine if certain types of asphalt art may be more effective or if art may be more effective under specific conditions. Tables 11–14 below summarize trends for total, vulnerable user, and injury crash rates for study sites broken down by geographic region and site setting.

2.8. Discussion of Historical Crash Analysis Results

On the basis of a before-after historical crash analysis of 17 asphalt art study sites, implementation of asphalt art appears to have a positive impact on the rate of crashes of all types. The average of total, vulnerable user, and injury crash rates for the combined study sites were reduced by 17%, 50%, and 37% respectively after installation of asphalt art. While the average (aggregate) rate also decreased in the after period. The trend between presence of asphalt art and reduced crash rates was consistent across sites with a variety of roadway settings, traffic control types, and art improvement type. The results are likely due to the improved conspicuity of the intersection and roadway user movements. It should be noted that at several locations, after analysis periods overlapped with the COVID-19 pandemic, when injury crash rates were elevated nationwide.

The total crash rate decreased or remained at 0 in the after analysis period compared to the before period at all sites, except Piedmont Avenue & 10th Street in Atlanta, GA (+41%) and Ponce de Leon Avenue & Clairemont Avenue in Decatur, GA (+28%) (both signalized intersections). The Piedmont Avenue & 10th Street site is located in the rapidly growing Midtown area of Atlanta and accounted for 38% of the total crashes occurring at all sites. Despite increased total crash rate after art was installed, the intersection experienced a 17% decrease in the injury crash rate (crashes/year) and a 4% decrease in vulnerable user crash rate—two important and widely utilized performance indicators. The project could be considered successful on the basis of this decrease in the injury crash rate and vulnerable user crash rate (which typically result in an injury, if reported).

Additionally, according to the City of Atlanta, rapid redevelopment of immediate area surrounding the intersection near the time of the art installation, resulted in a nearly three-fold increase in bike activity (without bike improvements at the intersection itself), an 18% increase in motor vehicle volumes on Piedmont Street, and a

Table 11: **Average (Aggregated) Total, Vulnerable User, and Injury Crash Rates by Geographic Region**

Region	#	Total Crash Rate (Crashes/Year)			Vulnerable User Crash Rate (Crashes/Year)			Injury Crash Rate (Crashes/Year)		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
Northeast	6	3.52	2.47	-30%	0.40	0.21	-47%	1.24	0.78	-37%
Southeast	11	3.36	3.75	+12%	0.10	0.09	-11%	0.73	0.52	-28%
Total	**17**	**3.41**	**3.36**	**-1.2%**	**0.19**	**0.13**	**-32.3%**	**0.88**	**0.60**	**-31.6%**

Table 12: **Average (Aggregated) Total, Vulnerable User, and Injury Crash Rates by Site Setting**

Setting	#	Total Crash Rate (Crashes/Year)			Vulnerable User Crash Rate (Crashes/Year)			Injury Crash Rate (Crashes/Year)		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
Urban Core	7	2.30	1.01	-56%	0.04	0.06	+48%	1.01	0.18	-82%
Urban Residential	6	5.04	5.82	+16%	0.47	0.18	-62%	1.02	0.85	-17%
Suburban	4	2.64	1.32	-50%	0.00	0.13	IND	0.50	0.79	+60%
TOTAL	**17**	**3.41**	**3.36**	**-1.2%**	**0.19**	**0.13**	**-32.3%**	**0.88**	**0.60**	**-31.6%**

Table 13: **Average (Aggregated) Total, Vulnerable User, and Injury Crash Rates by Site Facility Type**

Traffic Control	#	Total Crash Rate (Crashes/Year)			Vulnerable User Crash Rate (Crashes/Year)			Injury Crash Rate (Crashes/Year)		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
Intersection - Signal Controlled	7	6.60	6.27	-5%	0.26	0.20	-23%	1.60	0.94	-42%
Intersection - Stop Controlled	7	1.37	1.15	-16%	0.22	0.10	-52%	0.50	0.42	-17%
Mid-Block	3	1.06	1.09	+3%	0.00	0.00	-	0.15	0.14	-10%
TOTAL	**17**	**3.41**	**3.36**	**-1.2%**	**0.19**	**0.13**	**-32.3%**	**0.88**	**0.60**	**-31.6%**

Table 14: **Average (Aggregated) Total, Vulnerable User, and Injury Crash Rates by Site Improvement Type**

Improvement	#	Total Crash Rate (Crashes/Year)			Vulnerable User Crash Rate (Crashes/Year)			Injury Crash Rate (Crashes/Year)		
		Before	After	Difference	Before	After	Difference	Before	After	Difference
Roadway Art Sites (Excl. Sites with Crosswalk Art)	6	2.45	1.96	-20%	0.27	0.08	-72%	0.50	0.45	-9%
Roadway Art + Crosswalk Art Sites	2	0.73	0.57	-22%	2.08	1.29	-38%	0.73	0.00	-100%
Crosswalk Art Sites (Excl. Sites with Roadway Art)	9	4.78	4.81	+1%	0.18	0.19	+8%	1.20	0.83	-31%
Combined (Average Rate)	**17**	**3.41**	**3.36**	**-1.2%**	**0.19**	**0.13**	**-32.3%**	**0.88**	**0.60**	**-31.6%**

likely a significant increase in pedestrian volumes. It is reasonable to expect an increase in total crash and vulnerable user rate when volumes increase significantly and is encouraging that the injury crash rate decreased despite this.

Although crash rates for specific crash types (vulnerable user and injury crashes) did increase for certain crash types in the after periods, sample sizes were often very small (most locations had 0 or 1 crash in before-after periods averaging over 3 years). As crashes are for the most part rare and random events with several contributing circumstances, when crash sample sizes are small, crash reductions at most individual locations are not statistically significant when evaluated individually.

The disaggregate analysis indicated mixed results for each crash type investigated when considering sites by setting. Increases in pedestrian crashes in urban locations may be due an increased rate of pedestrians, cyclists, and even motor vehicle traffic generated by improving the location with asphalt art and other developments. Crash rates decreased for signalized and unsignalized intersections and experienced an insignificant increase at mid-block crossing locations between the before and after analysis periods. Notably, the average crash rate decreased at signalized intersections despite the significant number of crashes at the Atlanta site.

