

# Critique of FHWA BL vs. WCL Study

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**Critique of *A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report (FHWA-RD-99-034)*, and *Bicycle Lanes vs Wide Curb Lanes: Operational & Safety Findings and Countermeasure Recommendations (FHWA-RD-99-035)*.**

**Disclaimer**

These two companion documents report on research conducted by the University of North Carolina Highway Safety Research Center, my former employer, for the Federal Highway Administration. Although I am listed as fifth author on each report, I do not endorse them. I did not review either document prior to its publication and release, and my inclusion as an author was done without my authorization.

My involvement with the project was limited to assisting with the development of the data coding scheme and a small amount of data reduction. I also analyzed collisions from the three cities. However, I found it necessary to recuse myself from the project. It was not possible to reduce the videotape data without having to make numerous subjective decisions because too many situations did not fit the coding scheme, or because of ambiguities. Given the lack of a comprehensive and consistent coding scheme, it is certain that there is much error in the data coding. Note, however, that my criticisms address the substance of the report.

**Primary Criticism**

- *Faulty research methodology.*

Table 1 below shows that the study compared Bike Lanes (BLs) on principally low volume and low speed roads with greater total width, to Wide Curb Lanes (WCLs) on high volume and high speed roads with less total width. Thus, the effects of the BL or WCL on bicyclist and motorist behavior were completely confounded by the effects of these three road attributes (i.e., volume, speed, and width), making it impossible to unambiguously ascribe the study’s findings to either the presence of BLs or WCLs. To make valid comparisons between roads with BLs and WCLs, the key sampling consideration should have been the selection of roads as nearly comparable as possible except for the presence of a BL or WCL. In the absence of equivalent samples, any differences in operations and behaviors on BLs as compared to WCLs could be due to disparities in motor vehicle volume, speed, or total pavement width. This is a fundamental and fatal flaw in the study design.

**Table 1. Site Parameters.**

<b>Facility</b>	<b>Motor Vehicle Volume</b>	<b># of Sites</b>	<b>Motor Vehicle Speed</b>	<b># of Sites</b>	<b>Total Avg Width</b>
Bicycle Lane Roads	High	8	>50 km/h	3	5.6 m
	Low	16	50 or less	21	
Wide Curb Lanes	High	16	>50 km/h	8	4.7 m
	Low	8	50 or less	16	

Simply put, without accounting for and ruling out effects of other key road characteristics, it is impossible to draw unambiguous conclusions about the effects of BLs and WCLs. The bias present due to the study design renders any conclusions invalid because alternative explanations for differences attributed to BLs and WCLs cannot be ruled out.

The investigators realized that the groups were not equal. On Page 14 of FHWA-RD-99-034 the report notes, “In the project cites, BL sites tended to concentrate at low traffic speed and low traffic volume locations, while WCL sites tended to concentrate at high traffic volume locations.” On Page 26 it says, “In particular, the BLs tended to be quite wide, ranging from 1.2 to 2.9 m, with an average of 1.8 m. Total width (BL + adjacent traffic lane) averaged 5.6 m for BL sites versus 4.7 m for WCL sites. This variability in widths across facility types makes it difficult to compare the model results for BLs and WCLs.” Despite recognition of the lack of comparability, the investigators did not discuss the methodological limitations of the study nor the effects of these limitations on the interpretation of the study’s findings. Acknowledgment and explanation of study limitations are typically included in any research report, and the conclusions adjusted accordingly. Instead, the investigators made comparisons and drew conclusions that cannot be supported because of the flawed study design.

If the investigators were unable to identify a sufficient sample of comparable BL and WCL roads, then consideration could have been given to alternative study designs. One possibility would have been a “before and after” design in which a WCL site was examined and later striped with a BL and re-examined. Similarly, a BL site could have been analyzed, the stripe removed and follow up study performed. At the least, a clinical analysis of a WCL site and BL site matched on volume, speed, and geometric measures should have been performed.

