Assessment of Bicycle-Friendly Speed Bumps: Report and Recommendation

Roger Geller March 2024

In 2020 PBOT traffic engineers and project managers began deploying "bicycle-friendly speed bumps" on some retrofit neighborhood greenway projects. Bicycle-friendly speed bumps (aka "speed cushions") have two channels that allow people bicycling to go through the channels rather than over the hump. This design change was a response to a long history of feedback from people bicycling about their dislike of speed bumps on neighborhood greenway streets.

In assessing whether speed cushions should become a PBOT standard for neighborhood greenways, this report analyzes three things: user preference for the cushions, their effectiveness at achieving the desired motor vehicle speed profile and cost implications. The report also presents non-quantifiable concerns expressed by some who bike on corridors with the cushions.

Executive Summary

- 80% of 543 on-line survey respondents indicated they prefer riding through the bicycle-friendly cushions
- This is similar to data from field observations, in which 78% of approximately 180 cyclists rode through the channels at six different locations
- This strong preference for the channels suggests that the channels represent a higher quality design than standard speed bumps. In that sense, their use better support our design policies ("Build the highest quality bikeways") than do standard speed bumps
- They also contribute to "maximize their [people bicycling] comfort and minimize delays" (design policies for bikeways) by eliminating the bump and the need for people to slow when biking over the bumps
- Bike-friendly speed cushions are able to produce the desired speed profile on neighborhood greenways, though that often requires more cushions than the bumps
- Across nine PBOT projects, additional cushions, as well as estimated higher cost (for city crews, only) to form the cushions, has resulted in an almost 20% cost increase over the use of standard speed bumps
- More than half of that cost differential arose from two of the nine projects; for some projects the number of cushions is identical or only minimally different from the number of bumps that would have been installed instead. This results in either no, or only minimal cost difference between cushions and bumps. For this reason, it will be important to evaluate each project independently when cost is an issue
- PBOT staff are currently developing designs for cushions on roadways of various width both with and without parking. There are likely combinations of width and parking that argue against speed cushions and in favor of speed bumps[1]
- Identified concerns to continue to be tracked include motorists veering to drive through a channel and potential for cyclists to become unbalance if hitting the cushion at an odd angle
- <u>Recommendation</u>: PBOT recommends that bicycle-friendly speed bumps (speed cushions) be the preferred speed bump used for neighborhood greenways. There are two main factors that would influence a choice of conventional speed bumps: relative cost and inability to provide cushions due to a disadvantageous combination of roadway width and on-street parking.

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[1] This is proving to be the case on roadways narrower than 30 feet curb to curb with on-street parking. The design goals of keeping the channels far enough apart so car wheel tracks don't fit in them conflicts with keeping the channels out of the door zones of parked cars. Thus, cushions may not be achievable on such roadways.

Background

Since 2018 PBOT has slowly rolled-out “bicycle-friendly speed bumps” on ten different streets[2]. The initial design (used on SE Clinton between 26th and 20th) has been refined in response to user feedback and staff observations. In 2021-22 speed cushions were installed on the other nine streets identified in the below footnote.

User Preference for the cushions

We assessed user preference for the speed cushions in two ways: field observations and an on-line user survey.

One-line user survey. The on-line survey was on a PBOT “Bike-Friendly Bumps” website. The survey was active from March 7, 2023, to early May. Five hundred and forty-three (543) people responded to the survey.

The survey posed three principal questions:

- When you encounter a “bike-friendly” speed bump, where do you prefer to ride? Potential answers: “through the channel”; “over the bump” “through the edge” (between the curb and bump) or “haven’t seen a bump like this”
- Which pavement markings do you prefer? Potential answers: “Aligned with channel”, “Not aligned with the channel”, “No preference”
- “Bike-friendly speed bumps may be more expensive than standard bumps. If bike-friendly bumps cost 10% more, then would you recommend: “install the bumps”, “save the money”, “no preference.

