EVALUATION OF SOLID GREEN BICYCLE LANES

TO INCREASE COMPLIANCE AND BICYCLE SAFETY

Submitted to:

Federal Highway Administration
Office of Traffic Operations

Submitted by:

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Department of Transportation

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NATURE OF THE PROBLEM

On-street bicycle lanes are designed for the exclusive use of cyclists to enhance safety and improve operations for all roadway users. Exclusive bicycle lanes segregate roadway users of different sizes and speeds to reduce the likelihood of crashes and improve mobility. Motorists have been observed driving, standing and parking in bicycle lanes, thereby undermining the safety and traffic flow benefits of these marked lanes. Motorists may be insufficiently aware of the presence of bicycle lanes and their obligation to avoid driving, standing or parking thereon. Frequent incursions of motorists into bicycle lanes can have an intimidating effect on cyclists and lead to reduced levels of cycling. This problem has been noted particularly where the bicycle lane is adjacent to the curb, rather than adjacent to a lane of curbside parking.

By emphasizing the portion of the roadway adjacent to the curb reserved for the exclusive or preferential use by cyclists, bicycle usage can be encouraged. Correct lane positioning is important for cyclists at intersection approaches – especially for the "right turn trap" type crash in which a vehicle encroaches into the bicycle lane for a right turn and strikes a cyclist. By defining the correct lane position cyclists may be more prominent in the cone of vision for both overtaking right turning motorists and oncoming left turning motorists. According to the Institute for Highway Safety/Highway Loss Data Institute website 35% of cyclist deaths in 2000 occurred at intersections. In New York City, intersections account for 88% of cyclist injuries and 84% of cyclist fatalities.[1] According to the FHWA's Transportation Air Quality – Selected Facts and Figures publication FHWA- PD-99-015, commuter trips by bicycle declined by 20% from 1980 to 1990, while urban traffic congestion levels from 1982 – 1996 had increases typically in the range of 20% - 30% (or more).

These developments are contrary to the goals of the National Bicycling and Walking Study FHWA-PD-94-023 which are:

1. To double the current percentage of total trips made by bicycling and walking, and;
2. To simultaneously reduce by ten percent the number of cyclists and pedestrians killed or injured in traffic crashes.

According to Kenneth R. Wykle, former Federal Highway Administrator, in his

1 Cyclist injury data comes from NYSDMV. Cyclist fatality data comes from NYPD/DOT database. Both data sets cover the period 2005-2009.

Pedaling into the 21st Century article “People shouldn’t have to use a gallon of gasoline to get a quart of milk. Increased use of bicycling as a means of transportation also will help protect the environment, reduce traffic congestion, and develop more livable communities.”

DESCRIPTION OF EXPERIMENTAL DEVICES

The "EVALUATION OF SOLID GREEN BICYCLE LANES TO INCREASE COMPLIANCE AND BICYCLE SAFETY" project was approved by FHWA in May 2005. The project was designed to answer two questions:

1. Does the use of the solid green marking prompt motorists to respect the bicycle lane (reducing encroachments) as well as be more aware of cyclists along the roadway?
2. Does the solid green pavement marking increase bicycle use by providing a well-defined area for the bicyclist in the roadway?

Beginning in 2007, New York City Department of Transportation (NYCDOT) has experimented with using green paint to demarcate curbside bike lanes in their entirety. To date, green painted lanes have been used in 28 projects for a total of 18.4 lane miles in New York City. As discussed in the original project proposal, the purpose of this experiment was to evaluate the effectiveness of solid green pavement marking between the bicycle lane striping. It was anticipated that the use of the solid green marking would prompt motorists to respect the bicycle lane (reducing encroachments) as well as be aware of cyclists along the roadway. In addition, the solid green pavement marking was expected to prompt greater bicycle use by providing a well-defined area for the bicyclist in the roadway. NYC Traffic Regulations prohibit cars from driving in bike lanes except when reasonable and necessary to make turns or comply with NYPD instructions (Section 4-12 (p)).