The negligible increases in overall and vulnerable user crash rates at improvement sites with crosswalk art alone may also be due to an increased rate of pedestrians, cyclists, and even motor vehicle traffic generated by site and nearby improvements. Despite a slight increase in overall (+1%) and vulnerable user (+8%) crashes at crosswalk art sites, injury crashes were reduced by 31%.

Disaggregate analyses in the present study are based on a very limited sample sizes using basic crash analysis techniques. As such, while we cannot infer direct causation, results generally indicated reduced crash rates after installation of art for most crash types across a range of settings, traffic control, and improvement types. As more post-implementation crash data becomes available for asphalt art sites, further study and analysis using larger sample sizes would provide more insight into effectiveness of different types of art improvements in different roadway contexts.

3. Behavioral Observational Assessment

3.1. Background and Scope

While historical crash data provides insight into the safety performance of a subject site, it is important to keep in mind that crashes are rare occurrences and almost always have multiple contributing factors. The sample size of pedestrian crashes at most locations is too small to be of statistical significance at most locations individually. This is indicated in the above historical crash data, in that most sites have few to zero pedestrian crashes over both analysis periods. In instances where pedestrian crashes occur infrequently, other factors such as near-miss conflicts between pedestrians and vehicles, observed road user behavior, and compliance with traffic control devices can provide insight on the safety impacts as a result of roadway treatments such as asphalt art.

To study the impact of asphalt art on driver and pedestrian behavior, five intersection sites with art projects in Bloomberg Philanthropies' Asphalt Art Initiative were selected with scheduled implementation dates for summer-fall 2021. Video was recorded of the intersection capturing vehicle and pedestrian behavior for a period prior to and following installation. Using this video, visual observations were performed to assess pedestrian and motorist behavior during each observation period. The observation assessment methodology, information about sites selected, and findings are presented in the sections below.

3.2. Methodology

Video recordings of each intersection location were collected for 48-hour periods during the same days of the week (when possible) to capture approaching vehicles and crossing movements at each leg of the intersection. Video was first reviewed at a high level to determine appropriate 8-hour analysis periods before and after the installation of the art/improvements. In some cases, this 8-hour period was broken into multiple segments to capture peak hour pedestrian volumes.

The video recordings were reviewed during the before and after analysis periods to conduct conflict analyses and record other observable behavior metrics. Pedestrian group crossings (as opposed to individual pedestrians, which were also recorded) were utilized for purposes of analysis. This metric is typical for pedestrian crossing studies as pedestrians waiting at an intersection typically arrive or cross in groups. As an example, if a child and parent arrived at an intersection together and crossed the roadway together, they would be counted as a single crossing, while if there were two individuals waiting at an intersection and one crossed during a “flashing don’t walk phase” while the other pedestrian decided to wait until the next interval, they would be counted as separate crossings.

As the observational study sites consisted of both signalized and unsignalized intersections, different metrics were captured based on different types of traffic control. The following details road-user behavior metrics assessed as part of this study.

3.2.1. Metrics at All Observation Sites

Pedestrian-Vehicle Conflicts

To compare road user behavior in the before and after conditions at signalized and unsignalized intersection locations, a conflict analysis was conducted using video data collected at each location. Conflict analysis involves observing and recording conflicts between pedestrians and drivers/vehicle. A conflict is defined as an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged, and at least one of the road users then takes action to avoid a crash. Such an action could be as simple as a routine application of the brakes to give way to a crossing pedestrian.

Pedestrian-vehicle conflicts range in severity by how likely they are to result in a crash. This analysis considered conflicts of two levels:

- **Low Crash Potential** – A motorist noticeably brakes to avoid striking a pedestrian or group; a pedestrian or group of pedestrians stops to avoid being in the path of an oncoming or turning vehicle, although the vehicle has appropriately yielded. Neither actions are sudden, atypical, or extreme. Vehicles passing their appropriate stop bar, or negotiation of space between pedestrian and vehicle in the crosswalk may suggest a Low Crash Potential conflict.
- **High Crash Potential** – A motorist noticeably and clearly suddenly stops or swerves to avoid striking a pedestrian or group of pedestrians in a fashion that suggests reduced control of the vehicle; a pedestrian or group of pedestrians jumps, runs, stops, or suddenly steps or lunges to avoid being struck by a vehicle.

An example of a Low Crash Potential conflict is when a vehicle turning towards a pedestrian in the crosswalk noticeably brakes to avoid conflicting with the pedestrian. This behavior is normal and as expected, as pedestrians are crossing with the signal and the car properly yields to them; however, this is still considered to be a conflict because, if the vehicle had not yielded quickly, the vehicle would have to suddenly break or swerve (indicating a High Crash Potential conflict) to avoid potential collision. A turning vehicle yielding the right of way to crossing pedestrians is also the most common type of Low Crash Potential conflict encountered. The goal of this conflict analysis is to identify observed differences in driver and pedestrian behavior and occurrences of crash-risk conflicts before and after art implementation.

To consider the rate of Low and High Crash Potential conflicts, the video recorded was also reviewed to quantify pedestrian activity. The following metrics pertaining to pedestrian activity were quantified:

- **Pedestrian Crossing Groups** – A pedestrian, or a group of pedestrians, that both approach the crosswalk and cross at the intersection simultaneously.
- **Pedestrians per Crossing Group** - The number of people present per pedestrian crossing as defined above.
- **Origin/Destination of Crossing Groups** – The origin and destination crosswalk for each group of pedestrian crossings.

Pedestrian Actions

An analysis was conducted of undesired pedestrian actions at intersections in before and after conditions using collected video data. Undesired pedestrian actions were recorded as follows:

- Pedestrian crossing against signal – When a pedestrian crosses the intersection while the movement is prohibited by the pedestrian signal and begins their movement while a solid "Don't Walk" symbol is displayed.
- Pedestrian crossing outside of crosswalk – When a pedestrian crosses mid-block, at an intersection approach outside the vicinity of the crosswalk or crosses the intersection at a diagonal.

