Parking Lane Width within a Complete Streets Environment

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Abstract

The City of Vancouver and many other municipalities have historically recommended a 2.5 m wide parking lane as this has traditionally been recommended by North American design guidelines such as those produced by TAC and the FHWA. With the desire to fit more amenities (such as vehicle lanes, bike lanes, parking lanes, bike parking, street furniture, etc.) into existing rights-of-way, there is pressure to maximize the use of the existing roadway, and this has included considering ways to reduce the width of parking lanes. In recent years, fitting one or two 2.5 m parking lanes in an urban street has become significantly more difficult and street designers have been looking for ways to minimize the width of various street elements. More recent *Complete Streets* oriented guidelines have recommended minimums as low as 2.14 m however they do not state why 2.14 m is acceptable. There is also minimal data demonstrating the interaction between the width of parking lanes and the impacts on adjacent bike lanes.

In order to better understand the effects of parking lane width on urban road operations, data was collected across downtown Vancouver in parking lanes adjacent to bike lanes. The parking lanes were a mix of curbside parking lanes and floating parking lanes where the bike lane is located between the parked vehicles and the curb.

The data demonstrates that parking lane width is correlated with the horizontal parking location of vehicles; in wide parking planes, vehicles park further from the curb and in narrow parking lanes, vehicles park closer to the curb. There is also a significant difference in horizontal parking location between curb parking lanes and floating parking lanes. Where there is a floating parking lane, the presence of a curb provides cyclists with 17-35 cm of more horizontal space than when there is only a painted buffer. This demonstrates the additional benefit of having a curb adjacent to a floating parking lane.

The investigation revealed that rather than 'needing' 2.5 m for safe horizontal clearance, this commonly-provided width simply allows motorists to park further into the roadway than is otherwise necessary. Overall, reducing parking lane width in exchange for widening a bike lane provides more space for people cycling. However reducing a parking lane to this 2.14 m minimum in order to also squeeze in a minimum width bike lanes is not recommended as the parked vehicles interfere too much with the adjacent bike lane. When municipalities are being asked to maximize their assets' return on investment, the implications of 'finding' extra space for multi-modal upgrades are an obvious benefit.

1.0 Introduction

The City of Vancouver (City) has traditionally recommended 2.5 m wide vehicle parking lanes. This minimum width has been recommended by many guidelines, but recent guidelines with a complete streets focus are now recommending a slightly narrower parking lane to allow more space for other uses (see Table 1). This minimum requirement has been difficult to reach in recent years and has restricted the design possibilities of implementing new bike lanes on existing streets. The City has designed some streets with parking lanes less than 2.5 m adjacent to cycling facilities. In doing so, the design assumes that by narrowing the parking lane, drivers will park their vehicle a different distance from the curb. This argument has merit and Furth (2010) determined that the lateral distacne of parked vehicles from the curb reduces with a narrower parking lane (see Table 2) (not adjacent to bike lanes).

Table 1: Recommended width of parking lanes adjacent to bike lanes

Organization	Document	Recommended Parking Width (m)	Minimum Parking Width (m)
AASHTO	Guide for the Planning, Design, and Operation of Bicycle Facilities	2.4	2.1
NCHRP	Recommended Bicycle Lane Widths for Various Roadway Characteristics	2.43 or 2.14 with a buffer	N/A
NACTO	Urban Streets Design Guide	2.14 to 2.74	N/A
ITE	Designing Walkable Urban Thoroughfares	2.43	2.14

Table 2: Parking Lane Width versus the Lateral Position of Parked Vehicles (Furth, 2010)

	Parking Lane Width		
	6 ft (1.83 m)	7 ft (2.14 m)	8 ft (2.44 m)
95^{th} - percentile distance from curb	0.8 ft (0.24 m)	1.24 ft (0.38 m)	1.68 ft (0.51 m)

The goal of this study is to determine an appropriate parking lane width, with a focus on understanding the effects of parking lane width on people using adjacent bike lanes. In the design of bike lanes, the width of the bike lane and adjacent parking lane can be seen as complimentary widths. For example; if there is 4.0 m of space, 1.5 m could be allocated to a bike lane and 2.5 m to a parking lane, or it could be designed with a 1.8 m bike lane and a 2.2 m parking lane. However, without knowing if narrowing a parking lane actually shifts parked vehicles closer to the curb, designers have no knowledge of how much space is actually gained for people cycling. This report aims to understand the varying level of comfort for a person cyclist based on the width of the bike lane and the effect (if any) of narrowing the width of parking lanes adjacent to bike lanes.