As a result of coordination between the Bicycle Technical Committee (BTC) and the Pavement Markings Technical Committee (PMTC) of the National Committee on Uniform Traffic Control Devices (NCUTCD), the color green was identified as the most likely color for this experiment. (In addition to common perception, the 2009 MUTCD defines the use of blue pavement markings for handicapped parking only in Section 3A.05.

NYCDOT elected to use the Ride-A-Way Coating Material, manufactured by Integrated Paving Concepts Inc., a "high performance premium coating material consisting of epoxy, modified acrylic polymers blended with sand and aggregate." StreetBond Colorant was added to provide color to the coating. Each lane received 2 coats of the Ride-A-Way Coating Material. NYCDOT's findings of the paint are as follows:

- The paint does not cause the lane to become slippery when wet (0.5 friction factor)
- It initially masks imperfections in the asphalt, but over time as the lane becomes dirty, imperfections become more pronounced and visible.
- The shade shows up well at night under the street light illumination of the city's high pressure sodium lamps.
- Refurbishment is required approximately every 3 to 5 years.

METHODOLOGY

To determine the impact of the solid green paint markings on driver and cyclist behavior, NYCDOT staff observed driver and cyclist behavior along four green paint treated curbside lanes and three standard bicycle lanes with white lane lines. Traffic counts were conducted during the PM peak period (4pm-6pm) in September of 2010.

Of the three control lanes, two are typical non-curbside bike lanes. The third, Clinton St. in Brooklyn between Remsen and Montague Streets is one of the few instances of a curbside bike lane that is not painted green. Due to the lack of unpainted curbside lanes to use as a control, this report compares compliance rates between green painted curbside bicycle lanes and non-curbside, unpainted bicycle lanes. As neither lane style features a protective buffer (e.g. median materials/plantings, barriers, repositioned parking lanes) NYCDOT believes that these lane types are similar enough to warrant a meaningful comparison. While all lane segments had similar land use characteristics, this study is unable to fully take into account the potential traffic pattern and volume differences that may arise from different land use and travel patterns.

NYCDOT surveyors noted both the total number of drivers and cyclists and the drivers' behavior and positioning on the road: standing in the bike lane, driving in the bike lane, and driving on the bike lane line. In addition, surveyors noted drivers' awareness of cyclists on the road by noting the percentage of time that the bike lane was obstructed when cyclists were present.

Chart 1: EVALUATION OF SOLID GREEN BICYCLE LANES TO INCREASE COMPLIANCE AND BICYCLE SAFETY-Study Locations

ID #	Street	Borough	Extents	Green Paint?
1	Hoyt St	Brooklyn	State Street to Atlantic Avenue	Yes
2	Clinton St	Manhattan	Delancey Street to Rivington Street	Yes
3	Clinton St	Brooklyn	Hunts Lane to Remsen Street	Yes
4	Prince St	Manhattan	Elizabeth Street to Mott Street	Yes
5	Bleecker St	Manhattan	Leroy to Carmine Street	Yes
6	Bleecker St	Manhattan	6th Avenue to MacDougal Street	No
7	E 10th	Manhattan	1st Avenue to Avenue A	No