3.2.2. Metrics at Unsignalized Observation Sites

Vehicle Yield/Stop Compliance

The goal of this yield compliance analysis is to identify observed differences in driver behavior with respect to compliance with yielding or stopping for pedestrians crossing or waiting to cross before and after art implementation, as well as noted behavior of pedestrians in the before and after observation periods.

Pedestrians have the right of way at unsignalized intersections, regardless of the presence or absence of a marked crosswalk, but people often have to wait for drivers to yield or stop for them before they start crossing. Particularly on higher-speed or higher-volume streets, drivers often fail to yield to pedestrians who are waiting to cross, and sometimes even fail to yield to people already in the crosswalk. In addition to injury risks, pedestrians face extended delays in crossing when drivers do not properly yield or stop for them.

As such, at unsignalized locations, the recorded videos were reviewed to analyze yielding behavior of drivers for crossing pedestrians along with other indicators of the traffic environment. The below metrics were recorded. It should be noted that only crossings with vehicles present at the intersection were analyzed, excluding crossings where pedestrians crossed with an adequate gap, unconflicted.

» **Vehicle Presence** – Whether there one or more vehicles approaching the observed crossing at the intersection at the time of the pedestrian crossing.

» **Non-Yielding Drivers/Vehicles** – The number of drivers who failed to yield to a pedestrian initiating crossing or in the crosswalk. This excludes any driver yielding to pedestrians even if suddenly braking in a manner that would constitute a potential crash conflict as defined in the section above.

» **Eventual Yield** – Whether or not the first or subsequent drivers, if present, eventually yielded to crossing pedestrians or pedestrians. If no vehicles yielded, pedestrians crossing during an adequate gap were noted as crossing with no eventual yield.

3.3. Observation Sites and Analysis Periods

A total of five sites were selected for observations analysis with asphalt art projects scheduled for installation in summer and fall 2021. Table 15 below provides a summary of each site, setting, intersection type, roadway/roadside improvement(s). Before and after street level and aerial photography is provided for each location in the **Appendix**. Table 16 provides a summary of locations by date of art installation and observation analysis periods. Before and after photos of each observation site are shown in Figures 2–6, illustrating the improvements made at each site.

Table 15: **Summary of Observational Assessment Sites**

#	City	State	Intersection	Traffic Control	Setting	Summary
1	Trenton	NJ	South Clinton Ave & Barlow St/ R Wallenberg Ave	Signal	Urban Core	Painted crosswalks
2	Richmond	VA	W Marshall St & Brook Rd	Signal	Urban Core	Curb extensions, bollards, painted intersection
3	Durham	NC	Club Blvd & Glendale Ave	Signal	Suburban	Painted crosswalks, painted intersection
4	Pittsburgh	PA	Roup Ave, S Fairmount St & Harriet St	Stop	Neighborhood Residential	Curb extensions, additional/revised marked crosswalks
5	Lancaster	PA	Strawberry St & Vine St	Stop	Urban Core	Curb extensions, bollards

Table 16: **Summary of Analysis Periods**

#	City	State	Intersection	Installation Date(s)	Before Observation Date	After Observation Date	Observation Period Times
1	Trenton	NJ	South Clinton Ave & Barlow St/ R Wallenberg Ave	9/4/21 - 9/5/21	8/24/2021	9/21/2021	7 AM–11 AM, 3 PM–7 PM
2	Richmond	VA	W Marshall St & Brook Rd	10/24/21 – 10/26/21	9/23/2021	11/16/2021	11 AM–7 PM
3	Durham	NC	Club Blvd & Glendale Ave	5/21/21- 5/24/21	5/15/2021	7/3/2021	10 AM–6 PM
4	Pittsburgh	PA	Roup Ave, S Fairmount St & Harriet St	9/23/21 – 9/24/21	9/9/2021	10/21/2021	8 AM–12 PM, 3:30 PM–7:30 PM
5	Lancaster	PA	Strawberry St & Vine St	9/11/21- 9/12/21	9/9/2021	10/24/2021	8 AM–12 PM, 3:30 PM–7:30 PM