			Riding Preference					
			Number			Percentage		
Type of cyclist	*Total*		Not seen a bump like this	Over	**Through**	Not seen a bump like this	Over	**Through**
No way no how	*10*	*2%*	4	2	**4**	40%	20%	**40%**
Interested but concerned	*101*	*19%*	7	21	**73**	7%	21%	**72%**
Enthused and confident	***257***	***47%***	5	31	**221**	2%	12%	**86%**
Strong and fearless	*173*	*32%*	3	36	**134**	2%	21%	**77%**
Blank	*2*	*0%*			**2**	0%	0%	**100%**
All cyclists	*543*		19	90	**434**	3%	17%	**80%**

Figure 1. Response to survey question: “What you encounter a ‘bike-friendly’ speed bump, do you prefer to go through the channel or over the hump”?

Results. The above table in Figure 1 shows the result from the first question about positioning. We were able to roughly group the respondents into the “4 Types of Cyclists” typology based on their self-

[2] N Kilpatrick, N Michigan, N Wabash, NE Alameda, NE Davis, NE Everett, SE Ankeny, SE Clinton, SE Woodward and SW 60th

reported level of cycling comfort[3]. Eighty percent of respondents indicated a preference for riding through the channel.

Field Observations. PBOT staff observed cyclist behavior at seven different speed bumps[4] and recorded 179 observations. Seventy-eight percent (78%) of cyclists chose to ride through the channel. Staff observed a wide range of "channel riding" based on location. One location (albeit with only 14 observations) found only 43% of cyclists going through the channels. The high range (with 35 cyclists) was 97% of people riding through the channel. Thoughts about this range are in the discussion at the end of this report.

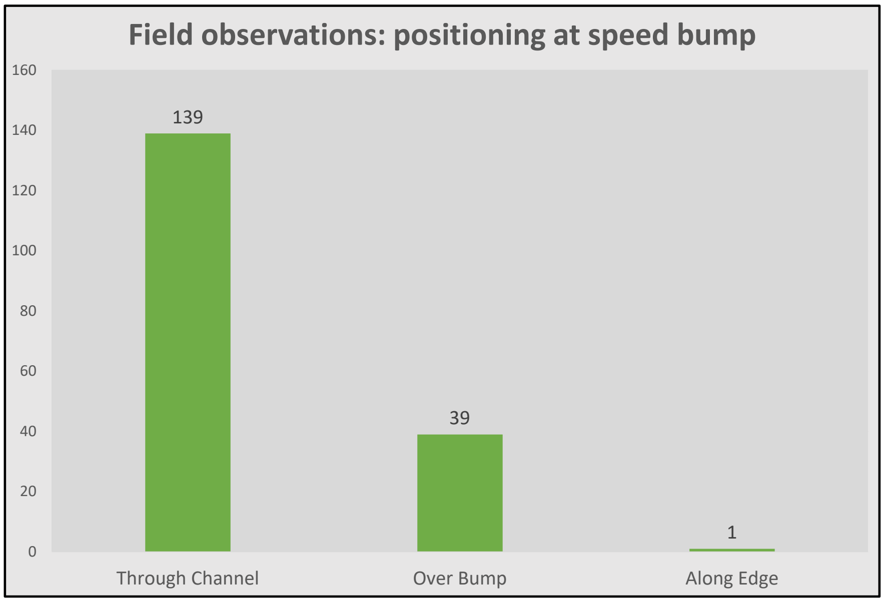

Figure 2. Results of field observations of cyclists at seven bike-friendly speed bumps.

Effectiveness at Speed Control

PBOT engineering staff have identified that most projects will require more bicycle-friendly bumps than conventional bumps to achieve the desired outcome. With an increased number of bumps, the bicycle-friendly speed bumps are effective at realizing the guidance for auto speeds on neighborhood greenways.

The below table in Figure 3 shows the before and after speed data at the six installations for which data is currently available. Cells outlined in orange show speeds that exceed our recommendation for 85th percentile speeds on neighborhood greenways (ie., 21 mph or greater). On all corridors, speeds after

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[3] Based on which of the following statements they agreed with: "I'll only ride on neighborhood greenways, on off-street paths, or in protected lanes" (Interested but Concerned, 19% of respondents). I'll ride on busy streets in a bike lane" (Enthused and confident, 47% of respondents). "I'm comfortable riding on most streets, even without bike lanes" (Strong and Fearless, 32% of respondents). "I will not ride a bike on any street, regardless of infrastructure or conditions" (No Way, No How, 2% of respondents).