8	Clinton St	Brooklyn	Remsen Street to Montague Street	No

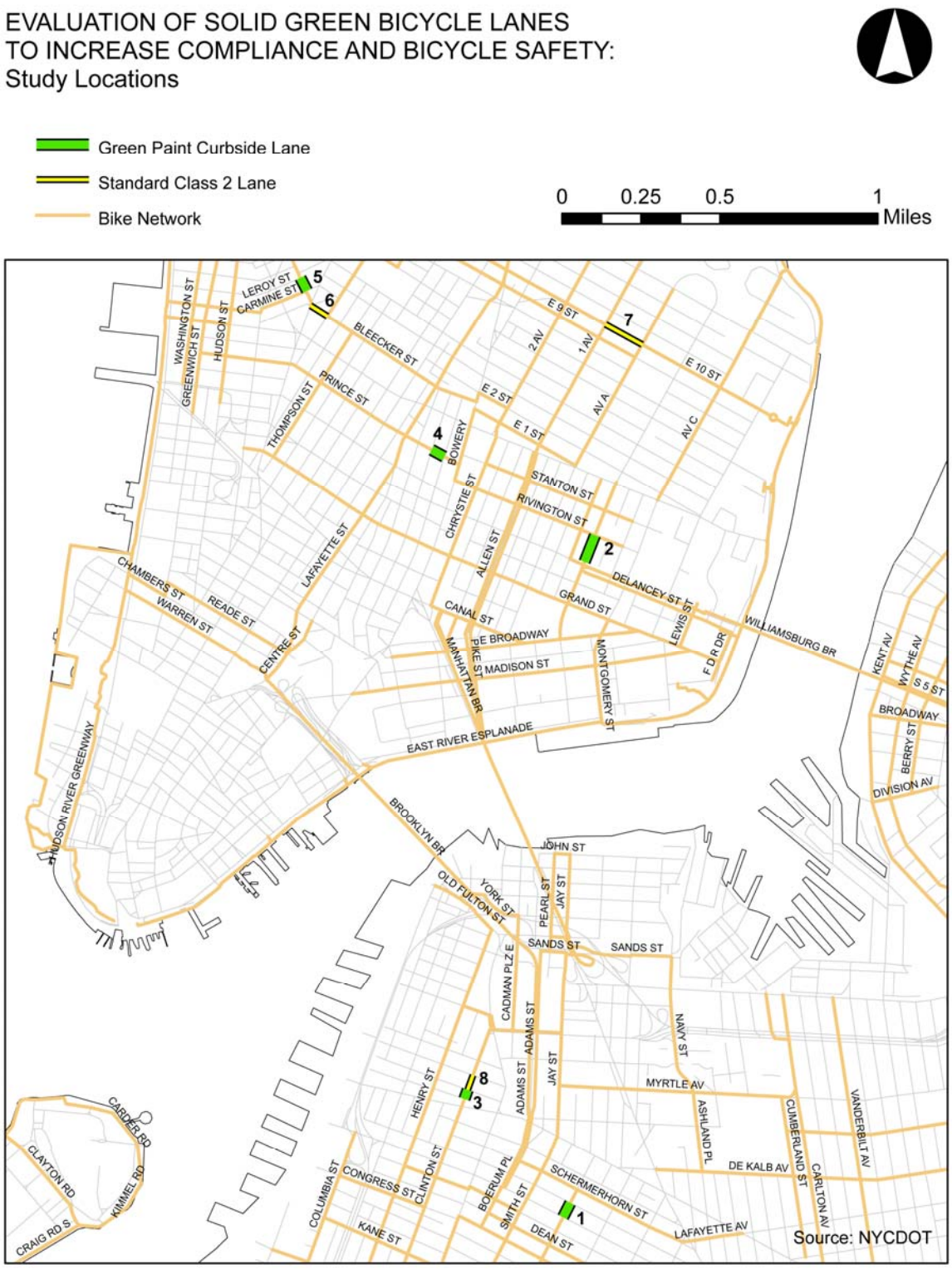

Figure 1: Study Locations

FINDINGS

Does the use of the solid green marking prompt motorists to respect the bicycle lane (reducing encroachments) as well as be more aware of cyclists along the roadway?

NYCDOT data indicates that the green paint treatment resulted in fewer instances of drivers encroaching on the bike lane by driving on the bike lane boundary line. Overall, 7% of drivers on the green paint treated streets drove on the bike lane boundary line as opposed to 16% of drivers on streets with the typical non-painted bike lane treatment. The data also showed fewer instances in driving in the bike lane; on average, 4% of drivers drove in the bike lane on green paint treated streets as opposed to 7% of typical streets. The frequency of standing or parking in the bike lane between the two different paint treatments was comparable.