2.0 Data Collection

Data for this study was collected over a series of days in August, 2014. The lateral position in the roadway was collected for a total of 330 parked vehicles on Union Street, Richards Street, Expo Boulevard, Quebec Street, Homer Street, Melville Street, Alberni Street, and Yukon Street. When data was collected, vehicles were categorized by vehicle type as either: PC, SUV, VAN or PICKUP. Particularly large or small cars, such as delivery trucks and Smart cars, were not included in the data collection process as they would skew the data set. For each street block that data was collected, the width of the bike lane, buffer and parking lane were also measured. Data for curb parking lanes (adjacent to the curb) and floating parking lanes (bike lane between the curb and parking lane) was kept separate for the entirety of this study. All floating parking lane data was collected where there was only a painted buffer between the parking lane and the bike lane (see Figure 1).

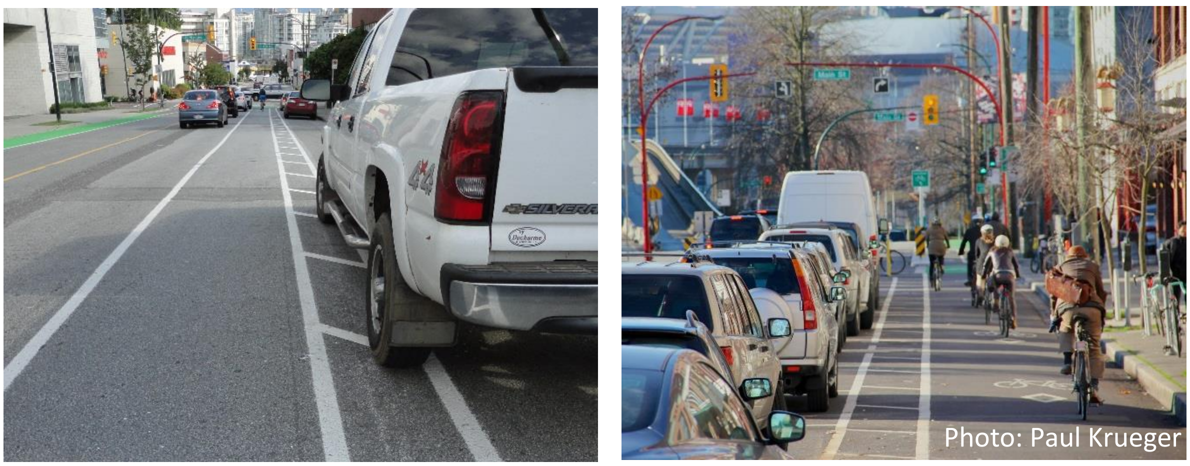

Figure 1: Example of Curb Parking Lane (Left) and Floating Parking Lane (Right)

The parking distance was measured for each parked vehicle. For curb parking lanes; of the two wheels adjacent to the curb, the distance was measured from the curb to the wheel furthest from the curb. For locations with floating parking lanes (Union Street, Expo Boulevard and Richards Street) the parking distance was measured between the wheel nearest to the bike lane and the edge of the parking lane adjacent to the painted buffer. This was chosen such that part of the vehicle most interacting with a person cycling in the bike lane is being measured.

Table 3 presents the mean lateral parking distance and associated standard deviation of all data collected. Table 4 presents the 85^{th} percentile lateral parking distance from the curb for curb parking lanes and the 15^{th} percentile lateral parking distance to the buffer for floating parking lanes. Mean distances are presented as they are easy to use for statistical analysis while 15^{th} / 85^{th} percentile is more useful for design purposes since they represent the most one vehicle out of every 8-9 vehicles (about one vehicle per block) is interacting with the adjacent bike lane. 15^{th} percentile represents the most one out of every 8-9 vehicles interacts with cyclists to the right of vehicle (useful for analyzing floating parking lanes) and the 85^{th} percentile represents the most one out of every 8-9 vehicles interacts with cyclists to the left of vehicle (useful for analyzing curb parking lanes).