Trenton, NJ

Figure 2: **Trenton, NJ - Before**

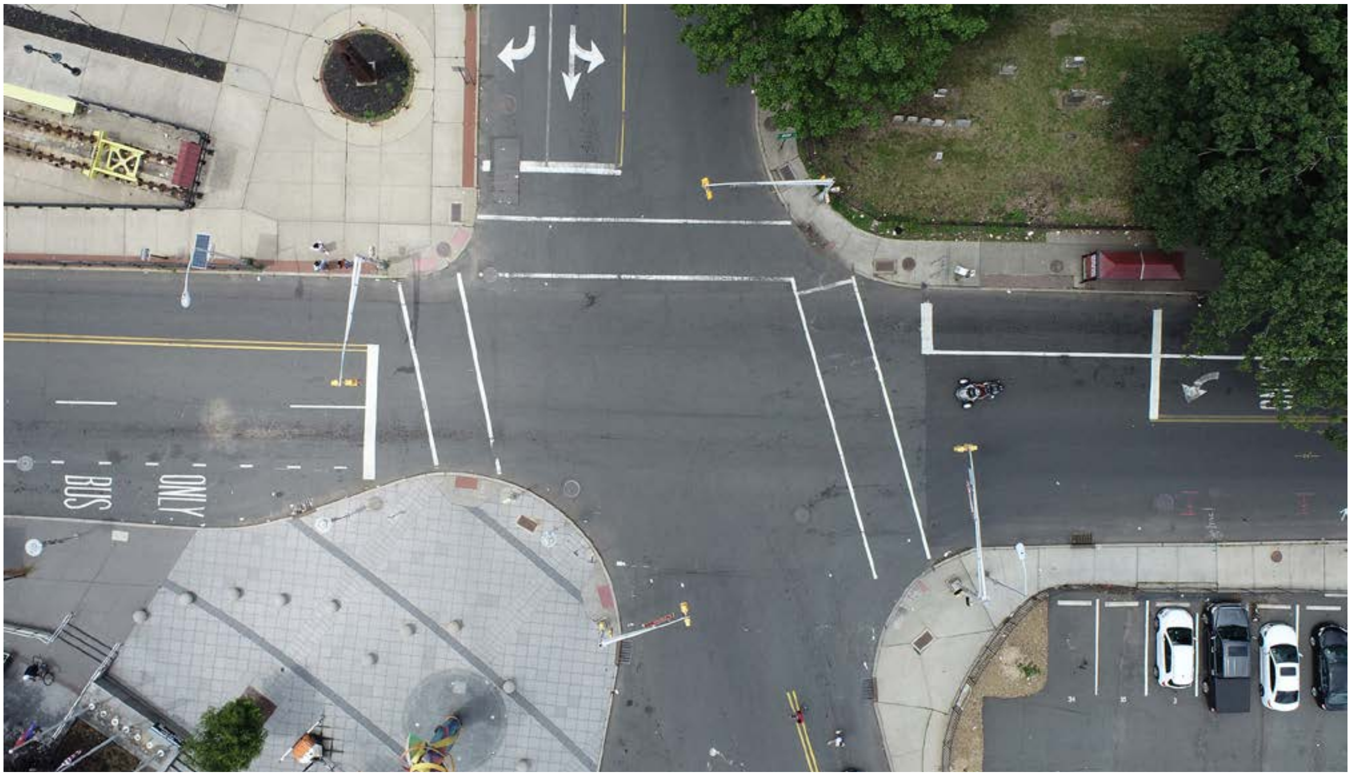


Figure 3: **Trenton, NJ - After**