Driver behavior—the likelihood of drivers driving in the bike lane—did not seem to be influenced by the presence of cyclists in either lane type. On average, cyclists riding in the lane found it unobstructed in 96% of the cases on green paint treated lanes as opposed to 93% of cases on the typical non-painted lanes.

A closer comparison of the two paired location sites, Clinton Street in Brooklyn, (sites #7 & #3 on the study locations map fig. 1) and Bleecker Street in Manhattan (sites # 5 & 6 on the study locations map fig. 1) suggests that the green paint may increase awareness of bicycle infrastructure more significantly than the data shows in aggregate.

The Clinton Street green painted curbside lane extends from Joralemon Street to Tillary Street (0.3 lane miles) with a short unpainted gap between Remsen and Montague Streets. Land use characteristics along this corridor are fairly uniform. NYCDOT surveyors counted 881 vehicles and 117 cyclists at study location # 3 (painted) and 1,112 vehicles and 112 cyclists at location #8 (unpainted) one block north. Cyclists make up 12% of the total traffic volume at location #3 and 9% of the total traffic volume at location #8.[2]

Over the study period, NYCDOT surveyors on Clinton Street reported that 1% of

2 Bicycle counts were conducted in September 2007 and September 2010 from 4-6pm on weekdays. The before count was conducted on Clinton Street, Brooklyn, between Montague and Pierpont (Pierrepont?) Streets, one block away from the 2010 count (location # 8).

drivers at location #3 (painted) drove in the bike lane as opposed to 11% of vehicles at location #8 (unpainted) one block north. An additional 7% of drivers at location #3 drove on the bike lane line as opposed to 16% at location #8. On Clinton Street, the green paint also seemed to also make drivers more aware of cyclists; at location #3 the Clinton Street lane was clear in 98% of the times when cyclists were in the lane as opposed to only 83% of the time at location #8.

The green paint treatment is featured on Bleecker Street from Hudson Street to 6th Avenue. Bleecker Street is unpainted east of 6th Avenue; the green paint treatment resumes east of Lafayette Street. Land use characteristics along this corridor are fairly uniform. NYCDOT surveyors counted 985 vehiclesand 177 cyclists at study location # 5 (painted) and 910 cars and 315 cyclists at location #6 (unpainted) approximately two blocks east. Cyclists make up 15% of the total traffic volume at location #5 and 26% of the total traffic volume at location #6. On Bleecker Street, surveyors reported that 5% of drivers at location #5 (painted) drove on the bike lane line as opposed to 15% of cars at location #6 (unpainted).

Does the solid green pavement marking increase bicycle use by providing a well-defined area for the bicyclist in the roadway?

The unprecedented growth in cycling in New York City over the past four years makes it difficult to evaluate the second question, the impact of the green paint markings alone on bicycle use. For example, cycling on Clinton Street, Brooklyn (location # 8) increased by 58% from September 2007 to September 2010.[3] However, commuter cycling in New York grew 321% from 1999-2009, with much of that growth occurring since 2006 when the City began its 200-lane-mile commitment to expand the existing cycling network. Commuter cycling has increased by 26% from 2008 to 2009 and more than doubled since 2005. While the green paint lanes are likely to be a factor in this growth, this report cannot separate their impact from the growth of the cycling network as a whole.

Anecdotally, most cyclists like the green paint treatment and believe that it is more effective at keeping cars from parking in bike lanes than regular striping. In particular, cyclists cite the conspicuousness of cars parked in green painted lanes as a deterrent to drivers parking there.