Table 3: Mean Parking Distance

Parking Lane Width	Vehicle Type														
	PC			SUV			PICKUP			VAN			TOTAL		
	Mean	Count	Std. Dev.	Mean	Count	Std. Dev.	Mean	Count	Std. Dev.	Mean	Count	Std. Dev.	Mean	Count	Std. Dev.
Curb Parking Configuration: Average Distance to curb (m)															
2.2	0.19	5	0.117	0.40	1	N/A	-	-	-	0.21	1	N/A	0.22	7	0.124
2.3	0.21	10	0.095	0.22	5	0.085	0.13	3	0.044	0.10	2	0.000	0.19	20	0.089
2.4	0.26	7	0.097	0.22	5	0.082	0.24	3	0.095	0.22	2	0.304	0.24	17	0.112
2.5	0.25	56	0.126	0.25	22	0.123	0.20	9	0.157	0.17	9	0.051	0.24	96	0.125
2.6	0.30	28	0.124	0.25	11	0.096	0.16	3	0.072	0.23	4	0.094	0.27	46	0.116
Reversed Parking Configuration: Average Distance to buffer (m)															
2.1	-0.08	8	0.113	-0.09	8	0.186	-0.18	2	0.177	-0.06	2	0.085	-0.09	20	0.143
2.3	0.09	21	0.162	0.01	9	0.181	-0.05	3	0.126	0.13	5	0.178	0.06	38	0.168
2.4	0.08	13	0.173	0.05	6	0.210	-0.12	1	N/A	-0.05	2	0.064	0.05	22	0.175
2.5	0.23	38	0.158	0.16	18	0.129	0.22	1	N/A	0.06	4	0.101	0.19	61	0.151

Table 4: 15th / 85th Percentile Parking Distance

Parking Lane Width	Vehicle Type									
	PC		SUV		PICKUP		VAN		TOTAL	
	Distance	Count	Distance	Count	Distance	Count	Distance	Count	Distance	Count
Curb Parking Configuration: 85th Percentile Distance to curb (m)										
2.2	0.30	5	0.40	1	-	-	0.21	1	0.32	7
2.3	0.28	10	0.29	5	0.16	3	0.10	2	0.26	20
2.4	0.33	7	0.29	5	0.31	3	0.37	2	0.33	17
2.5	0.39	56	0.39	22	0.37	9	0.22	9	0.38	96
2.6	0.39	28	0.35	11	0.21	3	0.29	4	0.37	46
Reversed Parking Configuration: 15th Percentile Distance to buffer (m)										
2.1	-0.15	8	-0.23	-0.09	-0.26	0.19	-0.10	2	-0.24	-0.06
2.3	-0.12	21	-0.14	0.01	-0.14	0.18	0.00	3	-0.14	0.13
2.4	-0.11	13	-0.14	0.05	-0.12	0.21	-0.08	1	-0.12	-0.05
2.5	0.05	38	0.00	0.16	0.22	0.13	-0.03	1	0.00	0.06

Figure 2 and Figure 3 graphically display the data for curb and floating parking lanes. The line of best fit and associated R^2 Value is presented for each data set. The trendline for the floating parking lanes has a higher R^2 Value than that of the curb parking lanes which could be caused by the smaller sample size. The difference in the R^2 values may also be due to the concrete curb present in curb parking lanes versus the painted buffer present in all floating parking lanes that were studied. A concrete curb may have a more direct impact on where people park their vehicles than a painted buffer which can easily be rolled over by a vehicle.