Richmond, VA

Figure 6: **Richmond, VA - Before**

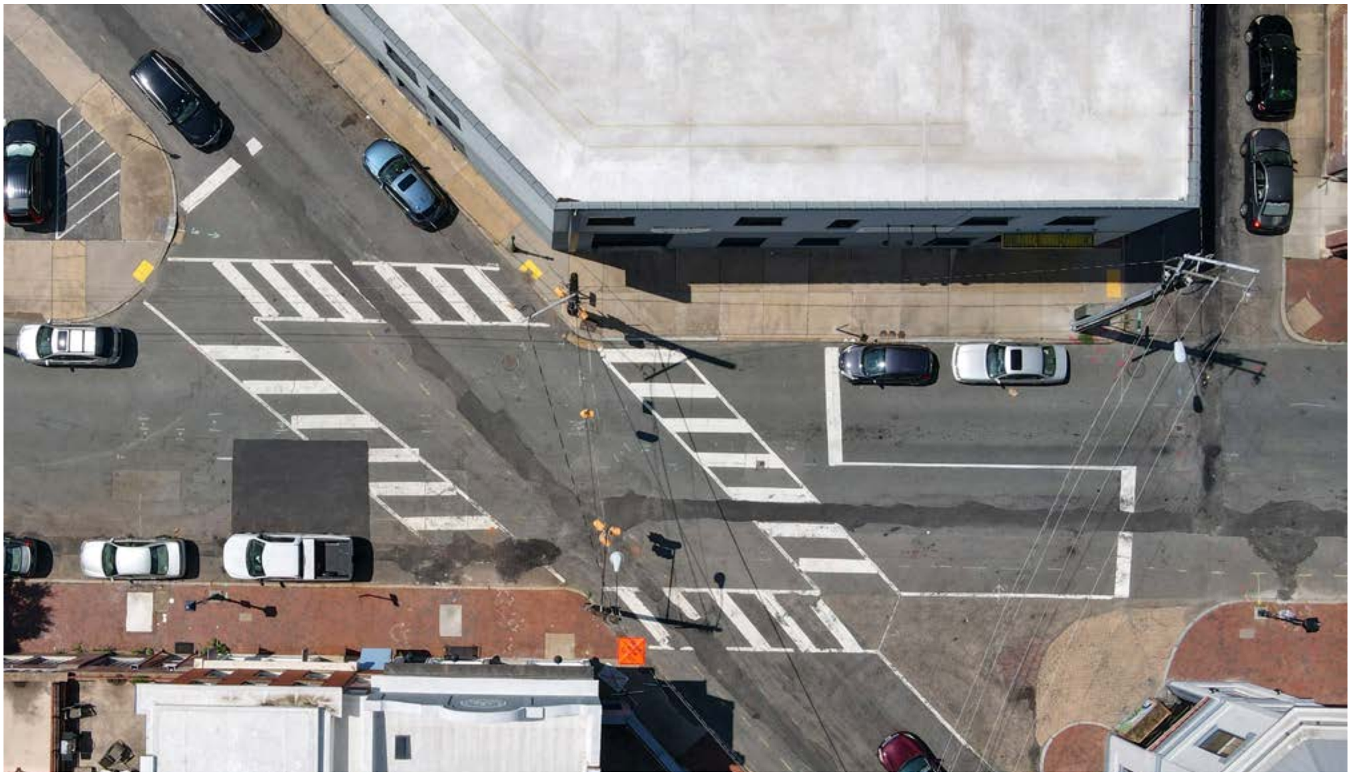
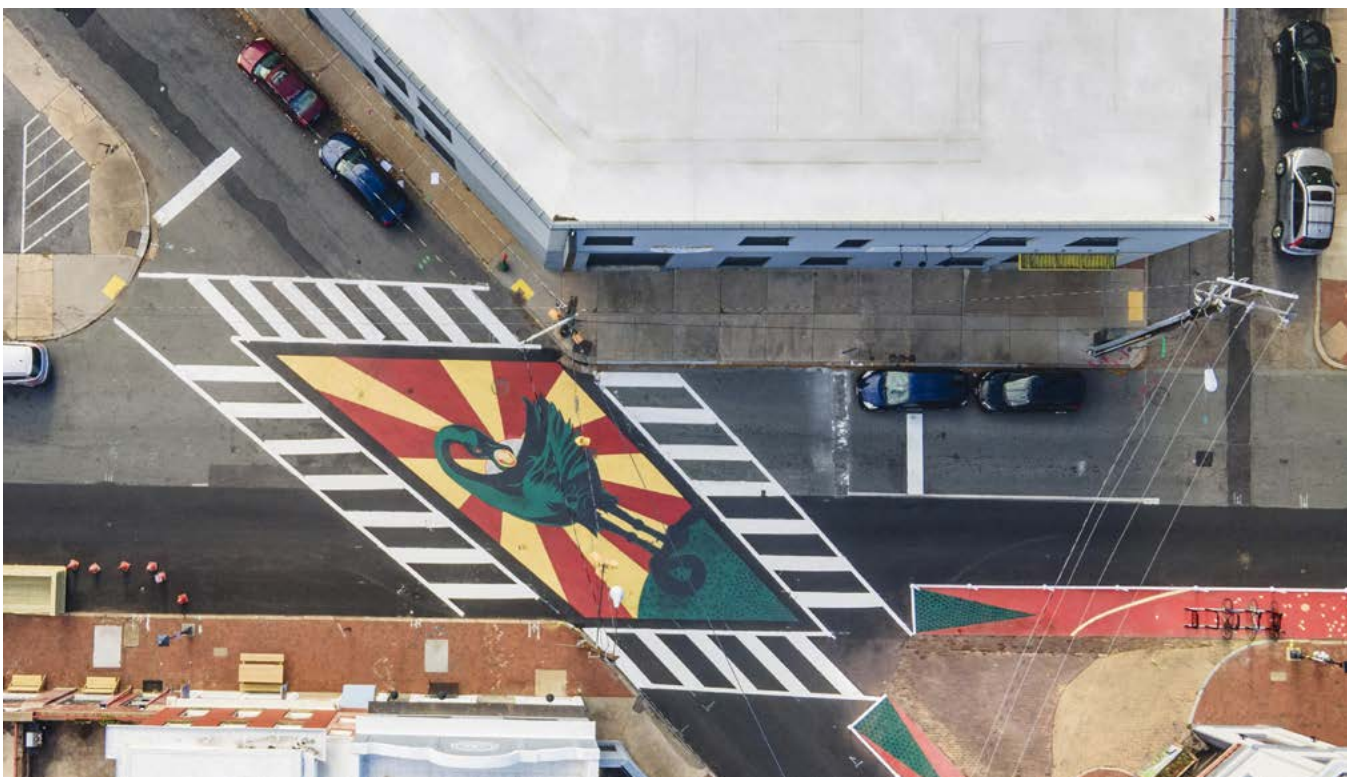