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3 Bicycle counts were conducted in September 2007 and September 2010 from 4-6pm on weekdays. The before count was conducted on Clinton Street, Brooklyn, between Montague and Pierpont (Pierrepont?) Streets, one block away from the 2010 count (location # 8).

CONCLUSIONS

The data collected by NYCDOT suggests that the green paint treatment can enhance bike lane visibility and limit instances of drivers driving in the bike lane or on the dividing line. Drivers were less likely to drive on the bike lane line by an average of 9 percentage points if the lane was painted green than if it was not painted. Driver behavior—the likelihood of drivers driving in the bike lane—remained essentially constant in both lane types regardless of the presence of cyclists. On average, cyclists found the bike lane clear 93%-95% of the time.

Significant increases in cycling in New York City over the past decade make it impossible to determine the exact impact of green painted lanes on cycling rates. Commuter cycling in New York City has increased by 26% from 2008 to 2009 and more than doubled since 2005. While the green paint lanes are likely to be a factor in this growth, this report cannot untangle their impact from the growth of the cycling network as a whole.

Overall, the green painted lanes have contributed to general increases in cycling rates and safety in New York City. As cycling in New York City has increased, cyclist injuries and fatalities have fallen steadily. Cyclist injuries fell 44 percentage points from 1999 to 2008. Cyclist fatalities have fluctuated but trended downward during the same period. This increase in ridership and safety is concurrent with the installation of green painted lanes and overall expansion of the city's bicycle network.

Chart 2: EVALUATION OF SOLID GREEN BICYCLE LANES TO INCREASE COMPLIANCE AND BICYCLE SAFETY-Findings

	ID #		Cyclists	Cars	Driver Behavior				Lane is clear when cyclist present?		Bicycles as % of all vehicles
					Standing in bike lane	Driving in bike lane	On bike lane line	In travel lane	Yes	No	
Green Paint	1	Hoyt Street (BK)	142	518	0%	1%	6%	93%	98%	2%	22%
	2	Clinton Street (MN)	152	1,266	1%	9%	9%	81%	88%	13%	11%
	3	Clinton Street (BK)	117	881	0%	1%	7%	92%	98%	2%	12%
	4	Prince Street (MN)	212	362	1%	2%	10%	87%	98%	2%	37%
	5	Bleecker Street (MN)	177	985	0%	2%	5%	93%	97%	3%	15%
	-	**All Green**	**623**	**3,027**	**1%**	**4%**	**7%**	**89%**	**96%**	**4%**	**17%**
Unpainted	6	Bleecker Street (MN)	315	910	0%	1%	15%	84%	100%	0%	26%
	7	E.10th Street (MN)	199	415	2%	7%	20%	71%	89%	11%	32%
	8	Clinton Street (BK)	112	1,112	0%	11%	16%	72%	83%	13%	9%
	-	**All Unpainted**	**626**	**2,437**	**1%**	**7%**	**16%**	**76%**	**93%**	**13%**	**20%**

All data collected in September, 2010 during the PM rush (4pm-6pm)