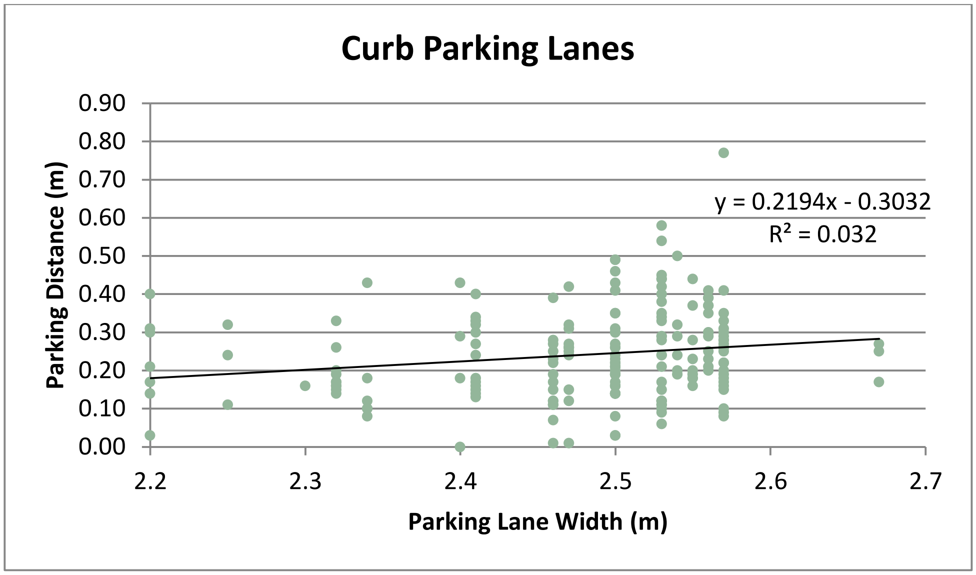

Figure 2: Curb Parking Lanes

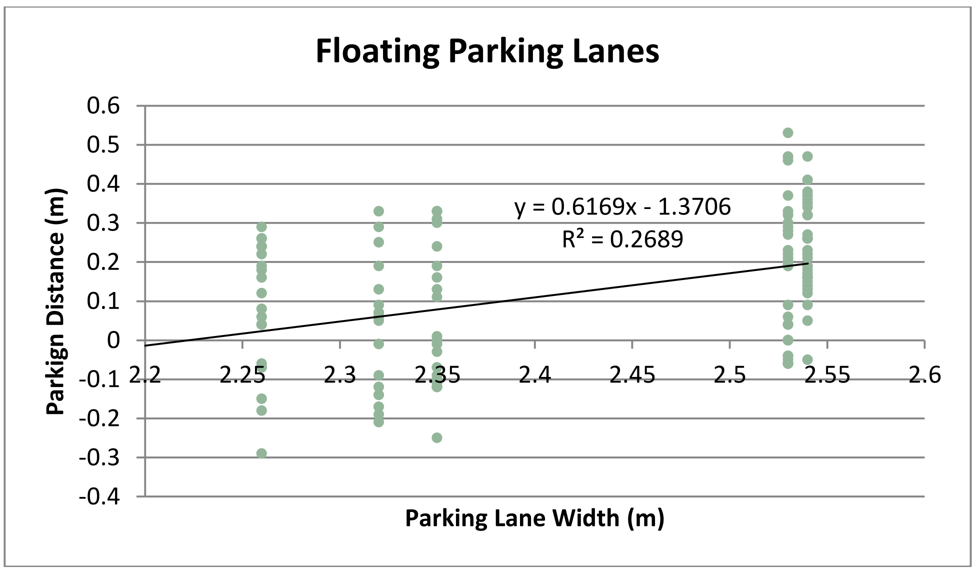

Figure 3: Floating Parking Lanes

3.0 Analysis

3.1 Vehicle Type

The first analysis is a comparison of the parking distance for the four vehicle types. As seen in Figure 4 and 5, the various vehicle types park at different distances from the curb/buffered bike lane. Overall, passenger cars and SUVs have similar parking patterns while pickup trucks and vans generally park closer to the curb. There was less data collected on 2.1 and 2.2 m parking lanes, making the average parking distances for these data points less accurate. Over the multiple parking lane widths, pickup trucks and vans have a more ircurb pattern; however this may be due to their smaller sample size for this vehicle type.