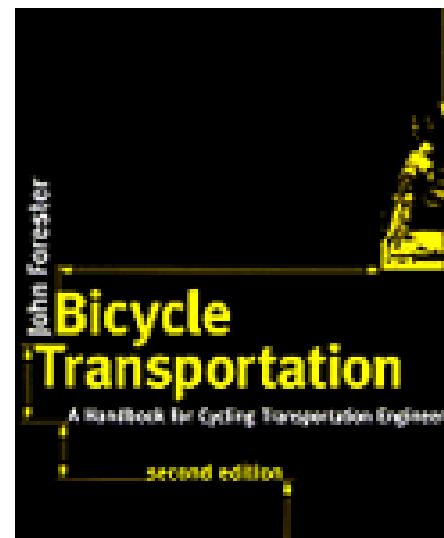
### Secondary Criticisms

While the primary criticism that the flawed methodology renders the study conclusions invalid, it is pertinent to describe additional criticisms in order to lend emphasis to the flaws of the study.

- *Incomplete, shallow, and biased literature review.*

That the “Brief Literature Review” is brief is an understatement. For such an important study the literature review should be thorough rather than brief. There is the conspicuous neglect of any mention of *Bicycle Transportation* (Forester, 1994), the seminal publication, a textbook, discussing the validity of the use of WCLs. This is an unfathomable omission.

Notably absent also is discussion that segregation by vehicle type violates the traffic science principles of uniformity, simplicity, and destination and speed positioning. No coverage of the social implications of segregating bicyclists with BLs is noted. There is no mention of the well known debris accumulation in BLs and associated nuisance, hazard, and increased maintenance needs. The typically greater right of way and construction costs of BLs is also avoided.



**Figure 1.** This textbook was not cited.

Whereas only a couple of small paragraphs were written about WCLs in the “Wide curb lanes review” section, five full pages were devoted to special “Other facilities,” demonstrating the report’s bias toward segregated facilities. The statement that “The primary objective of the current study was a comparative analysis of BLs versus WCLs.” is called into question.

Bias is also demonstrated in the pro BL/anti WCL comments found in *both* the “Bicycle lanes” and “Wide curb lanes” sections of the literature review. For example, the finding in Harkey and Stewart (1997) that there was more motorist encroachment into the adjacent or opposing lane on WCL roads was cited in both sections, presumably to add emphasis. (Note that Forester criticizes this finding as indicative that the WCL simply was not wide enough. While WCLs are sometimes for good reason narrower than combined BL with standard lane, WCLs can be just as wide or wider. Note also that only one encroachment for each facility type resulted in a conflict.)

There is no critique of questionable reports that were cited. For example, the literature review states, “Two other studies credited BLs with reducing bicycle-motor vehicle crashes by more than half in Corvallis, Oregon, and by two-thirds in Eugene, Oregon (Ronkin, no date; City of Eugene, 1980).” John Allen, author of the widely distributed *Street Smarts* booklet, criticizes these two “studies” as methodologically flawed at:

<http://www.bikexpert.com/research/synthesis/synthesisi.htm#corvallis>

- *Misrepresentation of data.*

Regarding wrong way riding, the report states “This may be related to the fact that WCLs are often associated with higher volume roadways and that maneuvering through intersections on these roadways can be a complex task. Thus, the bicyclist may choose what seems to be a safer route by riding the wrong way on an adjacent sidewalk or in the street.” Again it was recognized that the WCL and BL sites were unequal in terms of traffic intensity, and that this may have accounted for behavioral/operational differences, yet the abstract (FHWA-RD-99-035) emphasized the finding that more wrong way riding is associated with WCLs. This is a misrepresentation of the data.

The abstract also notes that, “Significantly more motor vehicles passing bicycles on the left encroached into the adjacent traffic lane from WCL situations compared with BL situations.” However, it was found that only one encroachment from each facility type resulted in a motor vehicle-motor vehicle conflict. If motorists encroach without conflict, this can be thought of as a positive for bicyclists since the motorist has opted to afford additional and abundant overtaking clearance. Proclaiming increased encroachments in the abstract without qualifying the statement is a misrepresentation of the findings.



**Figure 2.** Encroachment without conflict in a 15 ft WCL. This was not a necessity but a simple courtesy of the motorist.

- *Lack of detailed investigation of an unexpected major finding.*

The abstract of FHWA-RD-99-035 says, “Significant differences in operational behavior and conflicts were found between bike lanes and wide curb lanes but varied depending on the behavior being analyzed. Wrong-way riding and sidewalk riding were much more prevalent at WCL sites compared with BL sites.”