EVALUATION OF SOLID GREEN BICYCLE LANES TO INCREASE COMPLIANCE AND BICYCLE SAFETY: Study Locations

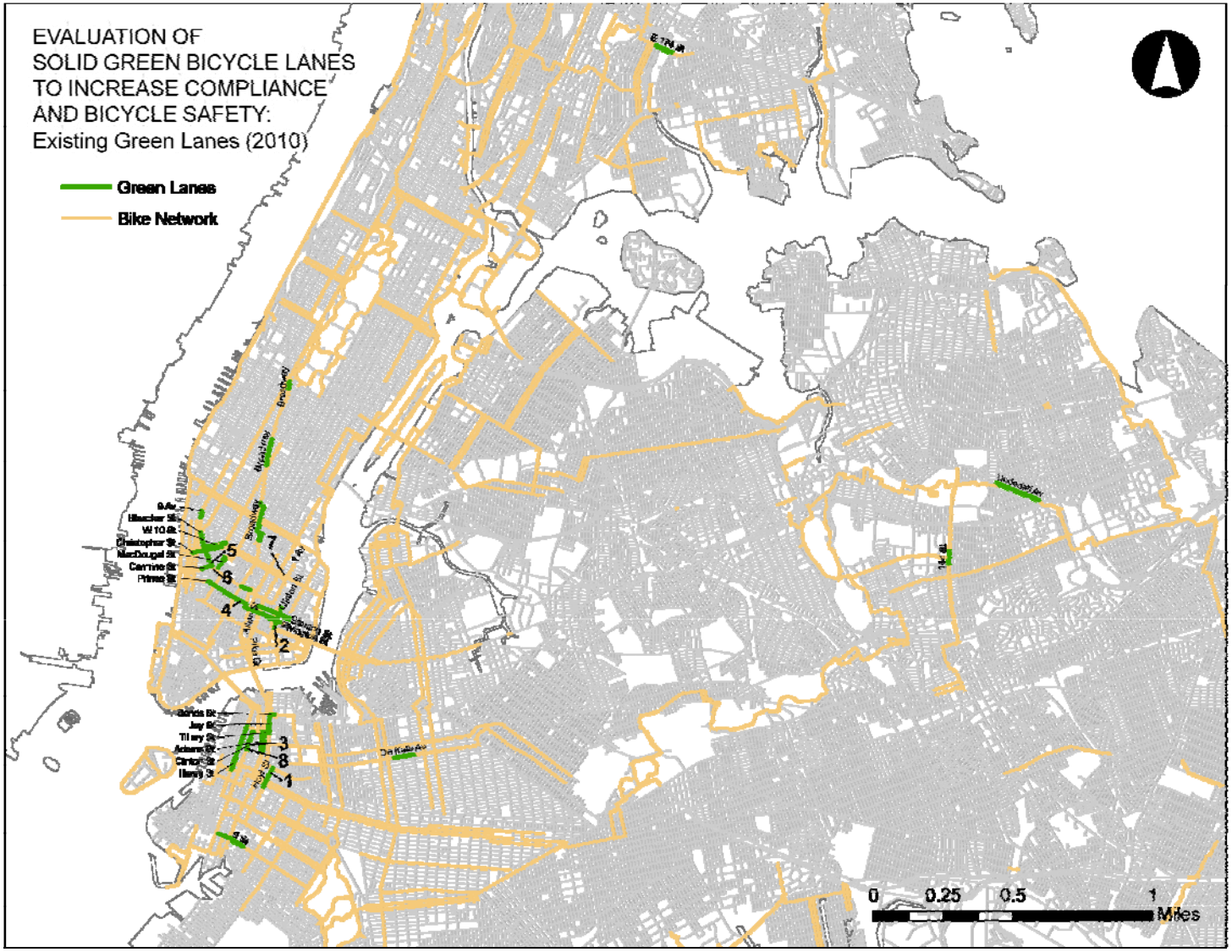

Figure 2: Existing Green Lanes

Study Location #1: Hoyt Street, Brooklyn

Extents: State Street to Atlantic Ave.

Study Location #2: Clinton Street, Manhattan

Extents: Delancey Street to Rivington Street

Study Location #3: Clinton Street, Brooklyn

Extents: Hunts Lane to Remsen Street

Study Location #4: Prince Street, Manhattan

Extents: Elizabeth Street to Mott Street

Study Location #5: Bleecker Street, Manhattan
Extents: 6th Ave. to MacDougal Street)

Study Location #6: East 10th Street, Manhattan
Extents: 1st Ave. to Ave. A

Study Location #7: Clinton Street, Brooklyn

Extents: Remsen Street to Montague Street

RELATED FINDINGS

Commuter cycling rates in New York City have risen dramatically over the past decade, a 321% increase from 1999 to 2009. Commuter cycling increased by 26% between 2008-2009 and more than doubled since 2005. Concurrent with this increase in commuter cycling, cyclist injuries and fatalities have fallen steadily. Cyclist injuries fell 44 percentage points from 1999 to 2008. Cyclist fatalities have fluctuated but trended downward during the same period. Much of the growth in cycling occurred since 2006 when NYCDOT began implementing its ambitious plan to install 200 lane miles of bicycle network in three years and complete the city's Bicycle Master Plan by 2030.