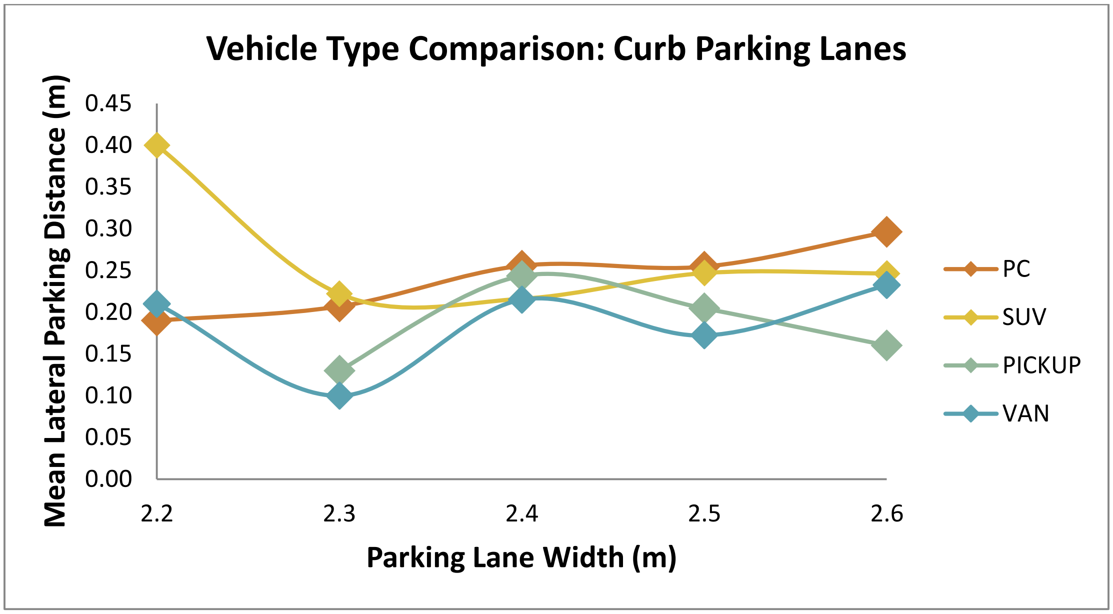

Figure 4: Vehicle Type Comparison (Curb Parking Lanes)

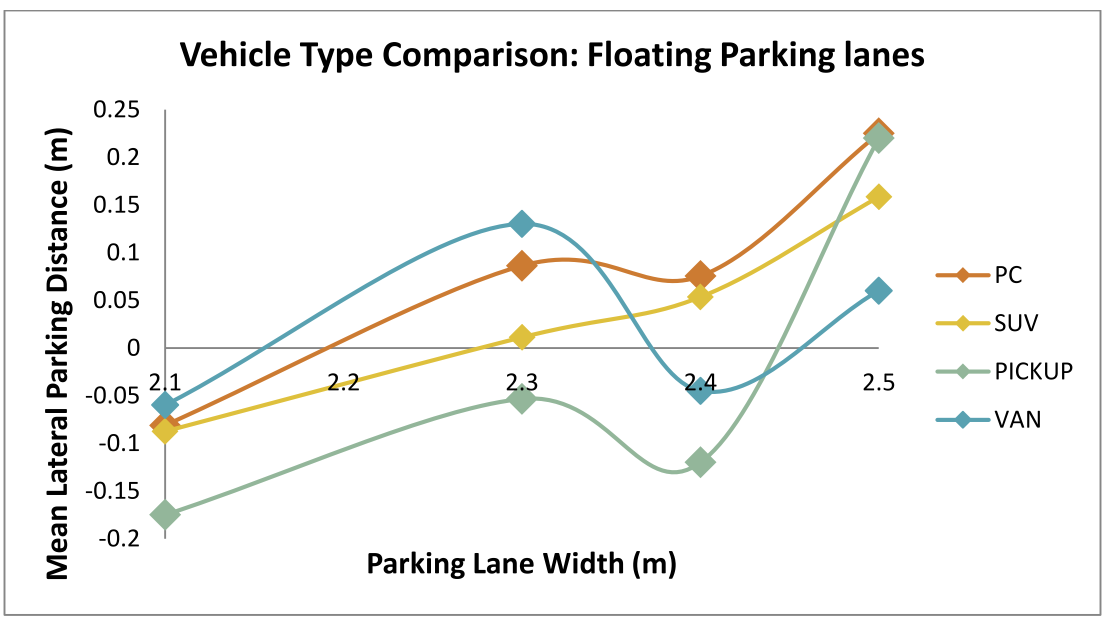

Figure 5: Vehicle Type Comparison (Floating Parking Lanes)

3.2 Parking Lane Width

The second analysis investigates how the width of the parking lane affects the parking distance of vehicles. The data is analyzed by comparing the mean parking distance and the 15th/85th percentile parking distance (all values are presented in Tables 3 and 4). Figure 6 graphically represents the mean and the 85th percentile parking distances for curb parking lanes as well as the mean and the 15th percentile parking distances for floating parking lanes.