[4] SE Ankeny at 30th, NE Alameda & 43rd, NE Alameda/42nd at Siskiyou, NE Alameda between 42nd and 43rd, NE Everett at 49th, NE Everett west of 49th, N Michigan and Sumner

installation were lower than pre-installation speeds. The installation on N Wabash produced after speeds that deviate the most from neighborhood greenway guidance. Engineering judgment indicates that the nearby signal may contribute to speeding as well as the fact that the two southern-most cushions are further apart than standard based on the pre-implementation speeds. Overall, the results for bike-friendly cushions are consistent with what we achieve with standard speed bumps.

	Speeds before					**Speeds after**				
	West/South	East/North	Range			West/South	East/North	Range		
Ankeny 28th-32nd	21.0	19.0	17	-	22	20.0	18.3	17	-	21
Everett 47th-60th	20.2	19.5	17	-	23	19.5	19.3	17	-	23
Woodward 64th-75th	24.5	24.3	21	-	26	19.8	20.0	18	-	22
Woodward 52nd-64th	22.0	22.0	18	-	26	21.4	20.2	18	-	25
Alameda near 56th	25.0	26.0	25	-	27	21.0	20.5	20	-	22
Michigan Killingsworth-Alberta	22.5	23.5	21	-	24	19.3	20.7	18	-	22
Wabash Lombard-Bryant	26.0	25.5	24	-	27	25.0	23.7	23	-	26

Figure 3. Before and after speed profiles of projects that used bicycle-friendly speed bumps. Cells highlighted in orange exceed the desired outcome of 20 mph 85th% speed.

Cost differential

Figure 4 below shows costs associated with the nine corridors in Portland with bike-friendly speed cushions. The table shows:

- The number of cushions installed (*row a*)
- The number of bumps that would have been installed had standard bumps been specified (*row b*)
- Who did the work (contractor or PBOT crews; *row n*)
- The planning level cost estimate for cushions (*rows f and j*)
- Six of 9 projects differed in the number of cushions v. bumps required by either zero or one (orange outlined cells)
- The price premium associated with installing cushions rather than bumps[5] (*rows h, I, l and m*).
- Half of the overall cost differential was driven by two projects with the greatest difference in number of cushions v. bumps.

[5] The premium is defined as the difference between installing cushions compared to the installation of bumps

Seven of the nine projects were installed by contractors and two were installed by PBOT (*row n*)[6]. *Row a* shows the number of cushions installed. *Row b* is the engineer's estimate of how many speed bumps would have been needed instead. While most projects require more cushions than bumps to achieve the desired speed outcome the difference for six of the nine was either zero or one. This is the first and primary reason that speed cushion projects usually cost more than would speed bumps on the same corridor[7]. The second factor applies to PBOT installations, only. As shown in Figure 5, the planning level estimate for PBOT installation of cushions is higher than for speed bumps. That is not the case for contract work, where the cost charged is identical for bumps and cushions.

		1	2	3	4	5	6	7	8	9	
	Greenway	**N Wabash**	**N Michigan**	**NE Alameda**	**NE Everett**	**NE Davis**	**SE Ankeny**	**SE Clinton**	**SE Woodwarc**	**SW 60th**	**Implement. Totals**
	Extent	Lombard-Bryant	Kill.-Alberta	41st-67th	47th-60th	60th-71st	28th-41st	21st-26th	52nd-75th	Vermont-Canby	
	Length	1,240	1,301	7,095	3,240	3,150	4,435	1,180	5,910	2,510	
a	**Cushions installed**	4	5	27	10	10	14	5	19	10	
b	**Bumps required**	4	4	22	10	9	13	3	18	7	
c											
d	**Estimated project costs**										
e											
f	**PBOT-installed cushions**	*$16,200*	*$20,250*	*$109,350*	**$40,500**	*$40,500*	*$56,700*	**$20,250**	*$76,950*	*$40,500*	**$60,750**
g	PBOT-installed bumps	*$10,000*	*$10,000*	*$55,000*	*$25,000*	*$22,500*	*$32,500*	*$7,500*	*$45,000*	*$17,500*	
h	Price premium ($)				*$15,500*			*$12,750*			
i	Price premium (%)				*62%*			*170%*			
j	**Contractor-installed cushions**	**$30,800**	**$38,500**	**$207,900**	*$77,000*	**$77,000**	**$107,800**	*$38,500*	**$146,300**	**$77,000**	**$685,300**
k	Contractor-installed bumps	*$30,800*	*$30,800*	*$169,400*	*$77,000*	*$69,300*	*$100,100*	*$23,100*	*$138,600*	*$53,900*	
l	Price premium ($)	*$0*	*$7,700*	*$38,500*		*$7,700*	*$7,700*		*$7,700*	*$23,100*	
m	Price premium (%)	*0%*	*25%*	*23%*		*11%*	*8%*		*6%*	*43%*	
n	Contract job or PBOT?	contract	contract	contract	PBOT	contract	contract	PBOT	contract	contract	**$746,050**