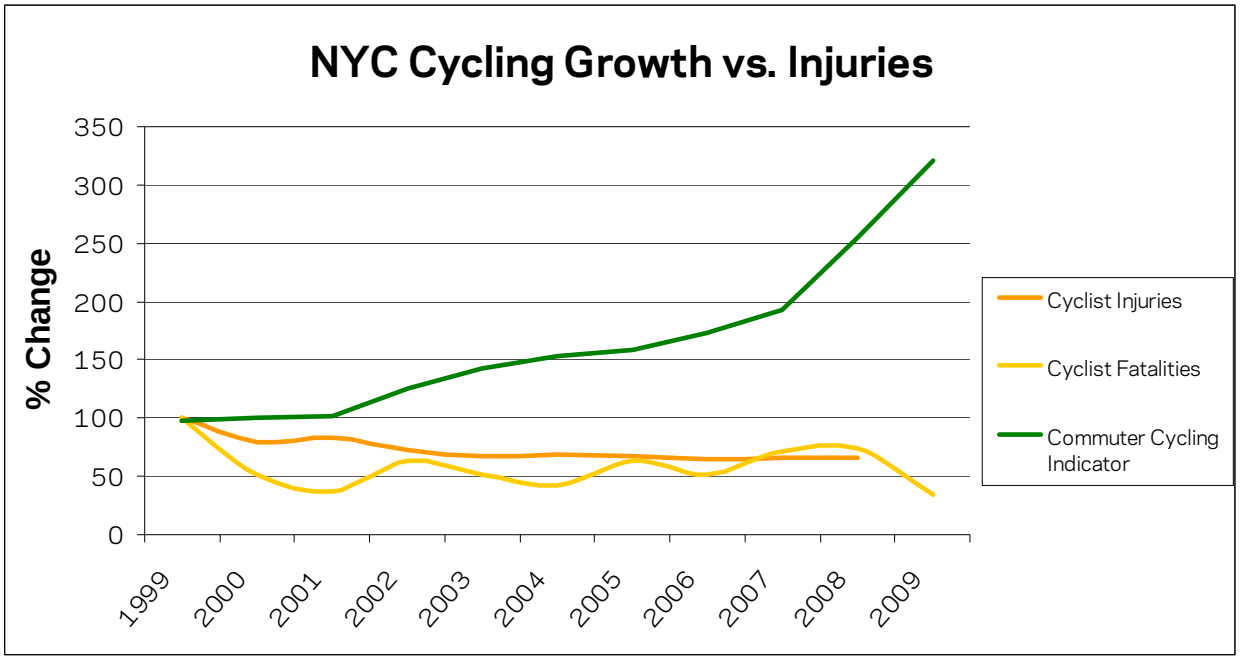

Figure 3: Cycling Growth vs. Injuries & Fatalities (Data from NYCDOT & NYSDOT)

The City of Portland, Oregon has experimented with colored markings at bicycle-motor vehicle crossings. The results of their experiments are contained in the Document "Portland's Blue Bike Lanes – Improved Safety through Enhanced Visibility", City of Portland Office of Transportation July 1, 1999. The conclusions included in this report indicated, among other results, statistically significant increases in motorists yielding to cyclists and an increase in motorists slowing or stopping when approaching conflict areas4.

4 City of Portland Office of Transportation, "Portland's Blue Bike Lanes – Improved Safety through Enhanced Visibility", July 1, 1999 p. 20.