Given that greater wrong way riding in WCLs was an unexpected and major finding that is prominently emphasized in the abstract and reports, a clinical analysis was warranted to see if one or more sites was responsible for this outcome, and to try to determine what factors might have caused the wrong way riding. A clinical examination of high conflict rate sites and of serious conflicts was done to better describe the nature of conflicts and to see if rogue sites were primarily responsible for discrepancies, but this level of effort was not performed for the unexpected finding of greater wrong way riding in WCLs. Wrong way riding is a known significant predisposing condition for collisions, adding more rationale for further investigation.

Wrong way riding, and indeed sidewalk riding, can be a response to the perceived risk from overtaking motor vehicles, or may be related to more favorable bicycling desire lines, which can be a function of origin, destination, and roadway characteristics. The WCL sites indeed had more and faster motor traffic, which would be expected to contribute to this aberrant bicyclist behavior. Moreover, rather than cross a wide, busy road twice in order to access an upstream destination, it may be quicker and easier for a bicyclist to ride a short distance the wrong way in the street or on a sidewalk. It may be that the WCL sites had more of this “desire line wrong way riding” because of the unique characteristics of the sites and travel patterns of bicyclists.



**Figure 3.** Rather than cross a 5 lane road twice in a short distance, this bicyclist opted to ride the wrong way on the sidewalk.

Wrong way riding in BLs has been such a recognized problem that the state of Florida, among others, marks an arrow in the BL to reinforce the correct direction of travel. A sign may also be placed on the back side of the BL sign to notify bicyclists when they are riding the wrong direction. It is likely these countermeasures were employed on some or all of the BLs examined in this study in Gainesville, at the least. No such educational messages were used in WCLs.

- *Contradictory evidence unreported, under-emphasized, or unexplained.*

On two separate occasions the study states that WCLs that are too wide are undesirable. On page 2 it says, “A desirable width for WCLs is 4.3 m. Lanes wider than 4.6 m sometimes result in the operation of two motor vehicles side by side.” On page 5 it notes, “WCLs should be 4.0 to 4.6 m wide (figure 4) to provide enough width for lane sharing but not so much width that motorists form two lanes at intersections (McHenry and Wallace, 1985).”

However, in this study the *average* width of WCLs was 4.7 m (15.4 ft), which is wider than the recommended maximum 4.6 m (15.1 ft) that allegedly results in the claimed deleterious effect of doubling up of motor vehicles at intersections. If this effect was deemed important enough to mention two times in the literature review, why was it not found in this study? And, if this effect was not found, that result should have been noted and the claims refuted.

Contrary results involve lateral spacing distances. “The relevant model again predicted distances from bike to curb to be smaller for BLs less than 1.5 m and larger for BLs equal to or wider than 1.5 m than for WCLs with similar traffic volume.”“With respect to separation distance between bicyclists and passing motor vehicles, there were no practical differences between BL sites and WCL sites. Instead, this distance was primarily a function of the total width available (either the WCL width or the BL width and adjacent motor vehicle lane width combined).”

These results conflict with Harkey and Stewart (1997), which was referenced in the report multiple times and whose authors are researchers at the same organization. Their study found that bicyclists position themselves further from the edge of pavement when a BL is present as compared to a WCL. They also found a significantly different separation distance between motorists and bicyclists due to the BL stripe. Motorists passed bicyclists closer with a BL stripe.

The study notes “Overall, 75 percent of bicyclists obeyed existing stop signs. Proportionally more bicyclists obeyed stop signs at BL sites (81 percent) than at WCL sites (55 percent)...The proportion of bicyclists with both somewhat unsafe (19 versus 5 percent) and definitely unsafe (3 versus 0 percent) movements was higher at BL sites. The differences between BL and WCL sites were significant when the somewhat unsafe and definitely unsafe categories were combined.”