Figure 7: **Richmond, VA - After**



Durham, NC

Figure 8: **Durham, NC - Before**

Figure 9: **Durham, NC - After**

Pittsburgh, PA

Figure 10: **Pittsburgh, PA - Before**

Figure 11: **Pittsburgh, PA - After**

Lancaster, PA

Figure 12: **Lancaster, PA - Before**

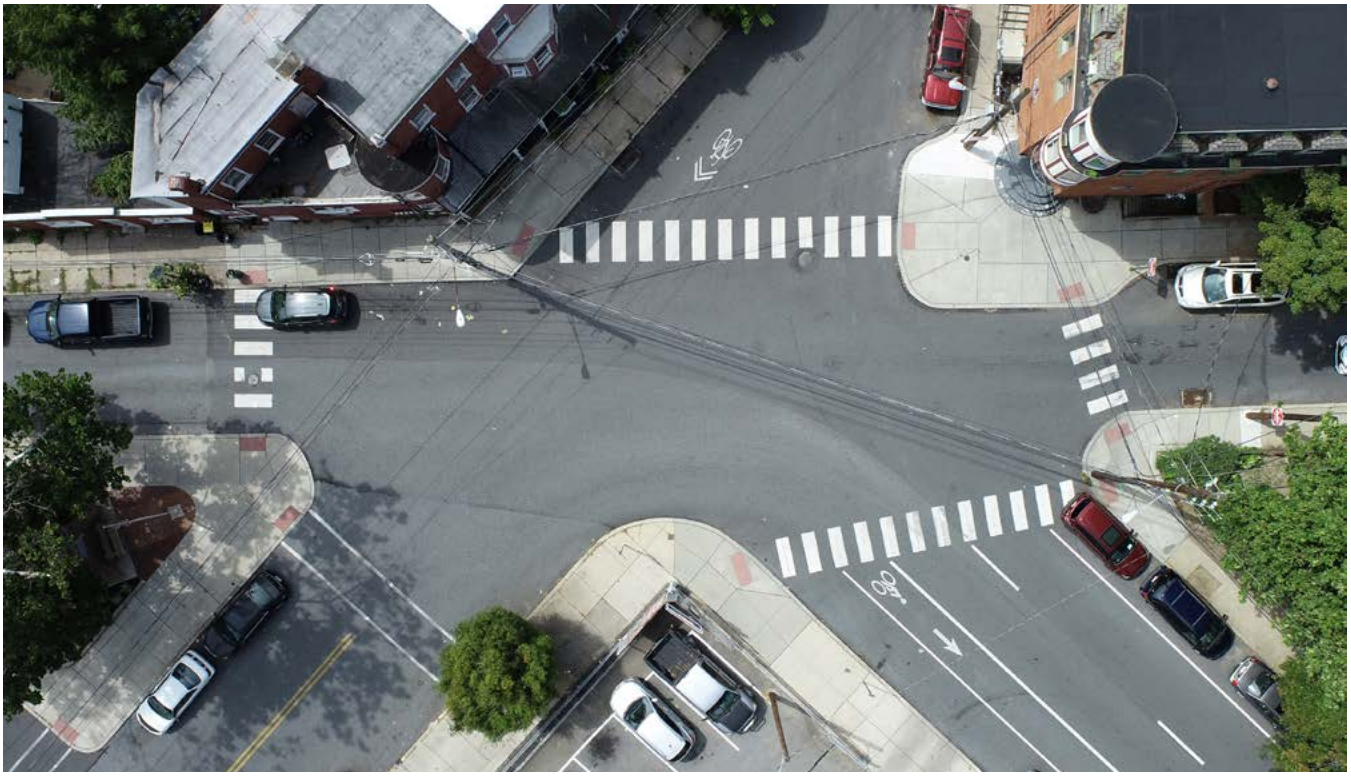
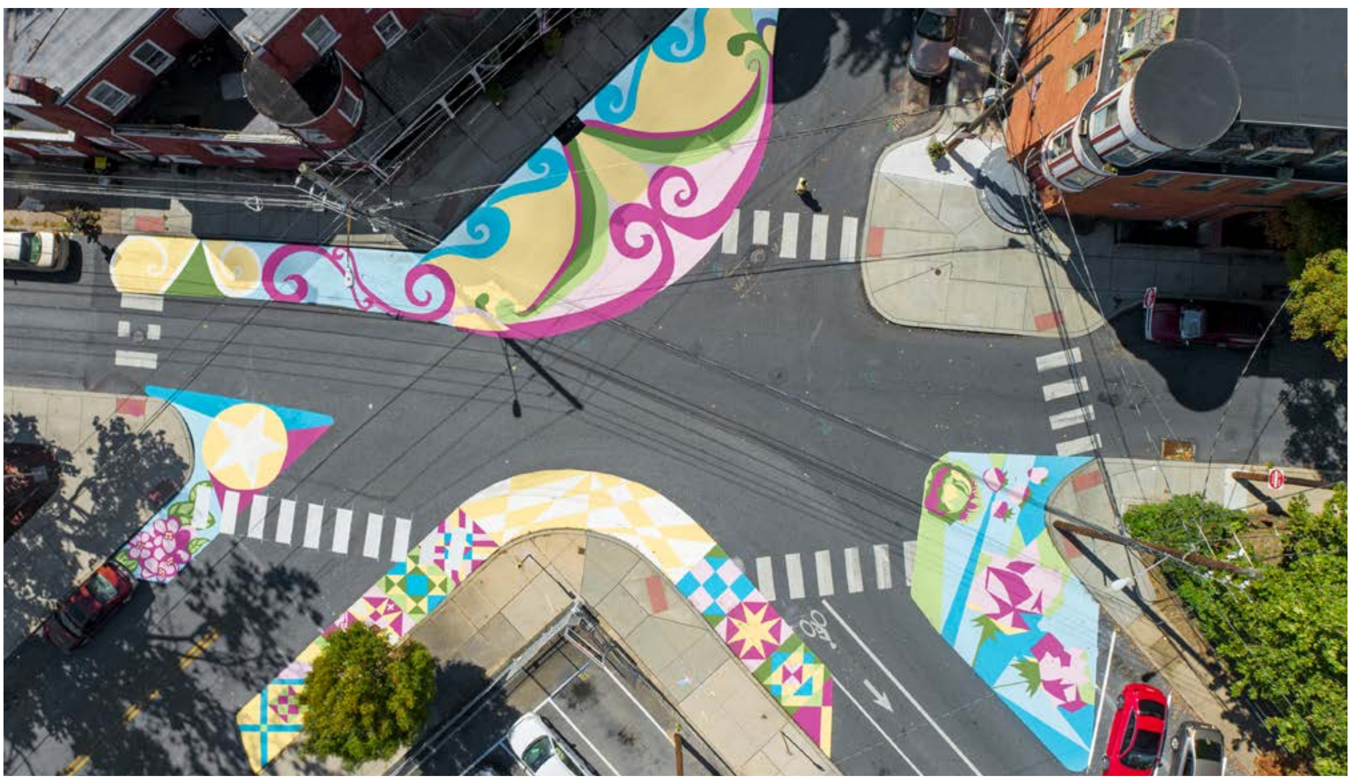


Figure 13: **Lancaster, PA - After**



3.4. Behavioral Assessment Results

3.4.1. Vehicle-Pedestrian Conflict Assessment

At both signalized locations, the total conflict rate and rate of low crash potential conflicts decreased after the installation of asphalt art. Tables 17 summarizes the results of the vehicle-pedestrian conflict assessments for each site, signalized observation sites aggregated, unsignalized observation sites aggregated, and all observation sites aggregated. The high crash potential conflict rate increased at the Trenton location negligibly (an absolute difference of 0.1% in the rate). The average (aggregated) low and high crash potential conflict rates decreased when considering observed crossing movements at combined signalized study sites.

At the Durham unsignalized site, the rate of both high and low crash potential conflicts decreased. The low crash potential conflict rate decreased by 61% (an absolute difference of six fewer occurrences) at the Pittsburgh site and increased by 23% (an absolute difference of two additional occurrences) at the Lancaster site. No high crash potential conflicts occurred during the before or after observation periods at the Pittsburgh and Lancaster sites. The average (aggregated) low and high crash potential conflict rates decreased when considering observed crossing movements at unsignalized study sites.

When considering all observed movements at observation sites aggregated, the rate of crossings involving a low and high crash potential conflict decreased by 27% and 18%, respectively, an overall decrease of 25%.