Figure 4. Planning level costs for nine installed speed cushion projects. Seven of the nine projects were installed by contractors and two by PBOT staff. Row n indicates who did the installation. Price premium for cushions ranged from 0% to 170%, depending on the project. Cells outlined in orange indicate where difference between required number of cushions and bumps was zero or one.

Figure 4 shows that the total cost spent on speed cushions on these nine projects was approximately $746,000. Figure 6 shows that if the projects had instead installed speed bumps then the same projects would have cost $625,000, resulting in a cost savings of approximately $120,000.

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[6] This is consistent with MO's stated ability to install at most only 40 speed bumps per year.

[7] It is worth putting this cost increase in the context of how implementation of speed bumps has changed over time and the effect this has had on costs. The first change affecting cost of speed bumps was the adjustment to our guidance for neighborhood greenways that lowered desired speed outcome from 25 mph to 20 mph. This both produced a better product and increased project costs. The cost increase resulted from the need for more bumps per 20 mph corridor than was required for 25 mph corridors.

The next change affecting cost has been our increasing reliance on contractors to deliver speed bump projects. Speed bumps had formerly been installed almost exclusively by PBOT crews through work orders. The only exception had been federally funded projects in which all work was contracted. When PBOT staff were no longer as available to install speed bumps we began hiring contractors to do the work. This shift resulted in a significant cost increase. The benefit was our ability to install the bumps, albeit at a higher cost for the same product.

Thus, over all nine projects this increased cost represents a premium of almost 20 percent. However, because this varies by project it is worth evaluating these costs on a project-by-project basis and not just globally.

Figure 4 demonstrates that the cost premium is dependent on the differential between the count of cushions versus bumps. On two of the projects there was no difference. On four of the projects the difference was just one cushion. The other three projects differed by 2, 3 and 5 cushions. More than half of the $120,000 cost differential was driven by the two projects with the greatest discrepancy in bumps versus cushions. Thus, it is useful to evaluate for each project the potential difference between number of cushions and bumps that would be required to see if cost will be a factor.

Fully loaded speed bump and cushion unit cost		
Installed by:	**PBOT**	**Contractor**
Planning-level unit costs		
Standard Bump	$2,500	$7,700
Speed cushion	$4,050	$7,700

Figure 6. Planning level cost estimates for speed bumps and speed cushions.

Total 9 corridor project costs: planning cost comparison of scenarios				
Actual project costs	$746,050		7 projects contracted; 2 installed by PBOT crews	
if all bumps	$625,400			
Difference	$120,650		19%	cost premium

Figure 5. Comparing planning level costs for cushion versus bumps on nine existing cushion projects. Had all cushion projects been bump projects, then there would have been savings of $120,000

Additional Considerations

As part of the on-line survey, we asked about the <u>alignment</u> of pavement markings to see if people biking preferred the pavement markings (shared lane markings and speed bump chevrons) aligned with the channel. Aligned markings aid in identifying the location of the channel, especially at night. PBOT's current guidance does not consider the channel when setting location of the above markings, though recent projects have been engineered to create that alignment (see Figure 8).

Figure 7. Markings aligned with channel in speed cushion on SE Woodward St. Preferred by 65% of survey respondents (31% had no preference). Aligned markings make it easier to identify channel under low-light conditions.

Sixty-five percent of respondents preferred that the markings be aligned with the channel while 31%

had no preference. Only five percent stated a preference that they not be aligned.

The below table in Figure 7 shows alignment preference based on cyclist typology.