The authors suggest the presence of a BL stripe results in greater stop sign compliance, but contradictorily, also a greater likelihood of unsafely disobeying it. A more plausible explanation is that bicyclists' behavior tends to be opportunistic. Bicyclists are likely to disobey a stop sign when they believe they're able to do so, which largely depends on cross traffic conditions, and not the presence or absence of a BL stripe. It could have been that higher intensity cross traffic on the BL streets induced greater stop sign adherence, but resulted in greater likelihood for an unsafe maneuver for those who didn't comply.

The study found that 38% of bicyclists failed to stop at stop signs in Gainesville, while only 20% and 17% didn't stop in the other two cities. Why the large discrepancy between cities? Clearly, something besides the presence or absence of a BL stripe is a factor in stop sign compliance.

The study also reports that 17 percent of bicyclists videotaped in Gainesville rode on sidewalks, with only 3 percent in Austin and 2 percent in Santa Barbara. There must be a reason for the markedly higher percent in Gainesville, but none is offered. In an analysis of collisions from the three cities (Pein, <http://www.bicyclinglife.com/Library/TaleOfThree.htm>) the author wrote, “The collision occurred on a multi-lane road (comprising more than two lanes) in 72% of the cases in Gainesville, 59% in Austin, and in 47% of the Santa Barbara crashes. It is possible that bicyclists in Gainesville are more likely to ride on sidewalks because of the large size and attendant complexity and voluminous motor traffic of that city's roads.”

Another under-emphasized result involves the percentage of experienced bicyclists. The report says, “See, for example, a statement in the *Florida Bicycle Facilities Planning and Design Manual* (Florida DOT, 1995) that WCLs should be used as a last resort because ‘only five percent of bicyclists feel comfortable using these facilities.’ ” This 5 percent figure was originally suggested by Wilkinson et al (1994), a document referenced in this report and a figure often cited by BL and Bike Path proponents as justification for BLs to provide for the allegedly 95% of bicyclists that prefer separation. As a component of the present study, more than 2900 bicyclists were surveyed with a questionnaire. On page 22 (FHWA-RD-99-034) it notes, “Finally, 34 percent of the bicyclists considered themselves to be experienced, versus merely casual, riders.” This refutes the 5% claim, but this conflicting discrepancy was not put forth.

- *Confusion of the issue.*

The report notes that “Many in the bicycling community have assumed that more experienced bicyclists tend to use WCLs and that lesser experienced bicyclists use BLs.” In reality it is thought that experienced bicyclists are more likely to prefer WCLs while lesser experienced tend to prefer BLs. All bicyclists use whatever road condition is available on their route.

- *Unsupported conclusions.*

“While both BLs and WCLs are acceptable facilities in many locations, the debate has sometimes forced decision makers to choose which facility type they prefer, to the exclusion of the other. More bicycle facilities might be in place in this country except for this long-standing division of opinion.” This is conjecture, and there is little logic in this statement. If one type of facility is chosen over the other, how can this have resulted in fewer facilities? If the investigators suggest “analysis paralysis” has led to both fewer BLs and WCLs, citation of examples should be given.

“Given the stated preferences of bicyclists for BLs in prior surveys (e.g., Rodale Press, 1992), along with increased comfort level on BLs found in developing the Bicycle Compatibility Index (BCI) (Harkey et al., 1998), use of this facility is recommended where there is adequate width, in that BLs are more likely to increase the amount of bicycling than WCLs.”

The study endorses BLs from their alleged ability to increase bicycling based on stated preference in an irrelevant 1992 Rodale Press survey and by BLs’ propensity to artificially raise users’ perceived comfort level as found in a flawed visual preference study, the BCI. In the Rodale Press survey respondents were asked, “6. Do you think you would sometimes commute to work by bicycle, or commute more often, if: a. There were safe bike lanes on roads and highways?” The choice was not between BLs and WCLs. The BCI had a flawed development. See [http://www.humantransport.org/bicycledriving/library/critique\\_BCI.pdf](http://www.humantransport.org/bicycledriving/library/critique_BCI.pdf) for a critique. To determine whether BLs increase bicycling beyond what can be expected with equivalent WCLs equally promoted, a methodologically valid comparison is necessary. This has not occurred.

The study concludes by saying, “Overall, we have not yet reached the critical mass necessary to make motorists and pedestrians aware of the regular presence of the bicycle. When this critical level of bicycling is reached, gains in a “share the road” mentality will come much more quickly than at present. Certainly not all the problems will disappear, but the ability to develop and implement solutions will be greatly enhanced.” Each of these three sentences is conjecture.