Table 17: **Pedestrian-Vehicle Conflict Assessment Results**

	Pedestrian Crossing Behavior/Action	Before		After		
		Crossings (#)	Crossings (%)	Crossings (#)	Crossings (%)	Conflict Rate Reduction (%)
Trenton, NJ	**Total Pedestrian Crossings**	**1,035**	-	**1,050**	-	-
	Crossings Involving a Conflict	68	6.6%	59	5.6%	-14.5%
	High Crash Potential Conflicts	13	1.3%	15	1.4%	+13.7%
	Low Crash Potential Conflicts	55	5.3%	44	4.2%	-21.1%
Richmond, VA	**Total Pedestrian Crossings**	**325**	-	**319**	-	-
	Crossings Involving a Conflict	14	4.3%	6	1.9%	-56.3%
	High Crash Potential Conflicts	5	1.5%	1	0.3%	-79.6%
	Low Crash Potential Conflicts	9	2.8%	5	1.6%	-43.4%
Aggregated for Signalized Sites Combined	**Total Pedestrian Crossings**	**1,360**	-	**1,369**	-	-
	Crossings Involving a Conflict	82	6.0%	65	4.7%	-21.3%
	High Crash Potential Conflicts	18	1.3%	16	1.2%	-11.7%
	Low Crash Potential Conflicts	64	4.7%	49	3.6%	-23.9%
Durham, NC	**Total Pedestrian Crossings**	**301**	-	**215**	-	-
	Crossings Involving a Conflict	6	2.0%	3	1.4%	-30.0%
	High Crash Potential Conflicts	1	0.3%	0	0.0%	-100.0%
	Low Crash Potential Conflicts	5	1.7%	3	1.4%	-16.0%
Pittsburgh, PA	**Total Pedestrian Crossings**	**287**	-	**372**	-	-
	Crossings Involving a Conflict	12	4.2%	6	1.6%	-61.4%
	High Crash Potential Conflicts	0	0.0%	0	0.0%	-
	Low Crash Potential Conflicts	12	4.2%	6	1.6%	-61.4%
Lancaster, PA	**Total Pedestrian Crossings**	**253**	-	**308**	-	-
	Crossings Involving a Conflict	4	1.6%	6	1.9%	+23.2%
	High Crash Potential Conflicts	0	0.0%	0	0.0%	-
	Low Crash Potential Conflicts	4	1.6%	6	1.9%	+23.2%
Aggregated for Unsignalized Sites Combined	**Total Pedestrian Crossings**	**841**	-	**895**	-	-
	Crossings Involving a Conflict	22	1.6%	15	1.1%	-32.3%
	High Crash Potential Conflicts	1	0.1%	0	0.0%	-100.0%
	Low Crash Potential Conflicts	21	1.5%	15	1.1%	-29.0%
Aggregated for Observational Sites Combined	**Total Pedestrian Crossings**	**2,201**	-	**2,264**	-	-
	Crossings Involving a Conflict	104	4.7%	80	3.5%	-25.2%
	High Crash Potential Conflicts	19	0.9%	16	0.7%	-18.1%
	Low Crash Potential Conflicts	85	3.9%	64	2.8%	-26.8%

3.4.2. Driver-Pedestrian Yield Assessment at Unsignalized Sites

Drivers were more likely to yield to pedestrians after asphalt art was installed. Table 18 summarizes the results of the pedestrian-vehicle yielding assessment for unsignalized intersection sites (Durham, NC; Pittsburgh, PA; and Lancaster PA sites, and the three unsignalized sites combined, respectively). While yield behavior results varied at each site, when considering observed crossings at all three unsignalized locations aggregated, the occurrences of the first/all vehicles yielding increased by 27% and the occurrences of no vehicles yielding before the pedestrian group crossed decreased by 27%.

Table 18: **Pedestrian-Vehicle Yield Assessment**

	Pedestrian Crossing Behavior/Action	Before		After		Difference
		Crossings (#)	Crossings (%)	Crossings (#)	Crossings (%)	
Durham, NC	**Crossings w/ Vehicle Present**	**50**	-	**38**	-	-
	All drivers yielded to pedestrian(s) crossing	7	14.0%	3	7.9%	-43.6%
	One or more drivers did not yield, but drivers eventually yielded	6	12.0%	7	18.4%	+53.5%
	No drivers yielded—pedestrian crossed during a gap	37	74.0%	28	73.7%	-0.4%
Pittsburgh, PA	**Crossings w/ Vehicle Present**	**26**	-	**30**	-	-
	All drivers yielded to pedestrian(s) crossing	24	92.3%	28	93.3%	+1.1%
	One or more drivers did not yield, but drivers eventually yielded	0	0.0%	1	3.3%	-
	No drivers yielded—pedestrian crossed during a gap	2	7.7%	1	3.3%	-56.7%
Lancaster, PA	**Crossings w/ Vehicle Present**	**36**	-	**93**	-	-
	All drivers yielded to pedestrian(s) crossing	25	69.4%	71	76.3%	+9.9%
	One or more drivers did not yield, but drivers eventually yielded	5	13.9%	4	4.3%	-69.0%
	No drivers yielded—pedestrian crossed during a gap	6	16.7%	18	19.4%	+16.1%
Aggregated for Unsignalized Sites Combined	**Crossings w/ Vehicle Present**	**112**	-	**161**	-	-
	All drivers yielded to pedestrian(s) crossing	56	50.0%	102	63.4%	+26.7%
	One or more drivers did not yield, but drivers eventually yielded	11	9.8%	12	7.5%	-24.1%
	No drivers yielded—pedestrian crossed during a gap	45	40.2%	47	29.2%	-27.3%

3.4.3. Pedestrian Actions Assessment

Table 19 summarizes the results of the pedestrian action assessment. The percentage of occurrences of undesirable pedestrian actions are calculated for each observation period by dividing the number of occurrences of undesired crossing actions by total number of crossings. At both signalized sites, the percentage crossings involving undesirable pedestrian actions (crossing against the signal and crossing outside the vicinity of the marked crosswalk) decreased in the period after asphalt art was installed.

The percentage of crossings involving pedestrians crossing outside of the marked crosswalk increased in the after period at unsignalized observation when combined despite a reduction at the Pittsburgh site. Pedestrian crossing actions were not recorded for the Durham site.

3.5. Discussion of Behavior Assessment Results

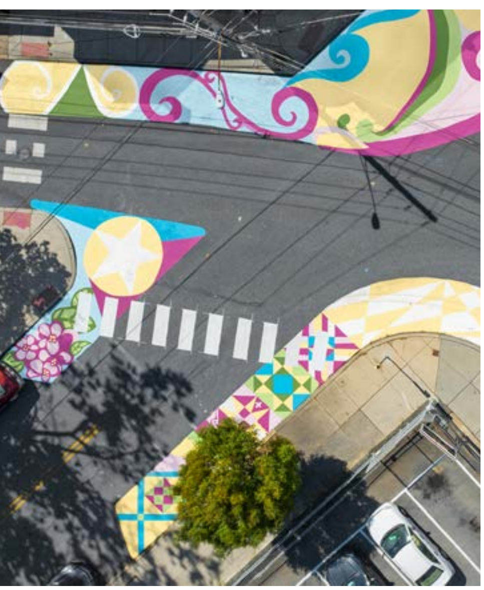
As crashes almost exclusively have multiple contributing circumstances and are often random events, road user behavior is a critical indictor of road safety performance at a site in addition to crash data. Across each metric analyzed, results indicated that asphalt art has an overall positive impact on safe driver and pedestrian behavior, resulting in a reduced (-25%) rate of driver/vehicle-pedestrian conflicts, improved (+27%) rate of drivers yielding to pedestrians, and reduced (-27 to -38%) rate of undesirable pedestrian actions in the after observation period.