			Marking alignment preference					
			Number			Percentage		
Type of cyclist	*Total*		Aligned with channel	Not Aligned	**No Preference**	Aligned with channel	Not Aligned	**No Preference**
No way no how	*10*	*2%*	5	2	3	50%	20%	30%
Interested but concerned	*99*	*18%*	63	5	31	64%	5%	31%
Enthused and confident	***256***	***47%***	172	11	73	67%	4%	29%
Strong and fearless	*171*	*31%*	106	6	59	62%	4%	35%
Blank	*2*	*0%*	2	0	0	100%	0%	0%
All cyclists	*538*		**348**	24	166	**65%**	4%	31%

Figure 8. Stated preference of 538 survey respondents regarding alignment of pavement markings. Respondents were asked which pavement markings they preferred and were then shown images of markings that were aligned or not aligned with the channel. "No preference was also an available choice.

Recognizing that bike-friendly cushions were likely to cost more than standard bumps, survey respondents were asked about what to do in case of increased costs. A slight majority of respondents recommended installing the cushions despite a potential 10% premium on cost[8]. Forty percent said to save money and nine percent had no preference (see Figure 9).

			Cost Consideration					
			Number			Percentage		
Type of cyclist	*Total*		Install the bumps	Save Money	No preferrence	Install the bumps	Save Money	No preferrence
No way no how	*10*	*2%*	3	6	1	30%	60%	10%
Interested but concerned	*101*	*19%*	54	40	7	53%	40%	7%
Enthused and confident	***254***	***47%***	123	102	29	48%	40%	11%
Strong and fearless	*171*	*31%*	95	64	12	56%	37%	7%
Blank	*2*	*0%*	1	1	0	50%	50%	0%
All cyclists	*538*		**276**	213	49	**51%**	40%	9%

Figure 9. Response to question about what to do if bike-friendly speed cushions cost 10% more than conventional speed bumps.

[8] The survey was conducted before analysis indicated a potential 20% cost premium associated with using speed cushions rather than speed bumps.

Some survey respondents also expressed concerns about the channel design, with the following being the most frequently mentioned:

- the speed cushions encouraged people driving to aim for the channels, resulting in erratic driving behavior
- the cushions posed a crash hazard, especially if a person biking hit them at an odd angle
- the cushions are uncomfortable for tricycles and bikes pulling trailers
- the channels are too far out into the roadway (for people who would rather stay to the right).

Regarding the third and fourth concerns, people biking do not have to ride through the channels. They may choose to follow any alignment over the bumps they choose. The channels are also positions to be out of the door zone of parked cars and toward the middle of the travel lane, which is typically the safest place to ride.

Regarding that the cushions can contribute to crashes: there have been no reported crashes on the cushions to date. When initially deployed, PBOT staff attempted to ride erratically through the channels at different speeds and angles of approach to see if the channels created discomfort in riding. They did not.

The issue of people driving altering their travel path to hit the channels has elicited two concerns. The first is that they make the channel ineffective. The second is that people driving in that manner pose a threat to other roadway users. The cushions are designed to not allow both wheels of motor vehicles to enter the channels at the same time. We have a spreadsheet from NHTSA (National Highway Traffic Safety Administration) with data about track widths for most passenger cars, pick-ups and SUVs sold in the US. The average track width for passenger cars is 4.84 feet. For pick-ups and SUVS the average track width is 5 feet. On 36’ wide roadways the distance between channels ranges from 10’-14’. The narrowest distance—designed for narrower roadways is 10’. Anything less than that would be considered substandard. Our speed data indicate that even though people may get one wheel in a channel it does not affect speed. However, that doesn’t mean that people don’t try.

Our field observers note this behavior by people driving, as have people who are casually riding along greenways. However, the observation is that while people driving may deflect toward the channel when there is nobody else on the roadway. When somebody else is on the roadway, people driving stay in their lane.

Discussion

This report presented data on the three principal areas of concern: user preference, achieving desired outcomes and cost. In summary:

1) Both field observations and an on-line survey confirmed that a majority of people bicycling (80%) prefer riding through the channels than over the bump.
2) Most, but not all, installations required a tighter spacing than conventional speed bumps (i.e., more cushions); with that tighter spacing the performance of the cushions is in line with the performance of conventional speed bumps,
3) The need for more cushions relative to bumps results in higher costs. Of the nine projects evaluated, two resulted in no cost differential (same number of cushions as bumps) and four projects each required one additional cushion. Three projects required more than two additional cushions relative

to bumps and resulted in the highest cost differential. Projects requiring one additional cushion cost an average of 9% more to implement than a comparable project using speed bumps.