## Conclusions

This research is fatally flawed by the sample problems described in the above Primary Criticism section. Moreover, it has a biased, incomplete literature review; lacks detailed investigation of an unexpected major finding; misrepresents data; found contradictory evidence that is unreported or under-emphasized; confuses an issue; and offers unsupported conclusions.

The study endorses BLs on the questionable premises that they are the majority of bicyclists' preferred facility, bicyclists have increased comfort using BLs, and this will result in increased bicyclist mode share, that being the ultimate goal of roadway enhancements. Preference studies are methodologically suspect, and allegations of increased bicycling mode share via BLs suffer from the "correlation does not equal causation" mistake. It has not been rigorously shown that BLs increase bicycling mode share more than would equivalent WCLs equally publicized.

Further, preference does not always match what ought to be done. It can be argued that bicyclists should not be misled by BL stripes to feel safer than they actually are and than their knowledge and experience can handle. A speculative increase in bicyclists may not be worth the operational, logistical, and social costs of BLs to all bicyclists.

BLs segregate, and arguably discriminate, based on vehicle type by using a substandard width lane at the right side of the road exclusively for bicycle users, a strategy incongruous with standard design practice and traffic operations. Skeptics may argue that it is unusual for drivers of vehicles to share (partially or fully) a single lane, as with a WCL. However, it is standard, uniform practice for users of un-striped pavement, inherently a single lane, to position themselves laterally within the space as context (speed and destination) requires, in essence sharing the lane. Segregation by vehicle type interferes with this convention.



**Figure 4.** A 16 ft WCL. The bicyclist can use as much or as little of the lane as required. Motorists can easily overtake.



**Figure 5.** Same total space but greater restriction with a BL stripe, and a loss of freedom for minority user bicyclists.

Moreover, the vast majority of roads do not have BL stripes, are not feasible to have BLs, do not need BLs, should not have BLs due to high speed bicycling descents or other operational constraints such as abundant turning movements, and will never have BLs. Normal roads (narrow, standard, or wide outside lanes) without BLs are the overwhelming majority. Thus, the primary expectation of both bicyclists and motorists is that bicyclists are using a normal travel lane (and that often the lane is “shared” when a motorist overtakes). The provision of BLs creates the unusual situation of the bicyclist operating to the right of an edge line.

Providing an inherently spotty BL network is a poor strategy that is inconsistent with the expectations of all road users. Where BLs exist, motorists expect bicyclists to be to the right of the stripe. Where no BL stripe exists, bicyclists are in the regular travel lane. This bicyclist lateral position inconsistency, sometimes along the same road, creates difficulties.

BLs by definition increase complexity by creating additional lanes, and thus the likelihood of left-adjacent motor vehicle visual obstructions, while reducing bicyclist lateral leeway and sight lines as compared to WCLs in which bicyclists can assume a left tracking position with impunity. While operating to the left of the BL is theoretically also possible when this space is outlined for bicyclists, laws — specific or implicit — and the stay-right mis-education that the stripe conveys to bicyclists and motorists alike, makes using the adjacent defacto “motor vehicle lane(s)” less appealing and less likely.

Figures 6-9 below depict contrasting bicyclist lateral positions that can occur under various scenarios, including but not limited to high speed bicycling or when preparing to turn left. Other variables held constant, increasingly left bicyclist lateral position results in improved visibility, greater stopping sight distance, and increased safety.

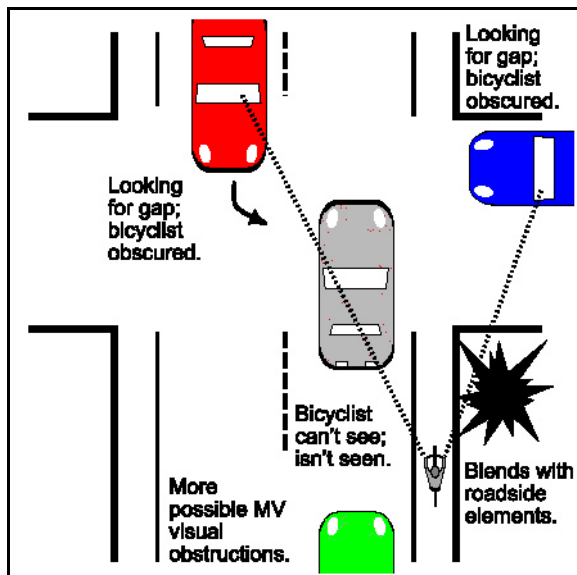


Figure 6. Poor Lateral Position.