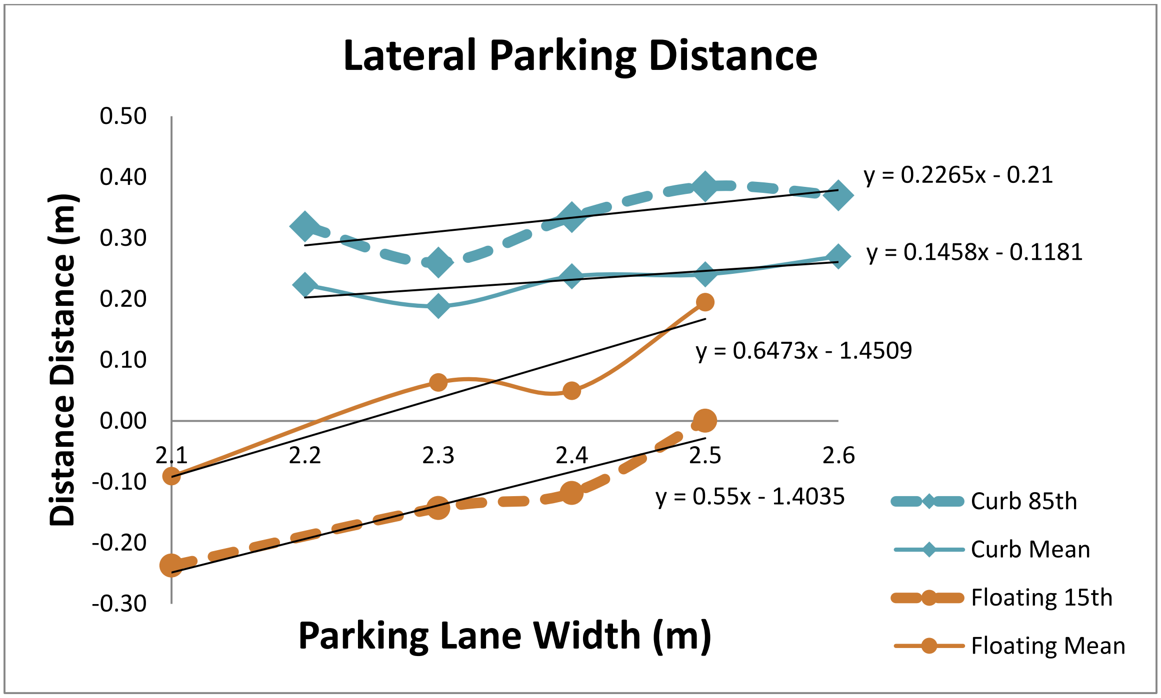

Figure 6: Lateral Parking Distance

Absolute Lateral Parking Distance

Several inferences can be made from Figure 6. First, vehicles clearly park at different lateral distances depending if they are parked in a curb parking lane or a floating parking lane. The mean value for reversed parking lanes with a width of 2.3 m and 2.4 m are significantly lower than those of curb parking lanes. The mean values for a parking lane width of 2.5 m are closer together, but the value for floating parking lanes is still lower. This effect is likely due to the construction of curb and floating parking lanes. Curb parking lanes have a concrete curb on their edge while the floating parking lanes in which data was collected only have a painted buffer between the parking lane and the bike lane. When only paint is present, it can be easier for vehicle drivers to maneuver in the parking space and allow them to park beyond the edge of the parking space.

Slope

The second inference from Figure 6 is the difference in the slopes of the trendlines for curb and floating parking lanes. The slopes represent the rate at which vehicles change their parking distance with a varying parking lane width. The slope for the curb parking trendlines are around 0.2 while for floating parking lanes they are around 0.6. This may also be due the presence of a physical barrier adjacent to curb parking lanes while floating parking lanes simply have a painted buffer.

Data Precision

The inferences that can be taken from the data should be limited to the precision of the collected data. As seen in Figure 2 and Figure 3, there is widespread variation in the parking distance versus the parking lane width. The R^2 value for curb parking lanes is only 0.03, stating that the parking lane width only explains 3% of the parking distance trend for the collected data. The data for floating parking has an R^2 value of 0.27, indicating a stronger relationship between lateral parking distance and parking lane width.