4) When asked if PBOT should spend up to 10% more to provide the channel, 51% said PBOT should spend the money; the other 49% said PBOT should save money or they didn't have a preference.

People biking along neighborhood greenways have a choice as to where to traverse bicycle-friendly speed cushions. They are overwhelmingly choosing the channel, which suggests that speed cushions provide a higher quality design for neighborhood greenways than do standard speed bumps[9]. PBOT's design policy for both City Bikeways and Major City Bikeways is to "build the highest quality bikeway facilities" in order to "maximize their [cyclist's] comfort and to minimize delays"[10]. Based on user preference, speed cushions seem to be the higher quality traffic calming device compared to standard speed bumps. They eliminate what can be a significant jolt and the need to check one's speed when navigating a bump—especially when biking downhill.

Speed cushions have been demonstrated to be effective at achieving desired speed profiles for people driving on the greenways.

Considerations. There are several considerations for moving forward. Principal among them is cost. With most projects there is likely a premium to be paid for speed cushions instead of speed bumps. That premium can range from minimal (one more cushion than speed bump) to more significant (up to five more cushions on one of the nine projects evaluated).

Is the additional cost worth it? Slightly more than half the cyclists surveyed (51%) supported spending the additional money when the cost differential was 10% or less. Forty percent of those surveyed thought PBOT should save the money, and 9% expressed no preference. It is worth noting that PBOT is already paying a significant premium by having speed bump work done by contractors rather than in-house (a more than 200% premium).

As this report is being prepared, PBOT finds itself in dire and unprecedented financial straits that elevates the question of financial stewardship.

Another consideration is a concern about motorist behavior in the presence of these bumps. There have been anecdotal reports of people driving in a manner to avoid going over the peak of the hump. This behavior has not resulted in a higher speed profile, nor in behavior that has caused either crashes or close calls.

A final consideration expressed in the on-line survey was concern by people biking over the bumps that they would hit the channel/bump at an odd angle that could cause them to crash[11]. There had also been concern expressed by some people biking that they are unable to see the channel at night and thus are

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[9] We also observed most people choosing to ride over the hump at one of the observed speed cushions. This seemed to be related to the cushion's proximity to a curve in the roadway. The natural path of the cyclists led them to the inside corner of the roadway, and thus over the hump rather than through the channel.

[10] Portland Transportation System Plan, Bicycle Classification descriptions for improvements for both Major City Bikeways and City Bikeways.

[11] There had been one anecdotal report of a person striking their pedal on the side of the bump when riding through the channels on the initial installation of these bumps on SE Clinton Street, between 21st and 26th. The design has since been refined to eliminate that possibility.

worried about where they might traverse the bump. PBOT staff have ridden repeatedly through and near the channels to identify if there is an angle of approach that would produce unsteadiness in riding. They found none. Though this concern was expressed by some, it appears not to be based on any crashes or unsteadiness caused by the bumps. This can be addressed, in part, by aligning roadway markings (sharrows and bump chevrons) in a manner to clearly identify the channels.

Recommendation

PBOT recommends that bicycle-friendly speed bumps be the preferred speed bump used for neighborhood greenways while being mindful of the need for the agency to trim costs. When the cost differential between speed bumps and speed cushions is minimal or zero, then the project should install the cushions. When the cost differential is high, then the Project Manager should identify if the budget is sufficient to cover the cost. Given PBOT's current financial situation, the agency is likely to default to conventional speed bumps as the less costly option. As budgets recover, this recommendation can be revisited.

PBOT also recommends continuing to monitor driver behavior and achieving desired speed outcomes when these bumps are used, and to continue to seek information of people bicycling having difficulty navigating the speed bumps.

Finally, as a design feature, PBOT recommends placing roadway markings associated with neighborhood greenways and the cushions in a manner that aligns with the channels. Those markings are intended to show the desired path of travel, which in the case of the bicycle-friendly speed bumps, is through the channel.