When considering road user behavior at sites by type of traffic control, driver/vehicle-pedestrian conflict rates were reduced at both signalized and unsignalized intersections while a greater rate of pedestrians were observed crossing outside of the marked crosswalk vicinity at unsignalized sites. The driver yield assessment was only performed for unsignalized sites only as traffic signals control vehicle and pedestrian movements at signalized intersections. Results indicate that drivers not only yielded immediately to pedestrians 27% more frequently after art was installed, but the frequency of no vehicles stopping for the pedestrian (pedestrian having to find a gap in traffic to cross) was reduced by 27%. While MUTCD rulings have suggested that the art may confuse drivers as to whether or not the art is part of a marked crosswalk, drivers yielded more often in the after observation period.

Table 19: **Pedestrian Actions at Observational Study Locations**

	Pedestrian Crossing Behavior/Action	Before		After		Difference
		Crossings (#)	Crossings (%)	Crossings (#)	Crossings (%)	
Trenton, NJ	**Total Crossings**	**1035**	-	**1050**	-	-
	Crossing Against Signal (Solid DON'T WALK)	363	35.1%	229	21.8%	-37.8%
	Crossing Outside of Marked Crosswalks	207	20.0%	139	13.2%	-33.8%
Richmond, VA	**Total Crossings**	**325**	-	**319**	-	-
	Crossing Against Signal (Solid DON'T WALK)	5	1.5%	1	0.3%	-79.6%
	Crossing Outside of Marked Crosswalks	68	20.9%	35	11.0%	-47.6%
Aggregated for Signalized Sites Combined	**Total Crossings**	**1360**	-	**1369**	-	-
	Crossing Against Signal (Solid DON'T WALK)	368	27.1%	230	16.8%	-37.9%
	Crossing Outside of Marked Crosswalks	275	20.2%	174	12.7%	-37.1%
Durham, NC	**Total Crossings**	**301**	-	**215**	-	-
	Crossing Outside of Marked Crosswalks	Not Available	Not Available	Not Available	Not Available	Not Available
Pittsburgh, PA	**Total Crossings**	**287**	-	**372**	-	-
	Crossing Outside of Marked Crosswalks	28	9.8%	23	6.2%	-36.6%
Lancaster, PA	**Total Crossings**	**253**	-	**308**	-	-
	Crossing Outside of Marked Crosswalks	42	16.6%	64	20.8%	+25.2%
Aggregated for Unsignalized Sites	**Total Crossings**	**841**	-	**895**	-	-
	Crossing Outside of Marked Crosswalks	70	5.1%	87	6.4%	+23.5%
Aggregated for Observational Sites Combined	**Total Crossings**	**2201**	-	**2264**	-	-
	Crossing Against Signal (Solid DON'T WALK) (Signalized Sites Only)	368	27.1%	230	16.8%	-37.9%
	Crossing Outside of Marked Crosswalks	345	15.7%	261	11.5%	-26.5%

4. Conclusion/Next Steps



As indicated in the results of both the historical crash analysis and observational behavior assessment, asphalt art had a strong positive correlation with improved safety benefits across aggregated and most individual study sites. Road user behavior clearly improved across the observed study sites in the after analysis periods.

At unsignalized intersections, there was a greater frequency of drivers immediately yielding to crossing pedestrians. Similarly, pedestrian-vehicle conflict assessments indicated a reduction in conflict rates at both signalized and unsignalized intersections. Good pedestrian crossing practices, such as crossing at marked crosswalk locations and crossing during the pedestrian phase, also improved substantially at signalized intersections with crossings against the signal dropping from 27% to 17%. Meanwhile, at unsignalized intersections, a few more people crossed outside the marked crosswalk, but the rate was still quite low (1% of people crossing the street).

On the basis of these positive findings, the study team recommends a significant expansion of this study to include asphalt art sites in a variety of roadway and land use contexts. This would allow for a more detailed assessment of which elements of projects (the art itself, additional traffic control, roadway, or roadside improvements, etc.) are the most effective, and also take into account other changes that may have taken place after the implementation period (redevelopment, population growth, changes to local bike or transit networks, etc.). It will also be critical to have control groups to account for the random variation in crash rates over time. This would determine a crash modification factor for asphalt art projects and provide the research grounding that some transportation professionals have requested.

This study also provides important context and precedent for the FHWA and others working to improve the MUTCD and other design guidance in the U.S. and globally. As the FHWA is currently revising the MUTCD, this analysis could contribute to more immediate changes to the language of that document to be more supportive of asphalt art projects going forward. Federal adoption of the language regarding color crosswalks proposed jointly by ITE and NACTO could clarify guidance and go a long way toward removing arbitrary barriers to asphalt art implementation. Additionally, since asphalt art is not technically prohibited by the current MUTCD and has only been restricted through interpretation memos that did not undergo the Federal regulatory process, the FHWA could remove this ambiguity with another such interpretation memo citing the results of this study and clarifying that the use of color in crosswalks and the use of artwork on roadways is in fact permitted under the 2009 MUTCD (excluding controlled-access highways such as Interstates/freeways).

Last and perhaps most important, this study, with a rigorous analysis of nearly two dozen projects across the country, provides supporting quantitative data for residents and city officials to use to implement asphalt art projects in their own communities. The results provide evidence to decision-makers that these projects will likely reduce crashes and improve safety for the most vulnerable users on the road.

By contributing to the body of research on this topic and through the Asphalt Art Initiative and work by cities, the study team hopes to encourage more arts-focused transportation projects that contribute to safer city streets across the country and around the world.

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