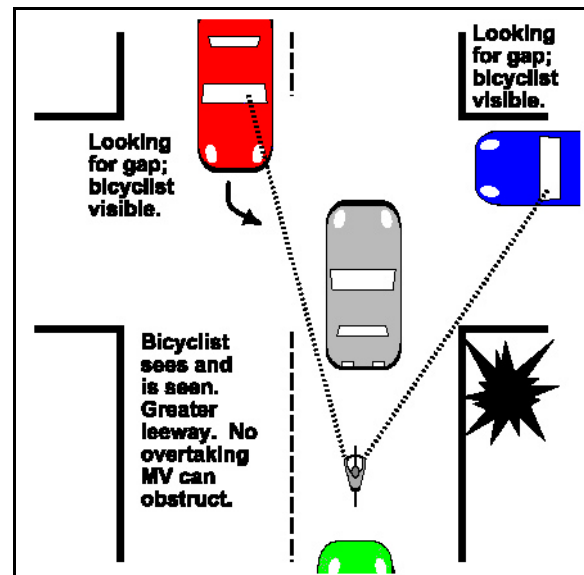
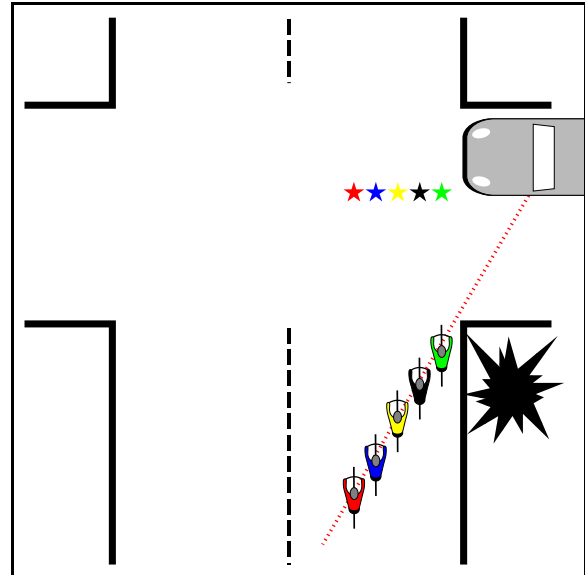


Figure 7. Improved Lateral Position.



**Figure 8.** Descending a 10% grade requires considerable operating space.



**Figure 9.** Sight line and impact points.

In Figure 9, each bicyclist 2 ft more laterally left is 3.5 feet further from the junction when first seen by the Drive Out motorist. The red bicyclist at 10 ft from the edge is 8 ft further left than the green bicyclist and has 14 ft more stopping distance. At 20 mph (29 ft/s) this provides nearly  $\frac{1}{2}$  second additional reaction time. Moreover, the potential impact point is correspondingly 8 ft further from the car, affording added stopping distance and reaction time for the motorist.

The design criteria for the safety of standard or wide lanes used by vehicles as a general class are superior to much narrower BLs intended for bicycles as a specific class. Rather than vouching for BLs, the study could have endorsed WCLs on the self evident grounds that a widened normal lane is consistent with standard roadway design practice and traffic theory, more readily enabling proper lateral destination and speed positioning than a BL case, and thus theoretical model user behavior for bicyclists and motorists.

Where it is desirable to widen the road to enhance motorist ability to overtake bicyclists and improve bicyclist comfort, providing additional space without a BL stripe is the superior accommodation. Where there is very high speed and dense motor traffic, the lack of high speed bicycling descents, and there are few intersections, driveways, and turning movements, there may be an operational advantage to BL stripe segregation that outweighs the costs. Such an advantage should be rigorously demonstrated before a BL is used.

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