The following tables demonstrate the degree of confidence that the parking distance is greater for a wider parking lane than a narrower lane. The calculations are performed based on the 85th percentile parking distance for curb parking lanes and the 15th percentile parking distance for floating parking lanes. The calculation of the degree of confidence assumes that the parking distance is normally distributed. The data provided in the tables provide evidence that wider parking lanes cause vehicles to park further from the curb. This finding is more significant for floating parking lanes than for curb parking lanes.

Table 5: Confidence for Curb Parking Lanes

		Wider Parking Lane Width (m)			
		2.3	**2.4**	**2.5**	**2.6**
Narrower Parking Lane Width (m)	**2.2**	26%	60%	64%	81%
	2.3		92%	98%	100%
	2.4			54%	84%
	2.5				91%

Table 6: Confidence for Floating Parking Lanes

		Wider Parking Lane Width (m)		
		2.3	**2.4**	**2.5**
Narrower Parking Lane Width (m)	**2.1**	100%	100%	100%
	2.3		38%	100%
	2.4			100%

4.0 Design Considerations

This section will discuss the impacts parking lanes have on adjacent bike lanes and discuss considerations for new designs.

4.1 Parked Vehicle Impedance into Bike Lanes

Based on the results in Section 3.2, the distance that parked vehicles impede into cycling facilities can be computed. In Tables 7 and 8, the distance to the curb/buffer are computed using the 85th / 15th percentile trendlines shown in Figure 6. For curb parking lanes, the impedance is calculated assuming a vehicle width of 1.8 m and a door zone of 1.0 m. For floating parking lanes, the only assumption is a 1.0 m door zone.

Table 7: Curb Parking Lanes Impedance into Cycling Facilities

Curb Parking Lanes		
Lane Width (m)	Distance to Curb (m) *85th Percentile*	Impedance into Buffer/Bike Lane (m)
2.5	0.36	0.66
2.4	0.33	0.73
2.3	0.31	0.81
2.2	0.29	0.89
2.1	0.27	0.97

Table 8: Reversed Parking Lanes Impedance into Cycling Facilities

Floating Parking Lanes		
Lane Width (m)	Distance to Buffer (m) *15th Percentile*	Impedance into Buffer/Bike Lane (m)
2.5	-0.03	1.03
2.4	-0.08	1.08
2.3	-0.14	1.14
2.2	-0.19	1.19
2.1	-0.25	1.25

From the equations of the trendline and the two previous tables, it is evident that the narrower the parking lane, the more impedance occurs. However, if the parking lane is narrowed in exchange for widening the adjacent bike lane/buffer, more of the roadway width is allocated to people cycling. From the data collected in this study, it can be estimated that for each reduction in a curb parking lane width of 10 cm and 10 cm increase in bike lane/buffer width; there is a net gain of 2.3 cm in space for cyclists (23%). Conversely, for each reduction in a floating parking lane width of 10 cm and 10 cm increase in bike lane/buffer width; there is a net gain of 4.5 cm in space for cyclists (45%).

4.2 Effect of a Curb on Floating Parking Lanes

In Vancouver, most of the floating parking lanes are separated from the adjacent bike lane solely by a painted buffer. This section evaluates the effect that a concrete curb has on the parking distance in floating parking lanes.

The parking distance for curb and floating parking lanes clearly have different patterns. The difference between the two patterns can be seen as the effect the curb has on drivers when they park their vehicle. This effect is quantified by taking the difference between the two 15th percentile trendlines. Figure 7 shows the 15th percentile parking distances for curb and floating parking lanes while Table 9 demonstrates the difference between the two trendlines. From the graph and the table, it can be seen that on narrower parking lanes, the presence of the curb has a larger effect on the parking distances of the parked vehicles. At a parking lane width of 2.5 m the difference is only 17 cm while at a parking lane width of 2.1 m the difference is 35 cm. Therefore, constructing a curb or another physical barrier likely has a more significant effect of protecting people cycling when there is a narrow parking lane.

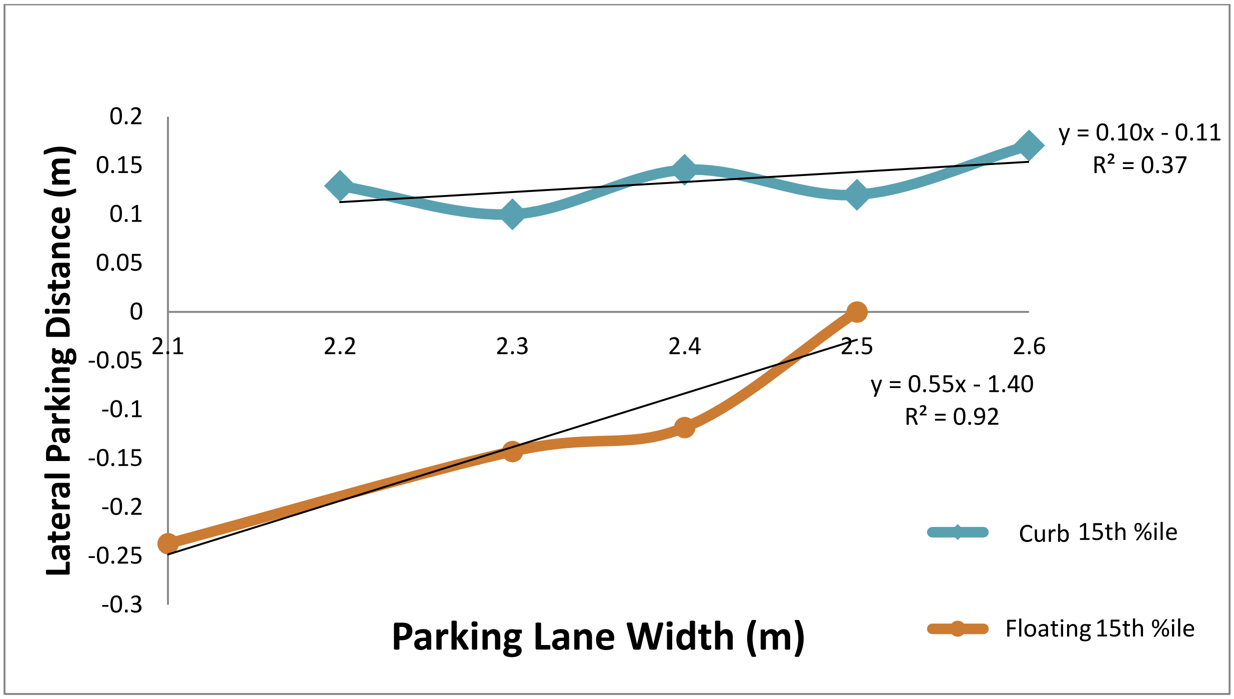

Figure 7: Effect of a Curb on Floating Parking Lanes

Table 9: Effect of the Curb

Lane Width (m)	Effect of the Curb (m) *Difference of 15th Percentile Parking Distance of Curb Parking Lanes and Reversed Parking Lanes*
2.5	0.17
2.4	0.22
2.3	0.26
2.2	0.31
2.1	0.35

5.0 Conclusions

This report highlights the interactions between parked vehicles and people cycling on adjacent bike lanes. The idea of reducing the width of a parking lane in order to increase the effective width of the bike lane is beneficial however there is minimal realized benefit for curb parking lanes. As shown in the discussion, each 10 cm of transfer from parking lane to bike lane/buffer generates 2.3 cm more space for cycling. Conversely, for reversed parking lanes with only a painted buffer, each 10 cm of transfer generates 4.5 cm for cycling. However, reducing the width of a parking lane without widening the buffer/bike lane decreases the effective width of the bike lane by causing vehicles to be parked further into the bike lane.

It should also be noted that by placing a bike lane adjacent to a narrow parking lane with no physical separation, it is expected that parked vehicles will significantly impede into the buffer and/or bike lane compared to a wider parking lane. These results demonstrate the benefit of physical separation when floating parking lanes are adjacent to bike lanes. The benefit of physical separation between floating parking lanes and bike lanes increases with narrower parking lanes.

The results from this study can provide valuable guidance when designing a parking lane adjacent to a bike lane. Furthermore, additional information on safety impacts of parking lane width and the distribution of vehicle widths should be incorporated into formal parking lane width guidelines.

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